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21ST Annual General Assembly

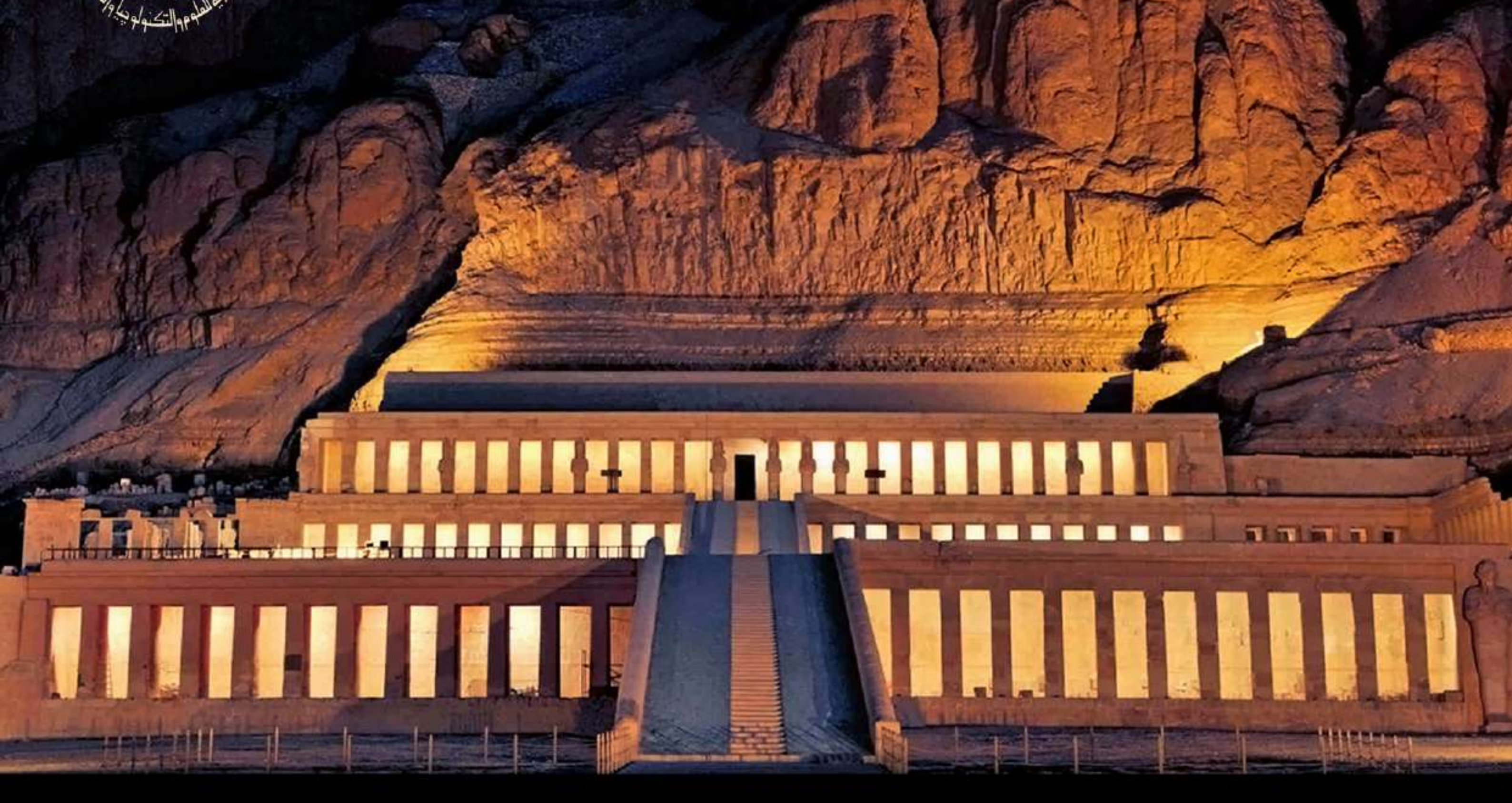
IAMU AGA21

26th-28th October 2021
Alexandria - Egypt

The 21st Annual General Assembly

Proceedings of the International Association of Maritime Universities (IAMU) Conference

Arab Academy
for Science, Technology and Maritime Transport



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Program Editors
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Preface

The 21st Annual General Assembly (AGA 21) is the annual meeting of the International Association of Maritime Universities (IAMU). The IAMU Conference (IAMUC), held annually as part of the AGA, brings together experts and official representatives of IAMU member universities from all over the world to discuss, exchange, and share recent progress and future trends in maritime education, training, research and other matters within the scope of IAMU.

The 21st AGA and IAMUC 21 are hosted by The Arab Academy for Science, Technology, and Maritime Transport (AASTMT), in the beautiful city of Alexandria, Egypt.

Due to travel restrictions imposed by the COVID-19 pandemic, and for the first time in 20 years, the IAMUC was canceled in 2020. In 2021, the International Executive Board (IEB) of the IAMU found it challenging to decide on how to proceed with the conference. Yet, after due consideration, it was decided to hold the conference in a hybrid mode, combining the regular "face to face" meeting with "online" participation, thus, enabling experts and scholars from around the globe to meet, disseminating the latest research advancements in the field of maritime education, training, research, and development.

The theme of the AGA21 IAMUC is "**Innovation and Sustainability of Maritime Industry in the Scope of Blue Economy and Green Concept"**. The IMAUC program is organized within eight topics;*Impact of Infectious Pandemic Disease is on The Future of The International Maritime Industry "What is After COVID 19"* - *GMP Applications and Human Capacity Building in Maritime Affairs* - *Smart Maritime Supply Chain and Logistics* - *Innovative MET Environment* - *New Trends in Maritime Transport and Job Opportunities* - *Efficiency of Shipping Port Management from Environmental Perspectives* - *Renewable Energy Resources Alternatives in Maritime Industry* - *Marine Pollution and Climate Change New Challenges.*

IAMUC 21 is a stimulating and informative gathering with a wonderful array of keynote and invited speakers from all over the world. Delegates will have a wide range of scientific researches to choose from, as the program consists of topic dedicated sessions, technical workshops, and discussions with eminent speakers covering a wide range of topics and aspects of the Maritime Domain.

The Proceedings of the IAMU Conference contains papers presented at the technical sessions. This year's IAMUC has received 127 high-level abstract submissions from 29 different countries and 49 different IAMU universities. Based on the following full paper submissions and the double peer-review process, 57 papers were accepted for inclusion in the Proceedings.

We hope your experience with AGA 21 and IAMUC 21 is a fruitful and long-lasting one. With your support and participation, the conference will continue its success for a long time.

Finally, we would like to thank the organizing committee, the members of the program committees, reviewers, and external reviewers. They have all collaborated to execute a world-class scientific conference appropriate to the respected work of the International Association of Maritime Universities and all member universities.

Prof. Yasser Gaber – Capt. Amr Moneer
IAMUC 21 Program Editors

Prof. Boris Svilicic
IAMUC Chief Program Editor

Theme:

Innovation and Sustainability of Maritime Industry in the Scope of Blue Economy and Green Concept

Organization Committees:

To make the AGA 21 and IAMUC 21 a success, the Arab Academy for Science, Technology and Maritime Transport (AASTMT), as the host, and the organized Executive Committees and International Program Committee with the cooperation of IEB members and members of the working groups supervised by Academic Affairs Committees.

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Impact of Infectious Pandemic Disease is on The Future of The International Maritime Industry “What is After COVID 19”

A Study on Impact of International Container Vessels during and Post Pandemic

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Abstract

The international trade is totally relying on shipping, more than 90% of the international trade is dependent on shipping. The dependence of shipping in the international trade is due to its low-cost transportation. The container ships are more popular in the international trade, as the containers are easy to handle at ports, reducing the turnaround time for ship, reducing the dwell time of cargo, containerization provides better security for the cargo, also used in multimodal and intermodal transportation and also facilitating liner trade.

The outbreak of COVID virus has put the entire world shipping industry in mess, causing great havoc to all economies. This paper analysis the impact of COVID on the traffic of international container vessels and also, how the impact has affected the growth of world container port throughput. If the world container port throughput is affected, then the traffic of container vessels is also affected. The traffic of the world container port throughput is linked with number of container ships around the globe and with container ships in dead weight. The Study is analysed, with 10 years' data (2011-2020) taken from secondary sources. The data is analysed using DEA-Efficient Frontier. The efficient frontier signifies an efficiency mark in the entire set of decision-making units (DMU). Each year is considered as a decision-making unit, to find out the efficiency year-on-year, in the first model comparison was made keeping world container port throughput as output (O) and number of ships globally is assigned as input (I). In the second model efficiency was compared with world container port throughput as output (O) and container ships dead weight as input (I). The Relative efficiency is also calculated, that is, by dividing efficiency of DMU's by the best efficient DMU. Before applying DEA, it is ascertained that the world container port throughput is correlated with number of container ships around the globe and similarly world container port throughput is correlated with container ships in dead weight. To study the impact of growth of world container port throughput, compound annual growth rate (CAGR) is calculated on a year-on-year basis. The traffic of the world container port throughput has declined in 2020, the efficiency and the relative efficiency calculated also shows a downward trend. The compound annual growth rate also shows a negative growth in 2020. This reflects that the world container port throughput

has declined in 2020, which means the traffic of container vessels throughout the word has suffered enormously, essentially due to the impact of COVID virus.

Key Words: Container Vessels, Container Port Throughput, COVID, Data Envelopment Analysis

1. Introduction and Background of the Study:

The global trade is completely relying on shipping, more than 90% of the international trade is dependent on shipping (Leivestad & Markkula, 2021). The dependence of shipping in the international trade is due to its low-cost transportation. The COVID 19 has an unprecedented challenge to maritime transport causing great havoc to all economies, due to which disruption caused to port traffic, port calls, liner trade causing slowdown in the seaborne trade(UNCTAD, 2020).

The container ships are most sought after, is due to the fact that container handling at ports became easy, optimum utilization of berth, ships turnaround time were reduced due to faster handling of containers than break-bulk cargos, lesser dwell time with better security for the cargo. Due to pandemic hit, container vessels were also affected significantly. The sudden drop in demand had an impact on global shipping especially containers (Notteboom et al., 2021).

This paper discusses the impact of COVID on international container vessels. If the world container port throughput is affected naturally the traffic of container vessels is also affected. The traffic of the world container port throughput in twenty foot equivalent (TEU) is allied to number of container ships around the globe. Further the world container port throughput is also linked with container ships in dead weight. The scope of this comparison, year on year, may yield the efficiency of container port throughput yearly this will lead to find out the impact of pandemic on international container Vessels.

This paper scrutinizes two research questions: (1) whether the COVID pandemic has an impact on the traffic of international container vessels (2) how the impact has affected the growth of world container port throughput. To analyse these questions, an effort is made, with 10 years' data (2011-2020). The data envelopment analysis is applied to find out the efficiency of world container port throughput with number of container ships as input, in the second model the efficiency of world container port throughput is calculated keeping container ships in dead weight as input. To investigate the impact of growth of world container port throughput, compound annual growth rate (CAGR) is calculated on a year-on-year basis. Before applying

DEA, it is ascertained that the world container port throughput is correlated with number of container ships around the globe and similarly world container port throughput is correlated with container ships in dead weight.

2. Literature Review:

During COVID container shipping lines got affected, during pandemic, container lines have attuned their strategies to manage them dip in container traffic, there was an impact of freight rate in the Asia-Europe sector. The shipping lines with all their alliance were aligned to adopt to blank sailing due to fall in demand(Notteboom et al., 2021).

The coronavirus has affected the global maritime sector including African maritime transport causing huge disruption to shipping and havoc to maritime transport, the pandemic hit has completely wrecked the global maritime transport. The shipping routes have been altered for survival, still the pandemic has caused maritime bankruptcies(Oyenuga, 2021).

Normally container ports operate with qualms due to many socio economic factors, COVID outbreak made more worse for container movement(Russell et al., 123 C.E.)

Due to COVID the cost of operation of freight forwarders and container transportation cost have gone up many fold causing disturbance to global logistics and last mile connectivity followed huge fall in demand for maritime transport(Nwokedi et al., 2021).

The Virus COVID-19 brought new disruption in operating the ships as the vessel has to undergo security check before berthing in ports, the chartering rates in container shipping market get disturbed due to change in traffic volume of containers, even cruise vessels had an impact(Yazır et al., 2020).

The entire global shipping sector was affected due to the influence of COVID. From the analysis it is found there is a drop in ship calls to 10.2% at EU ports in 2020 compared to the previous year. Still the shipping market has not picked up, the standing testimony is that, in January 2021, the number of ship calls at EU ports dropped by 6% when compared to the corresponding month in 2019(European Maritime Safety Agency (EMSA), 2021).

The growth of Global shipping markets got drastically affected due to COVID-19, equally fleet development also showed a sign of deterioration due to pandemic (Menhat et al., 2021)

The pandemic has hit so hard on global maritime transport and shipping business which has led to change in the strategy of shipping business and connected supply chain management.

The virus not only affected the shipping business and maritime transport but also the world trade (Hebbar & Mukesh, 2020)

The efficiency of six major container terminals in Malaysia was measured using frontier method of DEA, the study compared terminal equipment's with throughput (Mokhtar & Zaly, 2013)

The Covid 19 has affected the Nigerian supply chain as how it has affected the world, the country faces a huge shortage of essential goods, the unemployed problems started to increase, capacity were poorly utilized, the ports were disrupted to a larger extent due to pandemic (Babatunde & Ibrahim, 2020)

3. Model Derivation using Data Envelopment Analysis:

Data Envelopment Analysis (DEA) is a standardising technique used to evaluate efficiency(Tetteh et al., 2016), the efficiency of the output is measured based on the input used. In other words DEA is a benchmarking technique that evaluates operational efficiency (Munisamy & Singh, 2011). DEA is a flexible analysis method to evaluate efficiency. This input and output non-parametric model can also be adopted, if the relationship is unclear (Kaisar et al., 2006).

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}}$$

This paper analyses the data using DEA-Efficient Frontier. The efficient frontier signifies an efficiency mark in the entire set of decision-making units (DMU). The author uses DEA - Efficient frontier method to find out the efficiency of each year from 2011-2020 Each year is considered as a decision-making unit, to find out the efficiency year on year, in the first model, a comparison was made keeping world container port throughput as output (O) and number of ships globally is assigned as input (I). In the second model, efficiency is compared with world container port throughput as output (O) and container ships dead weight as input (I).

Relative efficiency is calculated by dividing the efficiency of DMU's, by the best efficient DMU.

i.e., **Relative Efficiency**:

$$0 \leq \text{Relative Efficiency} \leq 1$$

$$\frac{\text{Efficiency of } DMU_i}{\text{Efficiency of } DMU_{Best}}$$

To find out whether it is appropriate to compare the world container port throughput and number of ships globally, correlation was calculated, after ascertaining that the above two indicators are positively correlated, the DEA technique is applied. Similar calculation was also made comparing world container port throughput and container ships dead weight which was also positively correlated.

4. Data Analysis and Interpretation

The data for the analysis were collected from the various sources and analysed, the following are the detailed analysis.

Table-1- Correlation between container port throughput and No. of container ships

Year	Container Port Throughput in TEU (in Million) (x)	Number of Container Ships (y)
2011	584.33	4966.00
2012	618.16	5096.00
2013	648.92	5079.00
2014	680.53	5101.00
2015	692.43	5111.00
2016	703.52	5225.00
2017	757.12	5150.00
2018	795.74	5198.00
2019	811.22	5304.00
2020	775.00	5371.00

(Source of Data: UNCTADSTATS & statista.com)

R Calculation

$r = \sum ((X - M_y)(Y - M_x)) / \sqrt{((SS_x)(SS_y))}$
$r = 68464.583 / \sqrt{((53110.509)(125200.9))} = \mathbf{0.8396}$

The author wants to know whether there is, any relation exists between world container port throughput and number of container ships before calculating DEA. So, correlation was calculated between the above two variables it is found that the r = **0.8396** meaning there is a strong positive correlation between the above two variables.

Table-2 - Correlation between container port throughput and container ships in Dead weight

Year	Container Port Throughput in TEU (in Million) (x)	Container Ships in Dead weight tons (in thousands) (y)
2011	584.33	183691.41
2012	618.16	196820.99
2013	648.92	206322.14
2014	680.53	216199.14
2015	692.43	228229.99
2016	703.52	244398.64
2017	757.12	245683.48

2018	795.74	253632.59
2019	811.22	266087.20
2020	775.00	274856.49

(Source of Data: UNCTADSTATS & statista.com)

R Calculation

$r = \sum ((X - M_y)(Y - M_x)) / \sqrt{((SS_x)(SS_y))}$

$r = 20043784.381 / \sqrt{((53110.509)(8300401095.207))} = \mathbf{0.9546}$

Before calculating DEA, it has to ascertained whether there is any relation exist between world container port throughput and container ships in dead weight. Hence when calculating correlation between the above two variables it is found that the r = **0.9546** meaning there is a strong positive correlation between the above two variables.

Table-3-Measuring Efficiency of World Container Port Throughput Year on Year using DEA with Number of Container ships in the world as Input

Year	(O)Container Port Throughput in TEU (in Million)	(I)Number of Container Ships	Efficiency	Relative Efficiency
(a)	**(b)**	**(c)**	**(d)=(b)/(c)**	**(e)=d/0.1531**
2011	584.33	4966.00	0.1177	0.76863
2012	618.16	5096.00	0.1213	0.79239
2013	648.92	5079.00	0.1278	0.83460
2014	680.53	5101.00	0.1334	0.87148
2015	692.43	5111.00	0.1355	0.88498
2016	703.52	5225.00	0.1346	0.87954
2017	757.12	5150.00	0.1470	0.96033
2018	795.74	5198.00	0.1531	1.00000
2019	811.22	5304.00	0.1529	0.99908
2020	775.00	5371.00	0.1443	0.94257

Relative Efficiency:

$0 \leq$ Relative Efficiency ≤ 1

Efficiency of DMU_i / Efficiency of DMU_{Best}

To find out whether there is any impact of COVID on the traffic of international container vessels, the author has used world container port throughput and number of ships (world) as indicators. The analysis was made adopting Data Envelopment Analysis. While applying DEA, every year was made as decision making unit. Number of container ships throughout the world was marked as input and world container port throughput was marked as output (single input and output model). In 2020 the world container Port throughput is around 775.00 million TEU’s compared to 811.12 million TEU’s in 2019, in fact the pandemic hit was at peak in 2020 and many countries suffered during this period, this indicates the container vessel movement globally got affected essentially due to pandemic. The efficiency and relative efficiency of 2018 was the highest, calculated based on the single input and output model. The efficiency during 2020 is 0.1443 compared to 0.1529 in 2019. The relative efficiency also plunged to 0.94257 in 2020 compared 0.99908 in 2019, This drop in efficiency and relative efficiency during 2020 confirms that the COVID has an impact on container vessel traffic.

Table-4-Measuring Efficiency of World Container Port Throughput Year on Year using DEA, with Container Ships (World) in Dead weight as Input

Year	**(O)Container Port Throughput in TEU (Twenty-foot Equivalent Unit) in Million**	**(I)Container Ships in Dead weight tons (in thousands)**	**Efficiency**	**Relative Efficiency**
(a)	**(b)**	**(c)**	**(d)=(b)/(c)**	**(e)=d/0.003181**
2011	584.33	183691.41	0.003181	1.00000
2012	618.16	196820.99	0.003141	0.98733
2013	648.92	206322.14	0.003145	0.98873
2014	680.53	216199.14	0.003148	0.98952
2015	692.43	228229.99	0.003034	0.95375
2016	703.52	244398.64	0.002879	0.90492
2017	757.12	245683.48	0.003082	0.96877
2018	795.74	253632.59	0.003137	0.98627
2019	811.22	266087.20	0.003049	0.95840
2020	775.00	274856.49	0.002820	0.88639

Relative Efficiency:

$0 \leq$ Relative Efficiency ≤ 1

Efficiency of DMU_i / Efficiency of DMU_{Best}

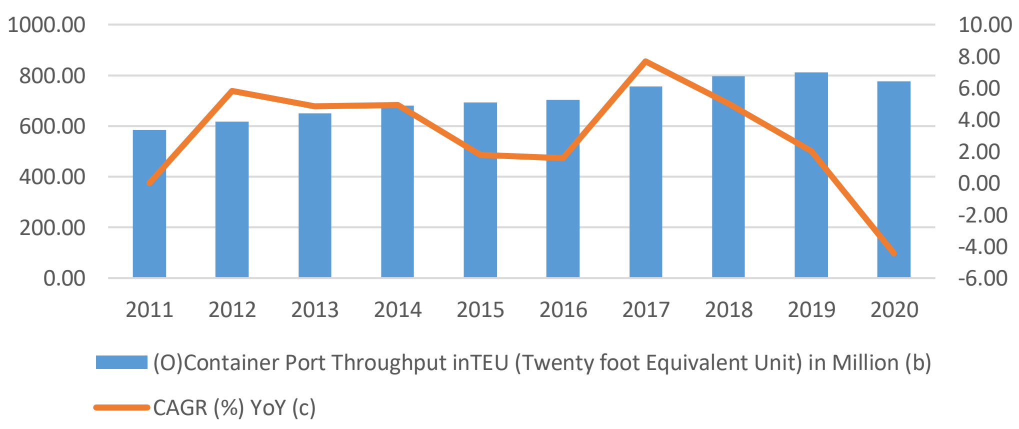
In the second model, the world container port throughput and container ships dead weight in tons is taken as indicators to find whether there is an impact of COVID on the traffic of container vessel globally. The analysis is made by using Data Envelopment Analysis. In the analysis every year was made as decision making unit. Container ships dead weight in tons (world) is taken as input and world container port throughput is marked as output (single input and output model). The efficiency and relative efficiency of 2011 was the highest, calculated based on the single input and output model. The efficiency during 2020 has declined to 0.002820 compared to 0.003049 in 2019. The relative efficiency also been dropped to 0.88639 in 2020 compared to 0.95840 in 2019. This witnesses a complete fall in the efficiency of container port throughput during 2020 which confirms that the COVID has an impact on international container vessel traffic.

Table-5-Measuring the growth of World Container Port Throughput Year on Year by using CAGR

YEAR	Container Port Throughput in TEU (in Million)	CAGR (%) YoY	CAGR (%) 2011 to 2018	CAGR (%) 2011 to 2019
(a)	(b)	(c)	(d)	(e)
2011	584.33	0.00	3.93	3.72
2012	618.16	5.82		
2013	648.92	4.85		
2014	680.53	4.94		
2015	692.43	1.76		
2016	703.52	1.59		
2017	757.12	7.68		
2018	795.74	5.02		
2019	811.22	2.01		
2020	775.00	-4.44		

(Source of Data: UNCTADSTATS & statista.com)

Figure-1 - Chart showing the Compounded Annual Growth Rate of World Container Port Throughput Year on Year



Measuring the growth of world container port throughput using CAGR is yet another method to find out whether the impact of COVID has affected the traffic of container vessel throughout the world. The CAGR is calculated year on year by using online calculating tool. The CAGR for 2020 shows a negative growth of -4.44 % as compared to a marginal growth of 2.01% in 2019. The pandemic is quite high in most of the countries during 2020, during the period the traffic of container vessel globally has declined. The CAGR from 2011 to 2018 is 3.93, meaning there is a significant growth rate up to 2018, the CAGR when calculated from 2011 to 2019, also shows a growth rate of 3.72 though the growth from 2018 to 2019 was slightly less this is due to the fact that some of the western countries have felt the impact of COVID in the latter period of 2019. From 2019 to 2020 there is complete negative growth on container port throughput essentially due to the impact of COVID.

5. Conclusion and Discussion

After ascertaining a positive correlation between world container port throughput with number of container ships (r = 0.8396) and container port throughput with container ships in dead weight (r = 0.9546) the DEA is calculated between world container port throughput with number of ships globally. It is understood (table-3) the efficiency during 2020 is 0.1443 compared to 0.1529 in 2019. Further the world container Port throughput in 2020 is around 775.00 million TEU's compared to 811.12 million TEU's in 2019 this decline in traffic is due to the fact the pandemic was at its peak in 2020 and many countries suffered during this period. The relative efficiency also weakened to 0.94257 in 2020 compared 0.99908 in 2019, proving a low traffic of container vessel globally essentially due to COVID.

The calculation of DEA in the second model, between world container port throughput and container ships dead weight in tons, also shows there is an impact of COVID on container port throughput, that is, (table-4) the efficiency during 2020 is 0.002820 compared to 0.003049 in 2019. The relative efficiency also has dropped to 0.88639 in 2020 compared to 0.95840 in 2019 substantiating the impact of COVID on the traffic of container vessel which was sluggish globally. The CAGR for 2020 (table-5) shows a negative growth of -4.44 % as compared to a marginal growth of 2.01% in 2019. The CAGR from 2011 to 2018 is 3.93, meaning there is a significant growth rate up to 2018, the CAGR when calculated from 2011 to 2019, shows a growth rate of 3.72 though the growth from 2018 to 2019 was slightly less this is due to the fact that some of the western countries have felt the impact of COVID in the latter period of 2019. From 2019 to 2020 there is complete negative growth on container port throughput essentially due to the impact of COVID. Still the pandemic is continuing it is difficult to ascertain post pandemic reaction on container vessels. The above analysis reflects that the world container port throughput has declined in 2020, which means the traffic of container vessels throughout the word has suffered enormously, essentially due to the impact of COVID.

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Fast Recovery or Stagnation? The Maritime Industry post COVID-19

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Abstract

Since the outbreak of COVID-19 in February 2020, the global maritime trade plunged by 9% in H1 2020, an unprecedented loss since the trade decrease triggered by the 2008 Financial Crisis. In addition to the disruptions of supply chains and decline of transportation sectors brought on by the pandemic, surging nationalism and protectionism, the retreat of globalization, and calls for more diversified global value chains and decoupling of economies have heightened the adverse impacts on survival and sustainable growth of the shipping industry. As a result, many people have adopted a more pessimistic view, and predicted that "the short-term outlook for maritime trade is grim, and that the industry's recovery is fraught with uncertainty," according to one UNCTAD report. Some even proclaimed to "wave goodbye to the greatest era of globalization," wrote The Economist in May of 2020.

This article argues that the maritime industry will have a strong and speedy recovery from the downturns despite transportation disruptions brought on by COVID-19, outcry for diversification of supply chains, and changes escalated and exacerbated by nationalist sentiments and protectionist conflicts. The adverse factors that the shipping industry faces would be marginal rather than fundamental in nature. Those marginally higher risks could be managed and ameliorated by multinational enterprises through alternate cross-border business strategies and harnessing of new technologies. Panic over the changes in supply chains (including nearshoring and reshoring) and diversifying production sites could be mitigated by emerging profitability earned from global specialization, rent-seeking strategies, and orchestrating a transformation in global value chains.

Most importantly, pandemic-driven fears that globalization could be “killed” will be minimized when actual data shows just the opposite - that globalization is expanding.

The paper also analyzes the elements that could strengthen the fast recovery and sustainable growth of the maritime industry. The vertical and horizontal integrations of maritime companies, especially the massive multinational enterprises, show their vast capacity in the cross-border movements of ideas, technology and portfolio capital, and consequently would help build up global production scale of economies and global amortization. Emerging technologies and their increasingly commonplace applications in digitalization, automation and robotics in maritime sectors, is crucial to sustaining both short-term productivity and long-term growth of the maritime industry.

The research provides evidence for why the maritime industry is poised for an expeditious post-pandemic recovery and seeks to answer many puzzling questions while our world still operates under globally disruptive and unprecedented pressures associated with the COVID-19 pandemic.

Keywords: Maritime industry, COVID-19, International trade, globalization

1 Introduction

After the outbreak of COVID-19 in early 2020, the world was sent into a catastrophic chaos. It was predicted that there would be an inevitable economic downturn similar to the most recent recession in 2008, when we went through prolonged economic slowdowns, high unemployment, unstable financial systems and decreasing GDPs in many parts of the world. However, starting from the third quarter (Q3) of 2020, there has been a strong resilience in the world economy, including international trade and maritime transportation. The merchandise trade for the Group of Twenty countries (G20) reached record level in Q1 2021. Exports and imports for the G20 increased by 8% and 8.1% respectively compared with the previous quarter. China, the G20’s largest merchandise trader, soared in Q1 2021, with growth rates of exports up by 18.8% and imports by 19.0%, according to OECD report in late May of 2021.

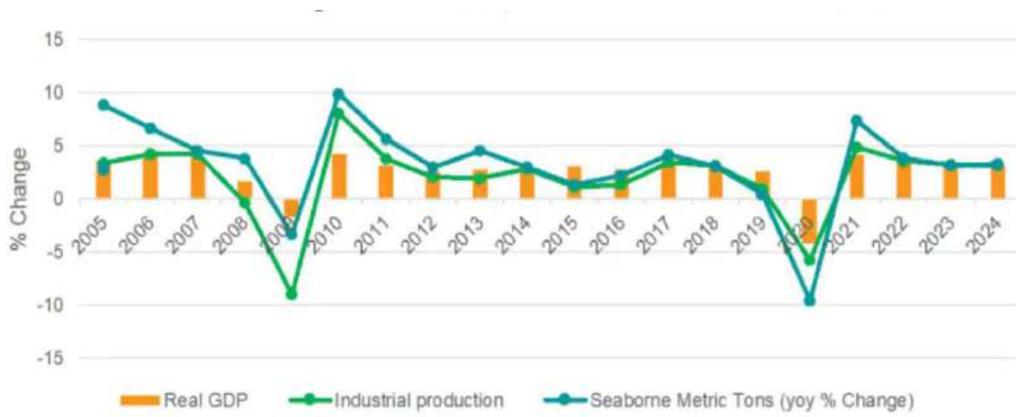
The paper intends to explain the factors that account for the strong rebound of the shipping industry from the third quarter of 2020 onward. It discusses that the concurrence of mitigated supply shocks and increased demand for consumption goods were key factors in the demonstrated resilience of the shipping industry, and how this industry was able to nimbly adapt to the catastrophic disruptions brought about by the COVID-19 pandemic. This research seeks to understand the exogenous features of the COVID-19 pandemic which offer the most compelling explanation for the major economies' steady rebound in three month of time from the onset of the pandemic last year. The exogenous nature associated with sharp economic downturns brought about by a global panmedic is different from economic recessions brought about by endogenous features. As exemplified by the recession in 2008, endogenous features, such as misallocation of capital and investments resulting in massive cross-defaults and systemic disruptions. In contrast to the estimated three months, it took two years for the 2008 recession to pull out of the bottom of its downturns and reach the pre-crisis level of production and growth.

The paper is organized as the following: Section One gives an introduction explaining the purpose and approach adopted by the analysis. Section Two presents statistics supporting the swift returns of the shipping industry. Section Three identifies the elements that account for the fast recovery in the shipping industry, and how those elements work collaboratively to contribute to global rebound. Section Four concludes.

2 Rapid Recovery of Shipping Industry under COVID-19 Pandemic

COVID-19 pandemic hit the world economy hard at the onset of last year, with global GDP down by 4.2% and international trade falling by 9.5%. The disruptions were quite comparable to the detrimental impact of the financial crisis of 2008 (See chart 1).

Chart 1 year-on-year % change in world GDP, real production and seaborne trade



Sources: (Gladen 2021)

Against the predictions of many, since Q3 2020, we have been continously observing a speedy and nimble recovery in G20 countries and some emerging economies. This pattern is reflected in all key economic indicators, such as world GDP, international merchandise trade, ship capacity and port utilization. By Q1 2021, global trade reached a record level and, with the exception of the UK, all G20 economies recouped positive growth rates, according to the report of Economic Cooperation and Development (OECD) in late May 2021 (see Chart 2)

Chart 2 Trade in goods: Exports, Percentage change, previous period, Q1 2019 – Q1 2021

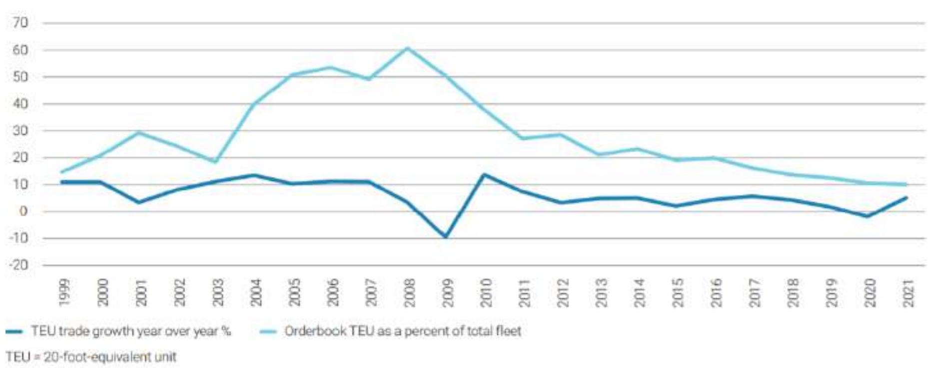
The above OECD data shows the quartely growth rates of merchandise trade from Q1 2019 to Q1 2021. The left graph shows the total OECD nations and the right graph shows the USA individally. The merchandise trade for total OECD members grew by 9.1% in Q3 2020 compared to the previous quarter, and by 4.8% in Q1 2021 compared to Q4 2020. For the USA the growth rate reaped 5.7% between the last quarter of 2020 and first quarter of 2021.

Equally as compelling for the rebound of the maritime dynamic can be found in the latest data on global containerized shipping. The world container trade has been relatively stable despite the

COVID-19 disruptions (see Chart 3). The stability of container trade under the pandemic should largely be credited with the following two factors: China makes up as much as over 40% of the global containerized trade, and in February 2020, Chinese containerized vessel calls dropped 16% while the country was in various stages of lockdown. With the decrease of COVID-19 cases and subsequent easing of lockdown restrictions, recovery was swift and the level of vessel calls returned to pre-pandemic levels immediately (Chart 3). Consumer demand for commercial goods remained high due to the shift in consumer priorities during the pandemic-induced lockdown. Although the nature of some of these goods had changed, demand was still booming.

The second recovery factor we observe is that container companies have been actively engaged in a series of vertical and horizontal integrations since 2015, benefitting business management. The philosophy held is that the more concentrated companies could be, the more efficient in risk management and rent-seeking adjustment they would be. Streamlined companies that are highly efficient on every level allow them to rapidly meet various challenges that would flummox a smaller individual company. Possessing more advanced capabilities, resources, and global contacts allow larger container companies during the pandemic to better communicate and redirect their distributions.

Chart 3 World container trade (TEU) : Q1 1999- Q1 2021



As early as Q3 2020, shipping vessel calls and port utilization were nearly to their full capacity. The global shortage of shipping containers, brought upon by strong demand for goods and tight container supply, drove cargo costs to record highs and hampered manufacturers in filling fast-recovering global goods orders. The Shanghai Container Freight Index (SCFI) shows the rise of freight rates far above the 2016-2019 level since week 21, around the time of mid-June of 2020.

Toward the end of May 2021, SCFI reached a record high of 3495.76, which grew by 250% from the pre-pandemic level.

Chart 4 Shanghai Container Freight Index January 2020 – May 2021

All of the charts are surely proof as to the phenomenal resilience that container shipping offers, and the recovery has been steady, continuing and encouraging.

3 The Factors leading the Strong Recovery of Shipping Industry

The statistics have clearly indicated the returns of the global economy as well as seaborne transport, and the trend continuously ticks upward as we speak. In this section, we will discuss the reasons that account for the resurgence of the shipping industry from a sharp downturn triggered by the COVID-19 outbreak. We will examine this issue from both the supply side and the demand side of maritime transportations.

3.1 Resilience of Supply Chains to COVID-19 Shocks

Supply shocks represent an unexpected change in the availability for raw materials, parts, and manufacturing capabilities. This was exactly what happened when COVID-19 was initially reported in January 2020 and quickly followed by massive lockdowns, first in China and then other parts of the world. As China makes up an estimated 40% of business for container shipping companies, seaborne trade plummeted by 9.5% instantly and total global trade fell significantly in the first half of 2020 (Gladden, 2021). Unlike the supply chain shocks resulting from internal disruptions, such as a misallocation of capital and investment that led to big cross-defaults exemplified by the 2008 financial crisis, global supply chains were robustly healthy before the

COVID-19 outbreak at the beginning of 2020. The same was true for the other major economic indicators, such as national GDPs, real production and unemployment rates. Though the outbreak of the global pandemic, followed by massive lockdowns, put a pause to the world, the economic fundamentals were still viable and supportive. Therefore when lockdowns were removed and COVID cases became less devastating, the exogenous nature of the COVID-19 crisis helped the maritime industry recapture the dynamic and productivity.

For the past ten years or so, shipping companies have been engaged actively in building up their resilience and adaptability to meet challenges imposed upon them. After going through the market consolidation of the 2014-2017 M&A (merger and acquisition) wave, the shipping companies became successful in risk control and capacity management, allowing them to maintain network integrity, minimize logistics and financial issues and cope effectively with both internal and external shocks. As a result, shipping companies could be able to handle the surge in shipping vessel calls effectively and maximize the shipping capacity in a short period of time.

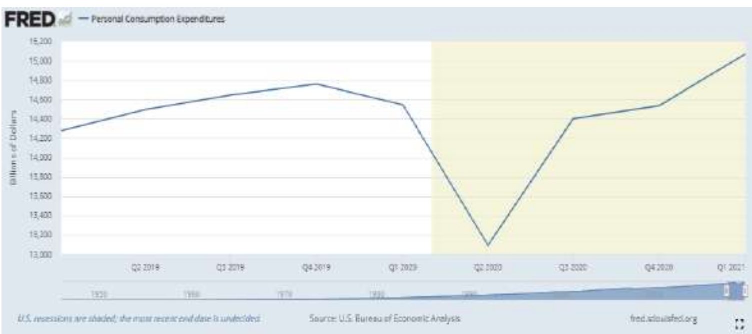
3.2 Recovery from demand Shocks

With huge lockdowns, demand shocks hit the world economy hard as well as the shipping industry, and demands for consumption goods decreased tremendously. However, the demand for basic goods has been relatively stable throughout the period, such as foodstuff and medicals. Among different categories of consumption goods, the demand for durable goods and capital goods, such as cars, ships, trucks and machineries has declined significantly. As soon as the pandemic became less destructive, consumers and industries recouped their confidence, and paddled with government relief funds, a rise in demand for goods took off almost immediately. In concurrence with the rise of other leading economic variables, like real production, GDP growth rates and international trade, increasing demands for consumption goods imposed a chain of positive impacts on both demand and supply sides of the shipping industry. The vessel calls for shipping companies increased immensely, and in the Q3 2020, demand for shipping service exceeded the supply of the fleet capacity, which led to the dramatic rise in the cost of cargo shipping (see Chart 4 for SCFI). The deferred demands and temporary disruptions of COVID-19 pandemic help explain rapid recovery of the economies of major countries and maritime industry as well.

At this point, even steadier economic returns would very well be expected, due to vast delivery of COVID vaccinations, savings accumulated during a long year of lockdowns, rescue packages and infrastructure investments implemented from major governments like the US. “Consumers are now back in the driver’s seat when it comes to economic activity, and that’s the way we like it.” as Gregory Daco, chief U.S. economist at Oxford Economics said.

Let us use the United States data as an example to illustrate the degree at which aggregate consumer spending has increased toward the end of the first quarter of 2021. Based on the statistics from the US Bureau of Economic Analysis, personal consumption expenditure in the first quarter of 2021 has jumped past the pre-pandemic levels and reached the record hitting level of over 15,000 Billion dollars (See Chart 5).

Chart 5 US personal Consumption Expenditure Q1 2019- Q1 2021



Spending on services is rebounding, but it is not growing as rapidly as expenditures on goods due to travel restrictions, lingering containments on entertainment, and limited capacity of restaurants. According to data by the US Bureau of Economic Analysis, the consumption on services only grew by 1.1%, while consumption on goods grew by 5.6% during the same period.

The observations suggest that we are still far from reaching the final phase of a clear and consistent recovery and returning to normal demand patterns, though major economic indicators show a robust and persistent path to recovery for the economy.

4 Conclusion

The COVID-19 pandemic put a stall on the world at the beginning of 2020, which resulted in the synchronization of supply shocks and demand shocks for the global economy, international trade and the shipping industry. However, instead of a prolonged downturn followed by a staggering and halting recovery comparable with the recessions triggered by previous business cycles, including the most recent one in 2008, a strong resilience has been clearly presented in the second half of the year. This is largely because of the exogenous nature of COVID -19 pandemic which was imposed on a generally healthy economic situation right before the COVID-19 outbreak. Therefore, when massive stimulus plans and infrastructure investments from major governments like the United States, together with the global deliveries of vaccinations, the economy was back on track quickly while many other economic indicators have already reached pre-pandemic levels.

The maritime industry is obviously a sector that gains accelerated recovery with mitigation of supply chain shocks and restoration of consumer and corporate confidence, which was reflected in the surge in demand for consumption goods. Seaborne trade is to gain a growth rate of 6.9% between 2021 and its preceding year, according to the forecasting of the Global Trade Atlas.

The pandemic's direct impact on the economy continues, and the after-effects will remain for years to come. New challenges imposed on maritime companies would be how to make supply chains more resilient without weakening their competitiveness, and how to incorporate more diversified supply bases without losing the advantage of scale economy and cost efficiency.

The 2021 resilience will not always be an upward curve for every country and every industry, with the exact pace of the recovery to be determined by developments of the pandemic and changes to government interventions, international cooperation, deliveries of vaccinations, travel restrictions and other containment measures. Yet the most promising news is that we are recovering and the recovery is faster than what most analysts would have expected at this time last year.

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Identification of Maritime Education and Training Institutions (METIs) risk in pandemic restrictions

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The unprecedented COVID-19 crisis apparently has questioned our systems' survivability nationally or even in a global context. The pandemic has proven the indispensable role of international shipping in our societies' sustainability. Still, one of the main challenges for the shipping industry is to secure the supply of competent seafarers. Typically, Maritime Education and Training Institutions' (METIs') core mission revolves around keeping such demand supplied, however in restrictive situations, METIs' capability to achieve their mission is still questionable. During the pandemic restrictions, METIs are likely exposed to many uncertainties that directly threaten their role and may lead to hazardous consequences. In such scenarios, many questions arise to challenge whether the institution/organizational levels of control are sufficient or additional barriers to keep the risk as low as reasonably practicable are needed.

Consequently, this research investigates the possible threats exposed to METIs under such conditions, the potential consequences if they lose control of their operations, and the required barriers to prevent, detect, or protect the METIs from such a failure. To achieve this aim, a survey was designed to capture the expertise of a group of Maritime Education and Training (MET) experts. The survey responses have been quantified and statistically analysed to comprehensively identify these risk factors, their contribution, and their effectiveness.

Keywords: Risk Modelling, Risk Analysis, Crisis Management, Bowtie, Maritime Safety, Maritime Education and Training

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1. Introduction

Shipping is usually considered a traditional industry that develops at a slow pace in adopting new technologies if compared with other transport means. (Turan et al., 2016). Nevertheless, the recent global surge of digitalization, automation and advanced modern technologies is transforming the industry probably faster than ever before (Brooks, M.R., Faust, P., 2018).

Typically, the global Maritime Education and Training (MET) system is responsible for supplying the maritime industry with seafarers equipped with predetermined sets of competencies. These competencies shall at least satisfy the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW-78), which has been adopted by the International Maritime Organization (IMO) last century (International Maritime Organization, 2018).

The MET system consists of three main stakeholders, the Maritime Education and Training Institutions (METIs) with their staff, curricula, and policies, the shipping companies, with their employees, ship technology, and lastly, the international/regional/national regulative bodies.

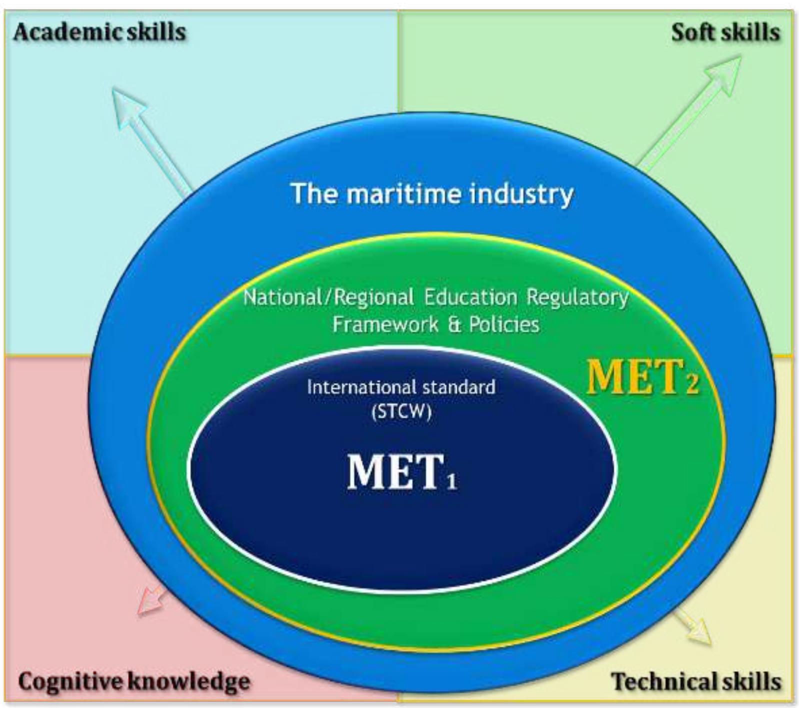

Figure 1: The existing gap between the current international, regional, national standards and the maritime industry demand for seafarers' education and training (by authors).

While METIs shall comply with international and national standards, they also should meet the industry needs. Such a complex framework has lately set the global MET system under enormous pressure as international standards are first and foremost driven by the traditional STCW convention, while the maritime industry recently evolves at a dynamic pace to a more sustainable future (Rowihil & Farag, 2021).

Although the STCW represents the minimum international standards for the education and training of seafarer's competencies, there are higher standards that may apply depending on the region or state policies/regulations in force. However, in both cases, there is a clear gap between the available standards and industry demand and expectation as illustrated in Figure 1 (International Association of Maritime Universities (IAMU), 2019) (Manuel, 2017).

2. The impact of the COVID-19 pandemic on MET and its stakeholders

The unprecedented COVID-19 crisis apparently has questioned our systems survivability nationally or even in a global context. The pandemic has proven the indispensable role of international shipping in our societies' sustainability. Still, one of the main challenges for the shipping industry is to secure the supply of competent seafarers. Typically, METIs core mission revolves around keeping such demand supplied, however in restrictive situations, METIs capability to achieve their mission is still questionable (Toquero, 2020).

Following the pandemic spread of COVID-19, there was a global lockdown and a worldwide travel ban. This ultimately caused a chaotic backlash on Seafarers' education and training, especially when it came to the renewal of Certificates of Compliances (COCs) and other mandatory training certificates which caused a major confusion in the maritime domain in general (Hebbar & Mukesh, 2020) (Doumbia-Henry, 2020).

The first impact of such circumstances had fallen on shipping companies when they faced their seafarers' certification problems, among many other logistic problems, with almost no access to METIs due to the global lockdown. As advised by a fleet personal manager in one of the major oil shipping companies, the first and quick solution was circling seafarers with valid certificates around their fleets, effective as it is, but with prolongated lockdown period, high levels of stress and fatigue showed on ships crews which affected their mental health and personal safety due to extended time onboard (Whiting, 2020). Nevertheless, the economic burden on both the company and the seafarers caused by seafarers' extended leave time at home. Shortly, the problem was transferred to the METI, when the revalidation inquiries reached numbers beyond negligence. In response, the METIs tried to employ the available technological solutions to deliver the courses remotely. Non-STCW courses were a moderate challenge, the METI only had to develop an adequate LMS and a platform to deliver the course on, with an appropriate online registration and payment system. The major problem was the delivery of the STCW courses, which always require approval from local administrations.

After a while, the problem had shifted to national maritime administrations with their usual reference to the STCW. Although the STCW code, section A, explicitly specifies the competencies required by each CoC holder with supplementary examples of how to demonstrate and evaluate these competencies, yet it does not clearly state how these competencies should be obtained, leaving national administrations to infer alternative methods according to their interpretations (International Maritime Organization, 2018). Accumulatively, this has led each administration to independently approach the challenge of delivering the STCW Courses online according to their initial understanding of the code (IMO, 2021).

The Egyptian administration, for example, had issued local decrees allowing the delivery of all theoretical courses online. On the other hand, it contended on the physical/direct delivery of all STCW courses that involve marine simulators and/or physical training such as firefighting, medical first aid, and survival techniques courses. Therefore, the Egyptian administration, as a temporary solution, approved the extension of all certificate's validity by three months, as their initial stand could still leave a massive number of seafarers with expired certificates due to their physical inability to attend these courses.(The Government of the Arab Republic of Egypt, 2020).

The COVID19 restrictions had clearly shown the complex nature of the MET domain. First, the shipping companies tried to adapt swiftly to the situation powered by their technical and organizational resources. The METIs were slowed down by the uncertainty of the situation and the need for administrations' approval every step of the way. while the administrations must deal with massive legislative challenges governed by the static framework of the STCW in such unprecedented conditions.

In pandemic restrictions, METIs are likely exposed to enormous uncertainties that directly threaten their mission and may lead to hazardous consequences. In such scenarios, many questions arise to challenge whether the institution levels of control are sufficient or additional barriers are needed to keep the risk as low as reasonably practicable.

Therefore, this research aims to investigate the possible threats on METIs under such conditions, the potential consequences on METIs if they lose control of their operations, and the needed barriers to prevent, detect and protect METIs from such a failure. To achieve these aims, a survey was designed to capture the expertise of a group of Maritime Education and Training (MET) experts.

3. The experts' survey[6]

The survey has three main sections to identify the METIs' risk of losing control during pandemic restrictions. All the survey questions follow the Likert Scale with 5 alternative answers as

[6] The experts survey link: https://docs.google.com/forms/d/e/1FAIpQLSc8dqwawFzg_Qel43DQ3GGI7Nw0unVDWhnI-sTZJBFBgQHYfQ/viewform

illustrated in Figure 2. At each section, there was an optional open question for the respondent to add new alternative answers which are not covered in the respective section.

The first section seeks to verify the possible threats by survey respondents. It also requires them to identify the level of contribution of each threat and the frequency of its occurrence. The second section aims to evaluate the consequences and their impact when METI loss of control event occurs during pandemic restrictions. The last section is dedicated to the validation of the proposed barriers and their effectiveness level to mitigate the aforementioned risk.

Threats

Agreement Levels (ALs)

Alternative	Code	W
Strongly agree	SA	5
Agree	A	4
Undecided	U	3
Disagree	D	2
Strongly disagree	SD	1

Contribution Level (CL)

Alternative	Code	W
Very high contribution	VH	5
High contribution	H	4
Moderate contribution	Mod	3
Low contribution	L	2
No contribution	No	1

Frequency (Freq)

Alternative	Code	W
Continuous	C	5
Yearly	Y	4
Monthly	M	3
Weekly	W	2
Never	N	1

Consequences

Agreement Levels (ALs)

Alternative	Code	W
Strongly agree	SA	5
Agree	A	4
Undecided	U	3
Disagree	D	2
Strongly disagree	SD	1

Impact Level (IL)

Alternative	Code	W
Loss of control (total failure)	Fail	5
Major concern	Maj	4
Medium concern	Med	3
Minor concern	Min	2
No concern	No	1

Barriers

Agreement Levels (ALs)

Alternative	Code	W
Strongly agree	SA	5
Agree	A	4
Undecided	U	3
Disagree	D	2
Strongly disagree	SD	1

Effectiveness Level (EL)

Alternative	Code	W
Excellent	Ex	5
Good	G	4
Fair	F	3
Poor	P	2
Very poor	VP	1

Figure 2: Survey alternative answers (Likert Scale)

3.1. Identification of the possible "Threats" to METIs under pandemic restrictions

The respondents are given a set of (10) threats proposed by the authors. Four groups of questions are prepared for each threat to achieving the first section's aim. The questions are as follow:

- **Q1.1**: To what extent do you agree that the following factors can be considered as "Threats" to the METI mission during pandemic restrictions (such as the current global COVID19 pandemic)?
- **Q1.2:** Define the contribution level of each of the following potential "Threats" to a METI to lose control over its operations/services during pandemic restrictions.
- **Q1.3:** Specify the occurrence frequency of each of the following potential "Threats" to a METI during pandemic restrictions.
- **Q1.4:** Please add below other possible "Threats" that you think are relevant and are not listed in the previous questions (optional).

3.2. Evaluation of potential "Consequences" when METI loses control.

The respondents are given a set of (08) Consequences proposed by the authors. Three groups of questions are prepared for each consequence to achieving the second section's aim. The questions are as follow:

- **Q2.1:** To what extent do you agree with the following potential "Consequences" if the METI loses control during pandemic restriction (such as the current global COVID19 pandemic)?
- **Q2.2**: Define the impact level of each of the following potential "Consequences", if METI loses control during pandemic restrictions.
- **Q2.3:** Please add below other potential "Consequences" that you think are relevant and not listed in the previous questions (optional).

3.3. Validation of the proposed barriers/solutions and their effectiveness:

Likewise, to the previous sections, the respondents are given a set of (11) barriers/solutions proposed by the authors. Three group of questions are prepared for each barrier to meet the third section's aim. The questions are as follow:

- **Q3.1:** To what extent do you agree with the following proposed "Barriers" as possible solutions for METIs to minimise their risk during pandemic restrictions (Such as the current COVID19 pandemic).
- **Q3.2:** Define the effectiveness level of each of the following "Barriers", if effectively implemented, to prevent/detect/protect the METI from losing control during pandemic restrictions and potential consequences.
- **Q3.3:** Please add below other barriers/solutions that you think are relevant and not listed in the previous questions (optional).

For the survey results quantification, one of the techniques used to statistically exploit the Likert Scale-based surveys outputs is calculating the Relative Importance Index (RII) for each alternative. The RII could be used to indicate the respondents' preferences for each alternative (Johnson & LeBreton, 2004). Hence, The RII was used to analyse the level of agreement for questions Q1.1, Q1.2, and Q1.3. The RII can be calculated by using the following formula:

$$\boldsymbol{RII = \frac{\sum w}{A \times N} = \frac{5n_5+4n_4+3n_3+2n_2+1n_1}{5 \times n}\,(0 \leq RII \geq 1)} \qquad \textit{Equation (1)}$$

Where:

W: weight given to each alternative by the respondents and ranges from 1 to 5, (where "1" is "Strongly disagree" and "5" is "Strongly agree").

A: the highest weight (i.e., 5 in our case).

N: the total number of respondents.

Additionally, to measure the central tendency of the Likert Scale data for questions Q1.2, Q1.3, Q2.2, and Q3.2., and due to the nature of the sample data, the authors have used the Median (M) to estimate the level of the respondents answer for each question (Sullivan & Artino, 2013).

4. Data collection and analysis:

The survey was distributed among experts having a wide range of experience in MET. (39) responses were received from respondents belong to (11) MET organizations from Egypt, Turkey, the UK, Greece, India, Japan, Saudi Arabia, Croatia, Finland, and the USA. Figure 3 shows the responses count per each organization.

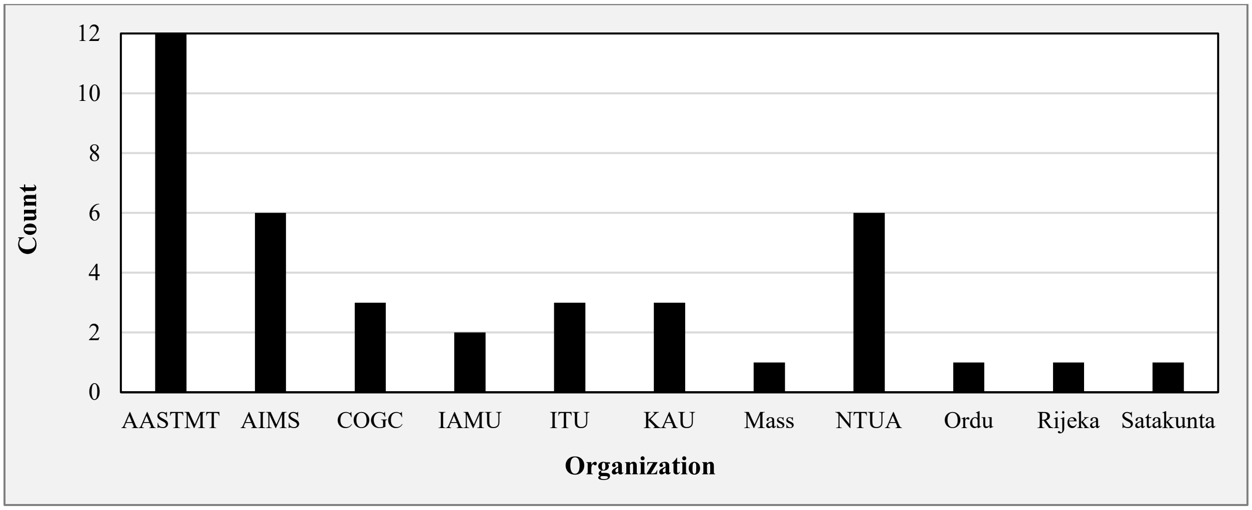

Figure 3: Count of survey respondents by their organizations

Figure 4 demonstrates the respondents' count by their different role levels in their respective organizations and years of experience.

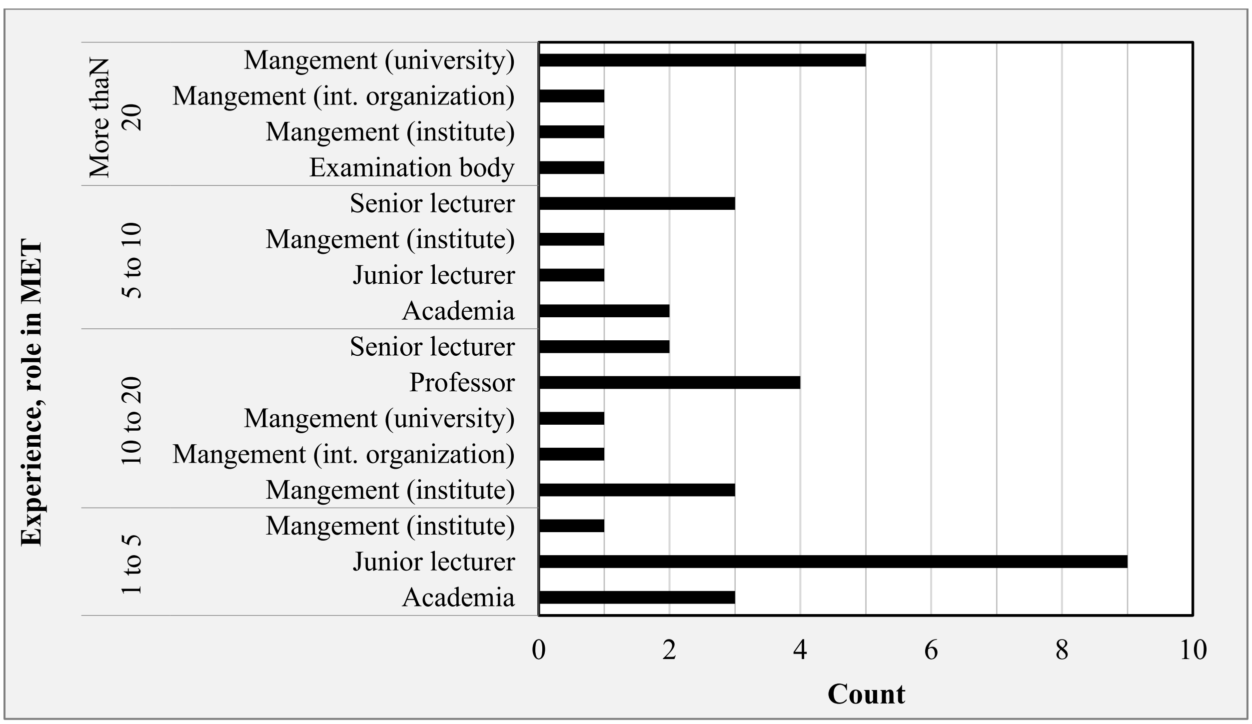

Figure 4: Count of survey respondents by their role and years of experience in MET

The obtained results were collected, organized, and quantified by using the Likert Scale shown in Figure 2. The data was also verified against any possible anomalies.

4.1. Threats:

The respondents' inputs were processed through Equation (1) to rank threats by their importance. The obtained results are detailed in Table 1.

Table 1: Identification of possible Threats to the METI's processes and operations in pandemic restrictions.

Code	Possible threat	RII	Rank	Contribution to the loss of control event (M)	Frequency (M)
T1	Non-conformity of the METI facilities and resources.	0.71	6	High	Yearly
T2	Non-conformity of the available Learning Management System (LMS).	0.72	5	High	Yearly
T3	Some of the program/course contents require direct/physical interaction with students/trainees.	0.95	1	Very high	Continuous
T4	The available technological solutions are not robust enough to ensure the security/verification of the registration, delivery of the education/training and assessment processes.	0.78	2	High	Yearly
T5	Staff are not able to efficiently implement the education program.	0.69	9	Moderate	Yearly
T6	Medical and mental health issues of staff (infection, overload, stress, etc.).	0.70	8	High	Yearly
T7	The current institution management system is not updated/fit to manage the situation.	0.64	10	Moderate	Yearly
T8	The current international/national standards/legislations. are not updated/fit to manage the situation.	0.75	3	High	Yearly
T9	Administrative constraints.	0.75	4	Moderate	Yearly
T10	Insufficient funds/budgets.	0.71	7	Moderate	Yearly

Moreover, the results show a consensus agreement on the importance of threat (T3): "Some of the program/course contents require direct/physical interaction with students/trainees". The collected data as well declare the very high contribution of the after mentioned barrier as declared by the collected responses. Figure 6 also show that threats T7, T5 and T6 scored the least importance, respectively. The respondents' uncertainty about threats T9 and T10 was the highest as 29% and 26% selected the "Undecided" answer.

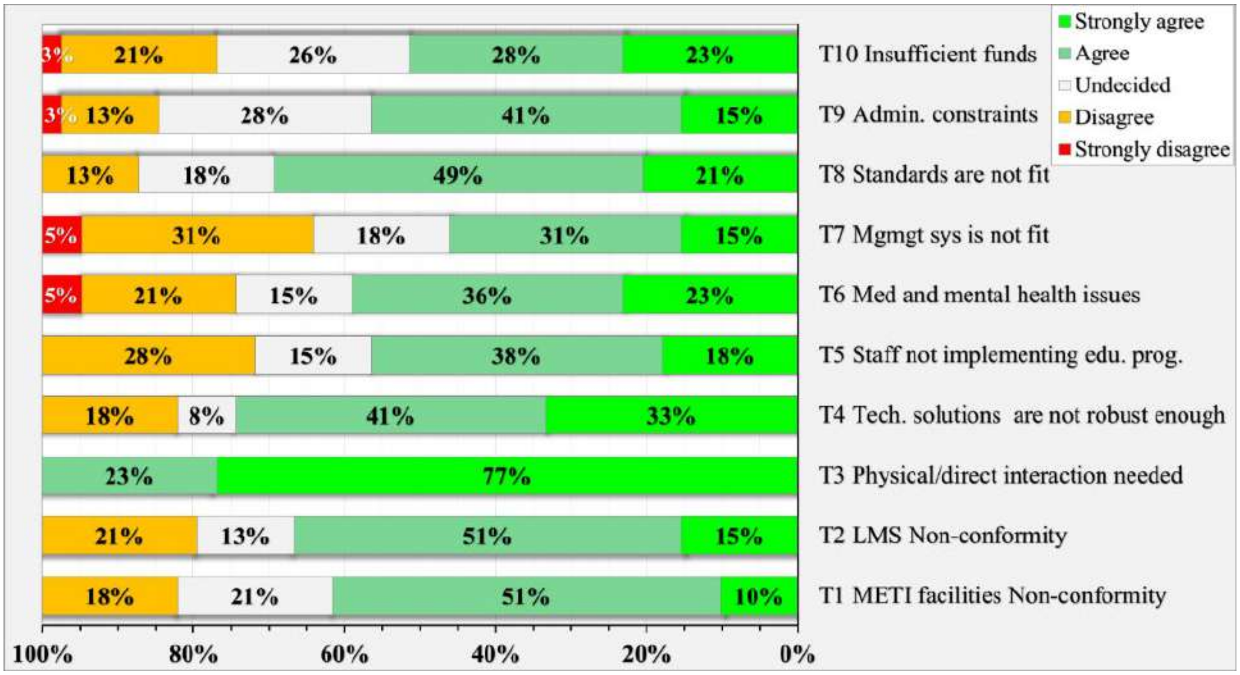

Figure 5: The survey respondents' evaluation of the possible threats to METIs during pandemic restrictions

4.2. Consequences:

Similarly, the consequences section was analyzed using the same method explained in section 4.1. The results shows that most of the survey respondents are concerned from C1 for the "Insufficient quality of educational/training services" occurrence. While 31% of them is uncertain with C7 for the "Closure of METI" occurrence. The consequences of METI loss of control in pandemic restriction are ranked according to their RII score with their potential impact in Table 2.

Table 2: Potential Consequences when METIs lose control in pandemic restrictions.

Code	**Potential consequence**	**RII**	**Rank**	**Impact/concern** (M)
C1	Insufficient quality of educational/training services	0.85	1	Major
C2	Failure to create favourable conditions for education and training activities of the students (their satisfaction)	0.83	2	Major
C3	Not efficiently achieving the program/course learning outcomes	0.77	3	Major
C4	Not fulfilling the accreditation and licensing requirements	0.72	5	Major
C5	Losing customers of the METI's services (students/trainees)	0.70	6	Major
C6	Extended program/course delays	0.75	4	Medium
C7	Closure of METI	0.65	7	Medium
C8	Harm to Institution's reputation	0.52	8	Major

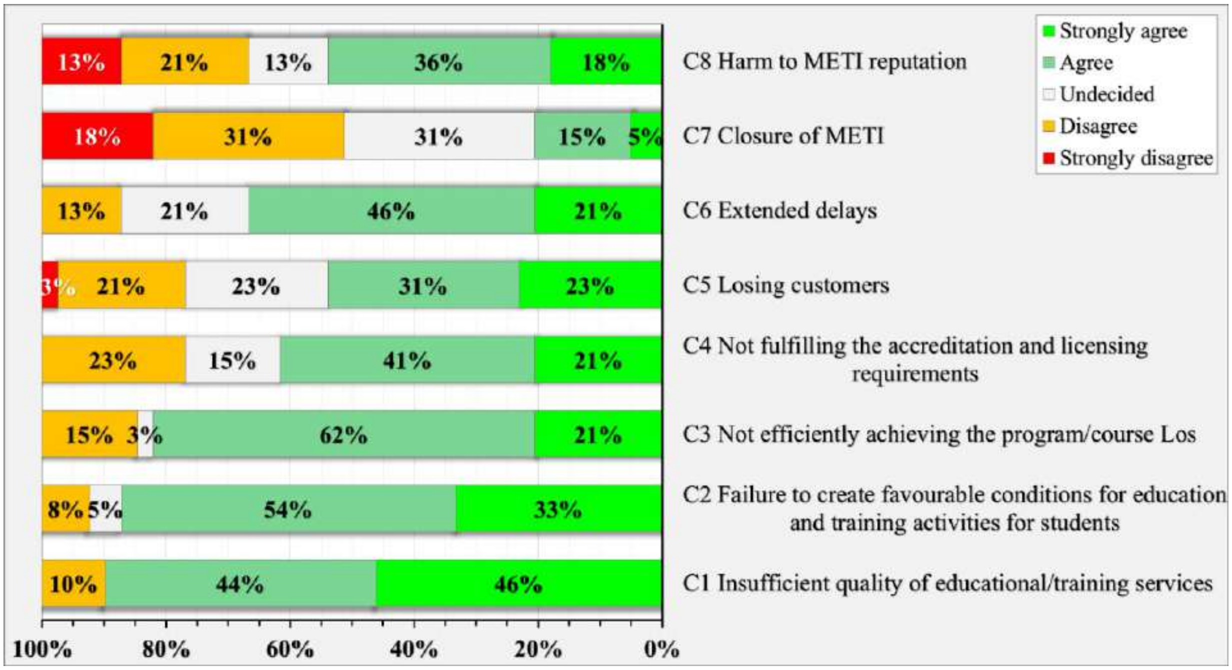

Figure 6: The survey respondents' evaluation of the potential consequences when METIs lose control in pandemic restrictions.

4.3. Barriers and solutions:

The proposed barriers were validated by the survey respondents. The respondents highly agreed with proposed barriers B6, B11 and B5, respectively as shown in Figure 7.

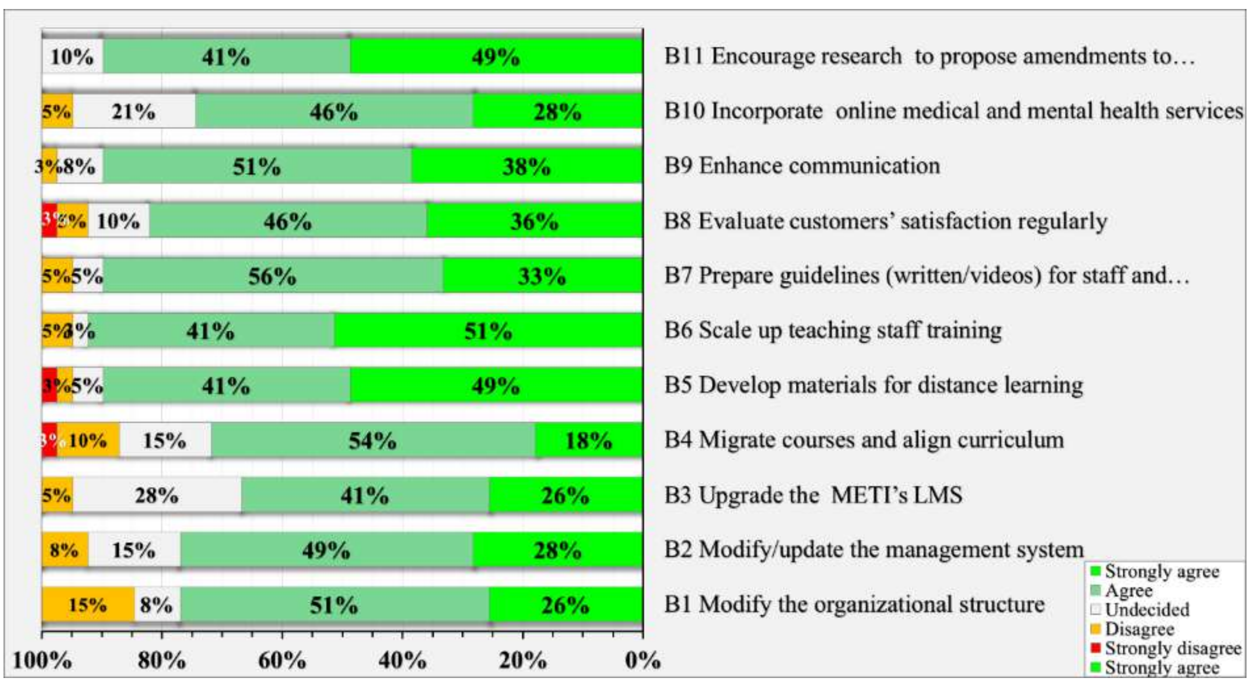

Figure 7: The survey respondents' evaluation of the proposed barriers and solutions

This, in turn, highlights the importance of METIs to adopt the following measures to mitigate the METIs risk under such conditions:

- scale up the teaching staff training for online teaching,
- develop new materials/techniques that incorporate distance learning/online teaching, and

- encourage research activities to propose amendments to the current international/national standards/legislation.

Moreover, most of the survey respondents think that barriers B5 and B6 have an excellent effect in mitigating the loss of control risk of their organization in pandemic restrictions. While 28% of them are uncertain of the importance of upgrading the institute Learning Management System (LMS).

Table 3 contains more details about the proposed barriers, their function, rank, and degree of effectiveness.

Table 3: The proposed barriers & solutions

Code	Proposed barrier	Function	Type	RII	Rank	Effectiveness (M)
B1	Modify the METI organizational structure	Preventive	Internal	0.774	9	Good
B2	Modify/update the METI management system	Preventive	Internal/ External	0.795	7	Good
B3	Invest more fund to upgrade the METI's LMS	Preventive	Internal/ External	0.774	10	Good
B4	Migrate courses and align curriculum competencies	Preventive	Internal/ External	0.749	11	Good
B5	Develop new materials/techniques that incorporate distance learning/online teaching.	Preventive	Internal	0.862	3	Excellent
B6	Scale up teaching staff training for online teaching.	Preventive	Internal	0.877	1	Excellent
B7	Prepare guidelines (written/videos) for staff and customers for better engagement with the new communication means.	Preventive	Internal	0.836	5	Good
B8	Continuously measure and evaluate customers' satisfaction (trainees, shipping companies, manning agencies).	Detective	Internal	0.815	6	Good
B9	Enhance the communication with staff and customers.	Detective	Internal	0.851	4	Good
B10	Incorporate an online mental health and medical services for staff.	Protective	Internal	0.795	8	Good
B11	Encourage research activities to propose amendments to the current international/national standards/legislation.	Preventive	Internal/ External	0.877	2	Good

5. Conclusion and future work.

This research has investigated the possible threats exposed to METIs under pandemic restrictions, the potential consequences if a loss of control occurs, and the required barriers to prevent, detect, or protect the METIs from such a failure. To achieve this aim, a survey was designed to capture the expertise of a group of Maritime Education and Training (MET) experts. The survey responses have been quantified and statistically analysed to comprehensively identify these risk factors, their contribution, and their effectiveness.

This study can provide the required control measures for METIs to achieve their mission despite the plethora of activities, customers, regulators, governance instruments, and stakeholders with their different interests, especially under restrictive conditions.

Future work:

The obtained survey data will be employed in a Bowtie model to link the identified risk threats and consequences together and assess the effectiveness of the proposed barriers.

Additionally, the current study only focused on METIs' perspective; still, further investigation is needed for other MET stakeholders as well, such as shipping companies, manning agencies, regulators … etc., for a more inclusive result.

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Impact of COVID19 on Ports and Maritime Transport (Georgian Ports Response to COVID19)

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Abstract

The importance of maritime transport and ports to international trade and the world economy is invaluable. It is maritime transport and seaports that ensure the integrity of the supply chain, which ensures the success of world trade and economic activities. The importance of maritime transport is confirmed by the fact that 80% of the transported goods come from maritime transport. Consequently, maintaining a sustainable supply chain is a guarantee of sustainable development in the world.

However, the new coronavirus (COVID19) changed the world and affected the civilized world, causing a crisis and having a very large impact on maritime transport and trade. The impact of the pandemic on maritime transport has challenged various industries whose operation and production depended on the production of raw materials, the processing of semi-finished products and more. Restrictions introduced to prevent the spread of the pandemic have led to the closure of ports, reduced working hours and manpower in ports, and freight-forwarding opportunities. Countries also avoided the spread of COVID-19, and therefore refrained from importing and exporting products and goods during the quarantine period, which led to a decrease in import-export, which in turn reduced demand for cargo. In some cases, due to the imposed restrictions, the transportation time was increased and it became impossible to transport goods with a specific nature. It was these restrictions that led to the slowdown in trade flows and supply chain operations. It was difficult to navigate and trade in different regions. Despite so many difficulties, restrictions, and the impact of the pandemic, maritime transport and seaports continued to operate to ensure the delivery of personalized goods to countries, such as: food, energy, raw materials, medicines and medical supplies.

We think that this topic is very important, it needs to be well researched and analyzed, because if we understand what impact the pandemic has had on maritime transport and ports, we will be able to quickly and easily lay out ways to respond to challenges and get the industry back to normal. The spread of the coronavirus has once again confirmed that the backbone of international trade is precisely maritime transport. Georgian ports are a good example of this.

This article discusses the impact of the new pandemic on maritime transport and ports, as well as the impacts identified and solutions found. The article analyzes for example the cargo turnover of Georgian ports during the pandemic. Based on the discussion and analysis of each of the above issues, conclusions are drawn.

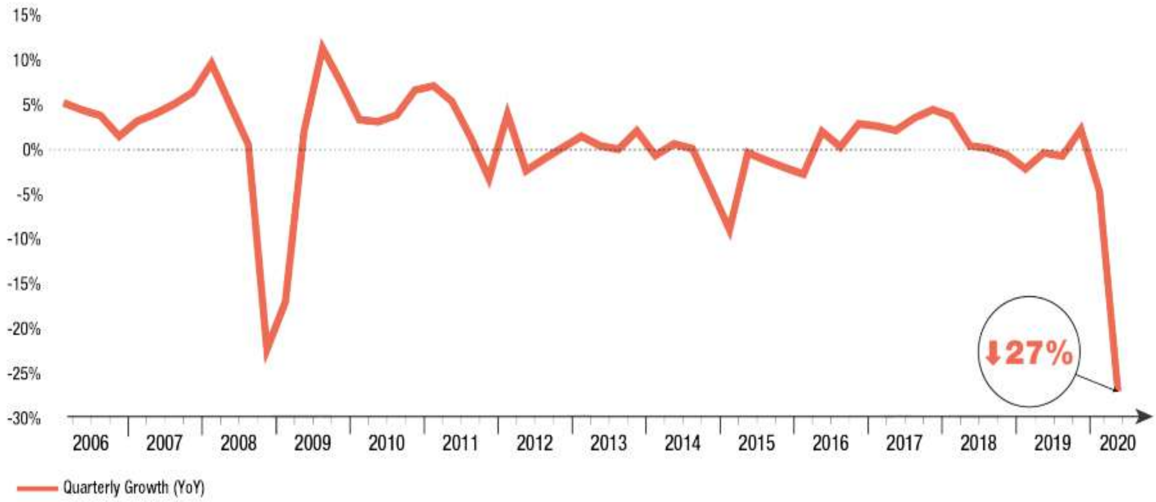
Keywords: Ports; Maritime Transport; Pandemic; Impact; Results

Main Text

The global pandemic has had a major impact on the world, the economy and the industrial sector. The world has changed completely and the world has set other priorities. From a quiet peaceful everyday life, people were overwhelmed by sudden fear and chaos. Changed their daily routine: They had to work, study and do any activity without leaving home.

The economy and important sectors for the economy also stopped. The economic damage caused by the pandemic has been compared to the economic crisis of 2008, and experts say that the damage caused during the pandemic even exceeded the consequences of the crisis - figure №1. As in the rest of the sector, the pandemic has had a major impact on maritime transport, maritime shipping and the maritime industry as a whole. Maritime transport as one of the cargo carrier on which more than 80% of the world cargo is transported turned out to be important for the transportation of goods needed during a pandemic. Nevertheless, the pandemic caused great damage to the field.

Figure №1 - Trends In Global Trade (Percentage Change)



Source: UNCTAD (2020). Global Trade Update. June
(https://unctad.org/en/pages/newsdetails.aspx?OriginalVersionID=2392)

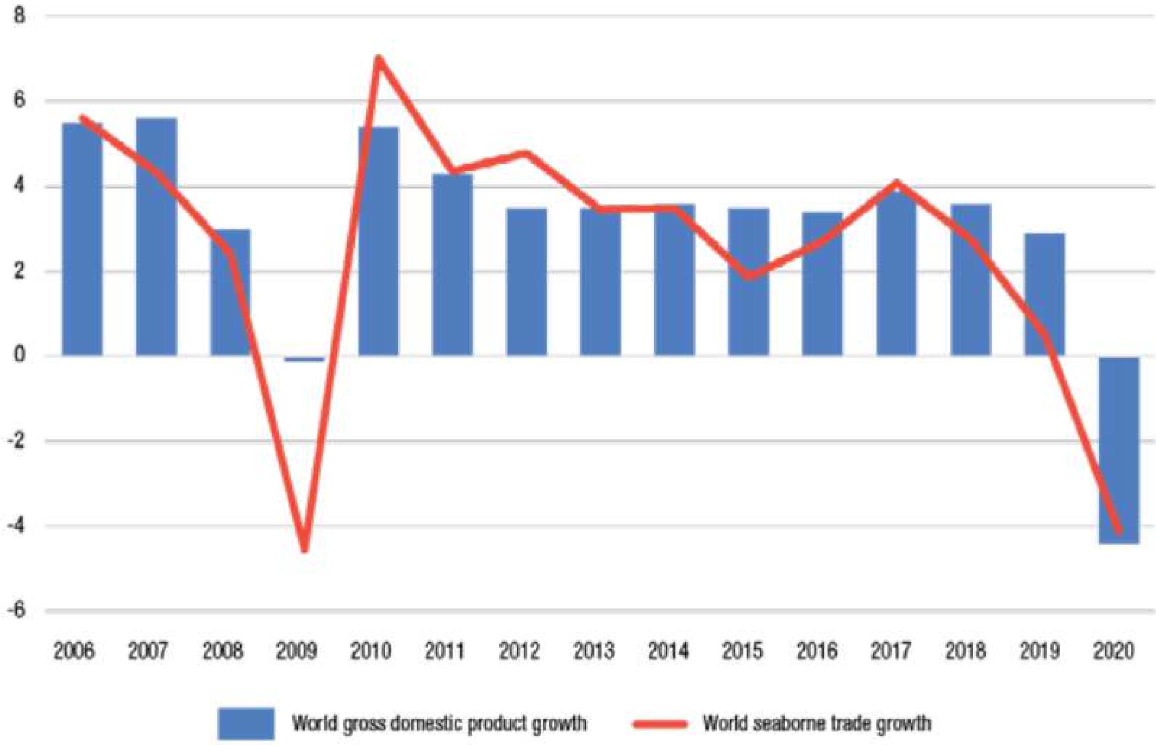
In order to ensure the health of the workers in the field, the world's leading ports have decided to close the ports or not to work at full capacity, some of them have also imposed bans on the processing of imported and exported goods, They especially avoided loading / unloading cargo coming from or passing through China.

Services at the ports were delayed due to the fact that ships, goods and crews entering the port were properly disinfected to prevent the spread of the virus, Consequently, all this hindered the fast and smooth operation of the logistics chain. In addition it all increased the cost of servicing ships and ports.

Also, the uncertainty caused by the pandemic caused fear among the population, there was no longer a high demand for household goods. Mostly medical products and food / groceries were in demand, hence all this led to a decrease in the import and export of goods.

Relatively smaller shipping companies have crashed and gone bankrupt and can no longer meet the challenges posed by the pandemic in the industry.

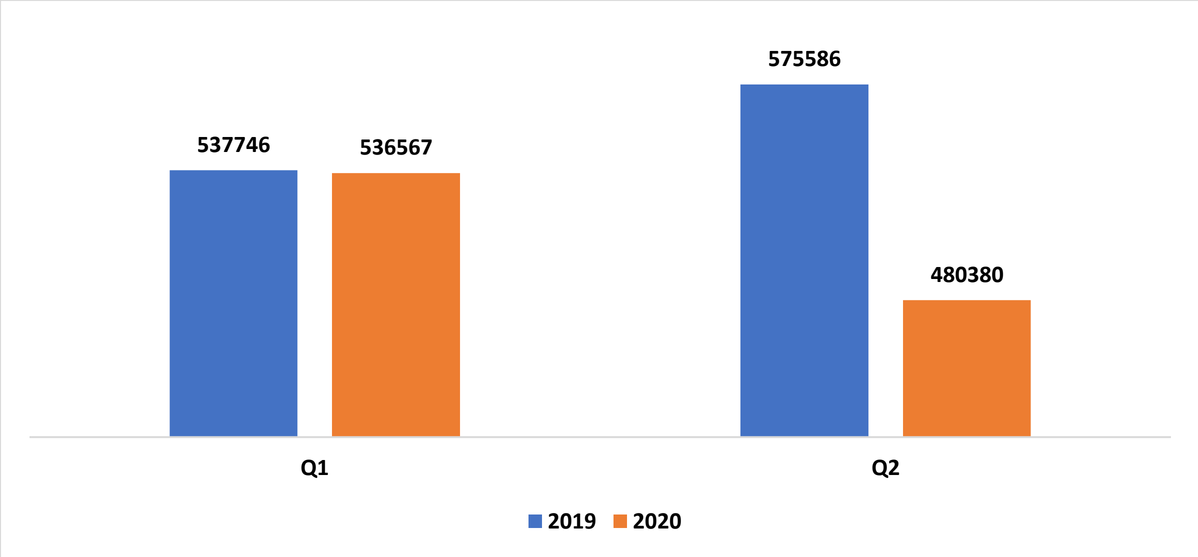
Figure №2 - Development Of International Maritime Trade And Global Output, 2006–2020



Source: UNCTAD calculations, based on the Review of Maritime Transport
https://unctad.org/system/files/official-document/rmt2020_en.pdf

As can be seen from the diagram, the decline in world maritime trade volume starts from the beginning of 2019 and drastically decreases at the end of 2020, and if we look at the chart we will see that the 2020 world maritime trade volume is almost equal to 2008, when the global economic crisis was the main challenge. If we look at the data of the ship calls worldwide we will see that here we have decreasing trend too. Figure №3 shows the date of ship calls worldwide for 2019-2020 years.

Figure №3 - Total Number Of Ship Calls Worldwide (2019-2020)



Source: UNCTAD COVID-19and Maritime Transport
https://unctad.org/system/files/official-document/dtltlb2021d1_en.pdf

Just like all over the world, the pandemic has affected Georgia's maritime transport and seaports. Currently, there are two ports in the country: Batumi Seaport and Poti Seaport. Also, the following terminals: Batumi International Container Terminal; Poti APM Terminal; Kulevi Black Sea Terminal and Supsa Oil Terminal.

Poti Seaport is the largest port in the country. Its management is carried out by APM Terminals, a subsidiary of the Danish AP Moller-Maersk Group. It is located east of the Black Sea and covers 28.9 hectares of land. The annual capacity of the port is about 10 million tons. It has 15 berths and a total length of berths of 2.9 kilometers. Out of which 11 berths are equipped with portable cranes for 6-40 tons. Table 1 presents the technical characteristics of the port berths.

Table №1 - Technical characteristics of Poti Seaport

Poti Seaport		
Berths	**Type**	**Depth (m)**
Berth 1	Liquid cargo	12.5
Berth 2	Railway ferry	12.5

Berth 3,4,5,6,8,9,10,11	General-bulk cargo	8.5; 8.5; 8.5; 9.75; 9.75; 8; 8; 8
Berth 7,14	Containers	8.25; 8.4
Berth 12	Passenger	6.1
Berth 13	Ro-Ro	6.5
Berth 15	Wheat	8.5

Source: https://www.apmterminals.com/ka/poti

Batumi Seaport is the second largest port in the country. Today the port is located on a 22 hectare plot of land and is located southeast of the Black Sea. Annual capacity of the port - 15 million. Tons of oil, 2 million. Tons of dry cargo, 100,000 TEU containers and 180,000 passengers. Currently, the management of the Batumi Seaport is carried out by the subsidiary company of JSC "KazTransOil" - "Batumi Industrial Holding", The port mainly handles liquid, dry, bulk cargoes and containers.

The port has 11 berths including: Oil terminal, container and ferry, dry cargo and passenger. Table № 2 presents the technical characteristics of the berths of the port.

Table №2 - Technical characteristics of Batumi Seaport

Batumi Seaport		
Berths	**Type**	**Depth (m)**
Berth 1, 2, 3	Oil Terminal	12.4; 10.20; 10.20
Berth 4,5	Container and ferry	12
Berth 6,7,8,9	Dry cargo	8.24; 11.5; 10.75; 10.24
Berth 10,11	Passenger	12.20; 8.60

Source: www.batumiport.com

Kulevi Black Sea Oil Terminal is managed by the State Oil Company of Azerbaijan “Socar”. The terminal occupies 96 hectares of land and has 2 berths. Its throughput - up to 10 million tons per year - allows it to overload oil products, out of which: 3 million tons of oil, 3 million tons of diesel and 4 million tons of fuel oil.

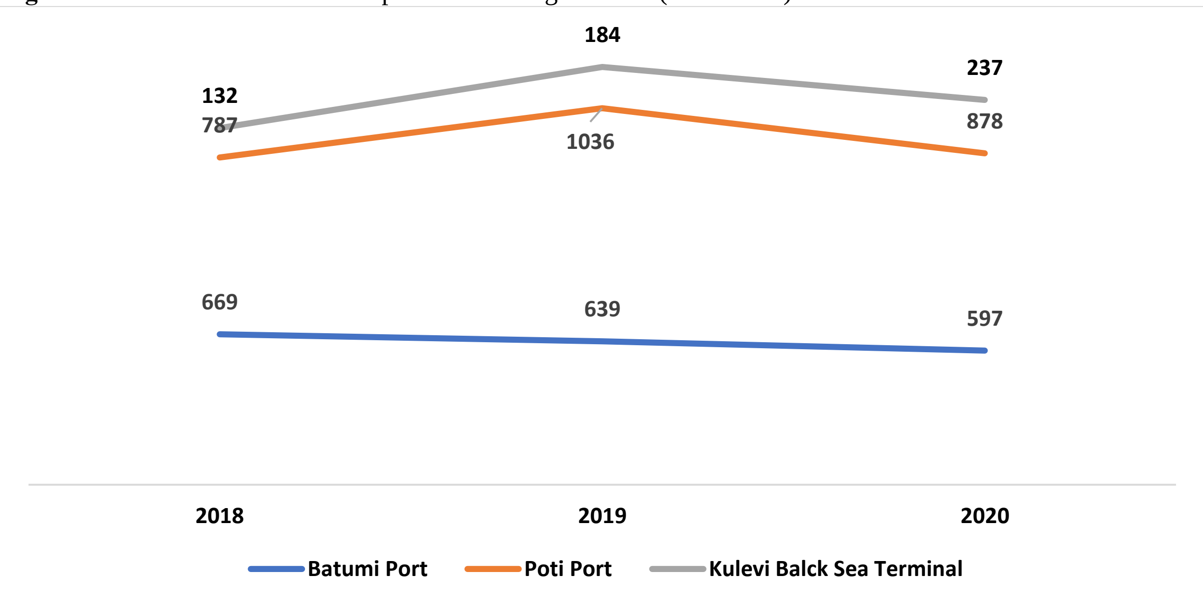
The Supsa terminal, located east of the Black Sea, is owned by British Petroleum and has a capacity of 4 million tonnes.

During the pandemic, Georgian ports went into continuous operation instead of being closed. The ports operated 24/7 to avoid any disruption to the logistics chain. With the great support of the Government of Georgia and the Maritime Transport Agency of Georgia, Georgian ports were able to work smoothly and in a coordinated manner during the pandemic, as a result, the volume of cargo transported in the transport corridor of Georgia increased during the pandemic. In addition, green corridors were set up in Georgian ports to rotate sailors.

As for the working regime and procedures of the port, all citizens on foreign ships and entering the ports were met by the quarantine service of the Customs Department of the Revenue Service of Georgia, who was checking the condition of the crew members and if there were any suspicious symptoms they were taken to the quarantine zone, they also were making decisions about opening / closing the border for ships. Accordingly, the incoming cargo was disinfected and then cargo operations were carried out.

Like the rest of the world, we have a small decrease of ship calls in Georgian ports. The picture has changed dramatically as countries, including Georgia, have begun imposing restrictions and lockdowns, this is confirmed by the data presented in the Figure №4.

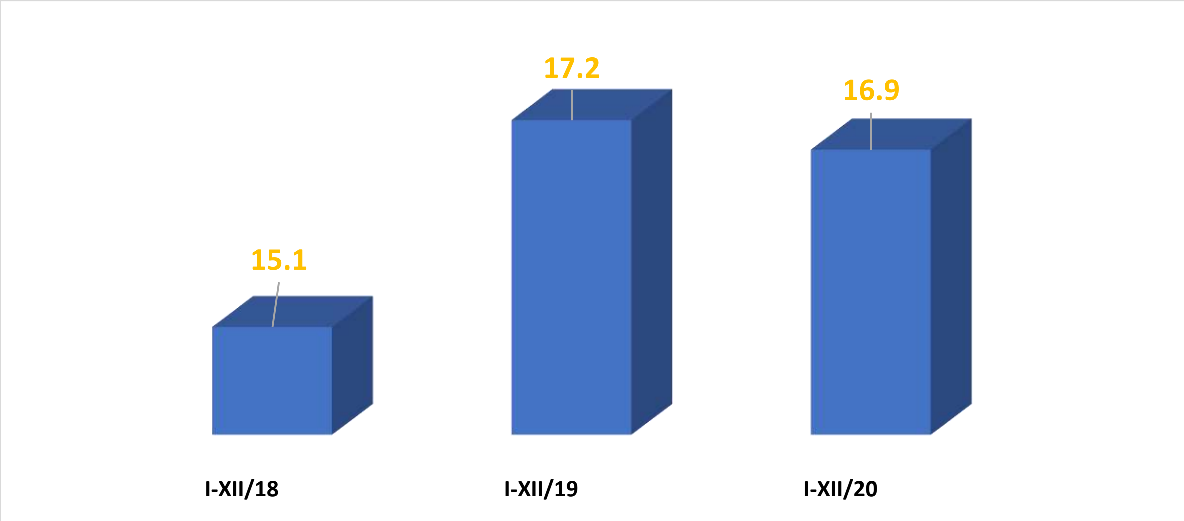
Figure №4 - Total Number Of Ship Calls in Georgian Ports (2018-2020)



Source: Annual Report – 2020 of Maritime Transport Agency of Georgia
http://mta.gov.ge/uploads/2020___1.pdf

If we look at the statistics of cargo turnover of Georgian ports during the last 3 years, we will see that despite the pandemic, Georgian ports have maintained the volume of cargo they processed before the pandemic.

Figure №1 – Volume (Million Tons) Of Cargo Processed At Georgian Seaports And Terminals (Total)

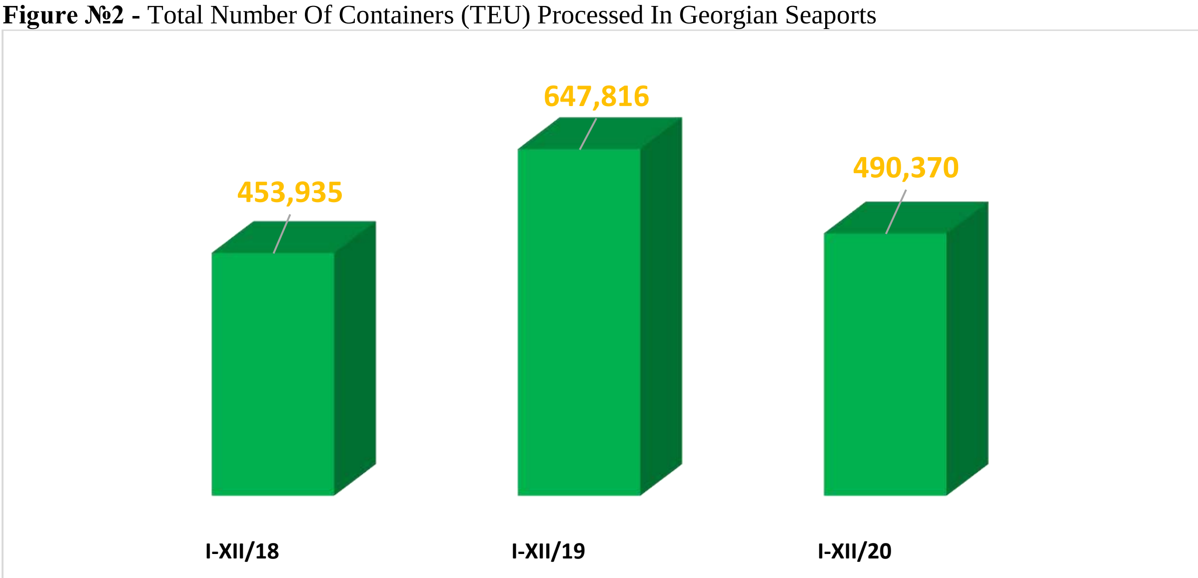


Source: Ministry of Economy and Sustainable Development of Georgia
http://www.economy.ge/index.php?page=ecoreview&s=26

Figure №1 shows the total amount of cargo processed in Georgian seaports and sea terminals (million tons). If we look at the number of processed cargoes and compare the data for 2018, 2019 and 2020, we will see that in fact the change between the volumes of processed cargoes is minimal and Compared to the 2019 data with the 2018 data we will see that on the contrary the volume has slightly increased in 2019. The figures also show that, despite the pandemic, there was no significant drop in this regard in 2020 (16.9 million tonnes) - we processed less cargo in 2017 (16.2 million tonnes) and 2018 (15.1 million tonnes).

As for container shipping in the country, we have literally the same picture here, figure №2 presents data on the total number of containers (TEU) processed in Georgian seaports.

Figure №2 - Total Number Of Containers (TEU) Processed In Georgian Seaports



Source: Ministry of Economy and Sustainable Development of Georgia
http://www.economy.ge/index.php?page=ecoreview&s=26

In this case, too, the 2019 data show a 30% increase compared to 2018. And we have a 25% decrease in 2020 compared to the same 2019 data. However the overall picture to assess the situation is stable. In 2020, compared to the previous year, the number of processed containers decreased in both Batumi and Poti seaports. In summary, we had the largest increase in this area in 2019 - 647,816 TEU. However, if we exclude this exceptional year, we will see that the total number of processed containers in seaports in 2018-2020 is steadily growing.

Conclusion

In view of all the above, international practice shows that the global world, including the global maritime sector, was not prepared for similar force majeure situations caused by the sudden appearance of a pandemic. Nevertheless, many ports around the world, including Georgian ports, have faced the challenge of a pandemic. But this is not enough, we should take the experience gained from the current situation as an example and start taking care of preparing ports and their workforce for unexpected force majeure situations.

For this, the management needs to work in the following directions:

- Introduction and use of more technologies and innovations in the work process;
- Ensuring continuity of cargo flows;
- Crisis situation strategy and action plan;
- Raising staff awareness about actions in similar situations;

By paying more attention to the issues listed, we will be able to respond to similar situations more effectively.

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LIFE AFTER COVID-19. CRUISE INDUSTRY RISING FROM THE ASHES

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Keywords: cruise industry, cruise tourism, pandemic, covid-19

After catastrophic waves of coronavirus disease that dramatically slammed world's economy, cruise industry appeared to be one of the most affected businesses [1] (Theodore Syriopoulos, 2020) Cruises had thrived for years: 55 ((CLIA), 2021) cruise lines, 400 executive partners, 53 000 travel agent members, 280 ships, $150 billion output business, 1,177,000 jobs and $50.24 billion in wages/salaries. [2] (CLIA, 2020) Though since 2020, the year that Adam Goldstein (Chairman of Cruise Lines International Association – CLIA) has called "a year unlike any other," almost all the cruise ships have dropped anchor. Relatively old ships were sold off or scrapped. Starting from the March 2020 three core cruise lines (Royal Caribbean, Carnival Corporation and Norwegian Cruise Lines) had experienced 60-80% drops in stock prices of their companies. (Team, 2020) [3] The cruise industry losses account for billions $.

However, every cloud has a silver lining. While much of the world had been stuck since the March 2020, the cruise industry was not wasting the time and has started adjusting to new requirements. According to CLIA report 2021 cruise lines are coming back equipped with "fleet of the future" (20 ships to debut in 2021), enhanced protocols, new onboard digital technologies, responsible tourism trend, cutting-edge maritime environmental technologies and record demand for 2023. The sector demonstrates incredible resilience and optimism supported by official numbers. ((CLIA), 2021) [4]

The paper reviews current situation of the global cruise industry and focuses on the steps already taken by cruise lines executives worldwide to overcome pandemic reality and those to be taken to optimize current situation and benefit from the post covid-19 rehabilitation processes.

The analysis is based on a desk research method, using official resources: reports, market analysis, expert opinions, press releases, previous studies and industry journals. The findings show specificities, future challenges and forecast of most possible ways for the sector development.

Introduction

The COVID-19 pandemic has taken a toll on most sectors of the travel industry, however, the cruise market turned out to be one of the less fortunate. The outbreak of the coronavirus aboard the Diamond Princess in February 2020 caused great reputational losses to the industry. The cruise ships became infamous as "floating Petri dishes". (Tan, 2020) [5] It was all clear that it would take a long time to regain consumers' loyalty after such notoriety. As a result, 'tourism on big water' was practically stopped. As the virus spread, major cruise line stocks began to fall in February 2020 and bottomed out in mid-March. Companies have suffered billions of losses that year, losing more than 70% of their value. In the first nine months of 2020, sales from the three largest operators - Carnival Corporation & PLC, Royal Caribbean Group and Norwegian Cruise Line - fell 65-75%. (Team, 2020)[3] The cruise association estimates that the travel suspension has reduced economic activity by more than $ 25 billion and cut 164,000 jobs in the United States alone. ((CLIA), 2021) [4] Cruise companies around the world are borrowing billions, refinancing and selling ships, hoping to set sail in the nearest future. The cumulative losses incurred by cruise lines and the coastal service industry supporting the cruise lines could well be trillions of dollars in 2020. (Hirohito Ito, 2020) [6]

Methodology

The purpose of this study was to provide a thorough overview of the industry in its earliest post covid-19 rehabilitation period. The study was conducted basically withing a desk research method, using official resources: reports, market analysis, expert opinions, press releases, previous studies and industry journals.

Methodology for data collection combines statistical data of official sources. Qualitative and quantitative information has been gathered to analyze and demonstrate current situation of cruise business and highlight the effectiveness of the strategy, chosen by cruise management.

Cruise industry overview

On October 30, 2020, the US Center for Disease Control (CDC) issued the Cruise Line Operating Conditions Framework for US Waters. To resume passenger traffic, companies had to build 'laboratories on ships' and take steps to isolate or quarantine passengers ashore. The CDC said that cruise ships would be allowed to operate after the conduction of a simulated voyages with volunteers portraying sick passengers. (CDC, 2021)[7]

Just days after the CDC lifted its cruise ban, replacing it with strict protocols, several passengers on board the Sea Dream1 ship in the Caribbean were tested positive for COVID-19 was. Then the congressmen sent a letter to the CDC asking them to return the restriction. So far, this has not happened, but US cruise lines due to strict safety rules were forced on their own initiative to cancel the trips, at least until the end of 2020. (2021 Cruise Industry News Annual Report, 2021)[13]

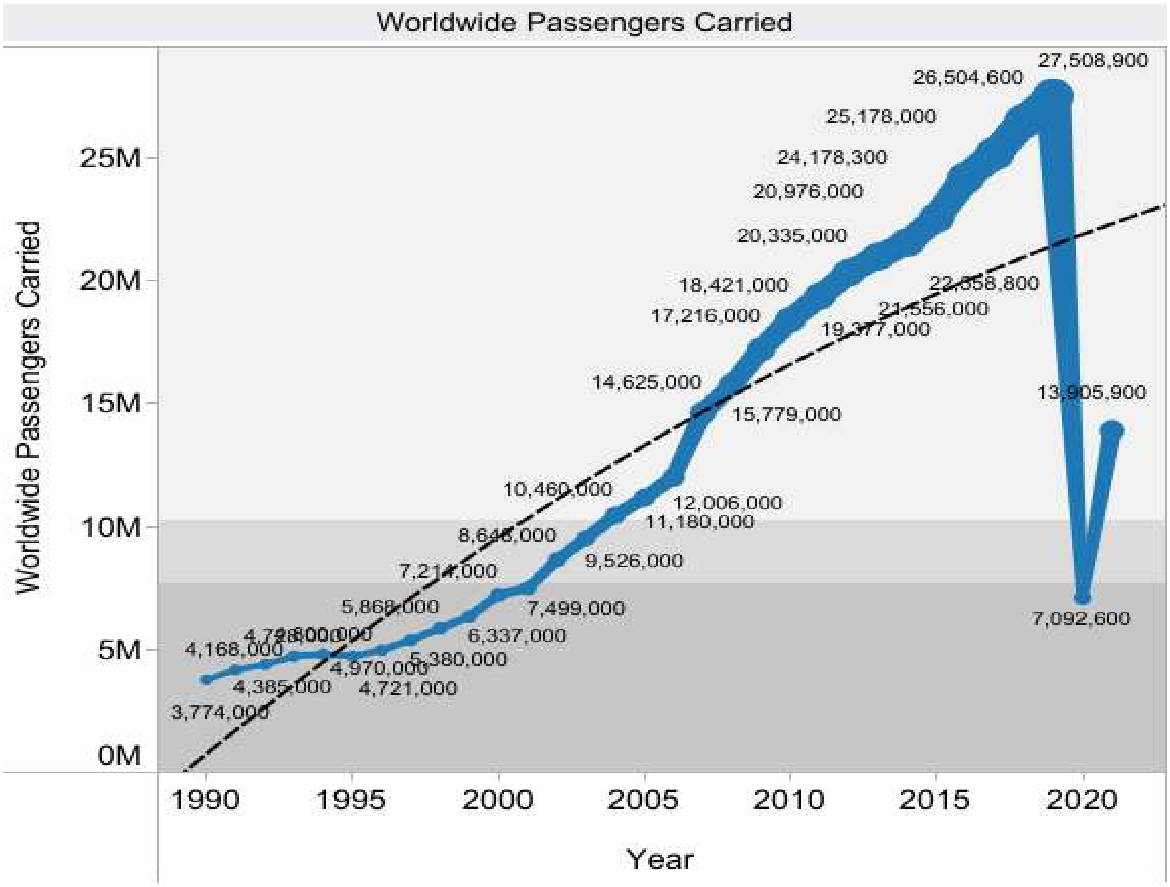
The industry has begun recovering only this Summer (2021), however, it will take years to hit 2019 levels. According to the president and CEO of CLIA Kelly Craighead, in 2019 cruise ships welcomed almost 30 million passengers, provided employment for 1.8 million people all over the world, paid 50,53$ billion in wages/salaries, and showed 154,5$ billion total output worldwide. [4] In terms of passenger traffic, between 2017 and 2019, the number of guests on board cruise ships increased from 26,7 million to 29,7 million (Statista, n.d.) [8].

According to Cruise market Watch, in 2020 the number of passengers fell to 7 million, that is similar to the 2000's rate. The estimated number of guests by the end of 2021 is 13.9 million, that is 96.2% growth over 2020 and a 49.4% decline from 2019.[9] Table 1.

The pause in cruise operations caused by the COVID-19 pandemic has had a devastating economic impact. In the recent report "State of Cruise Industry Outlook 2021" CLIA has declared that since mid-March till September 2020 more than 518,000 people have lost their jobs, resulting in 23$ billion loss in wages/salaries. During this period of time the cruise community has lost more than 77$ billion of global economic activity.[4]

The cruise industry hopes to recoup the multi-billion-dollar losses caused by the coronavirus pandemic. A year and a half have passed since the Diamond Princess cruise ship embarked on a fatal voyage in January 2020, which became a breeding ground for a brand new virus and showed the world the danger of mass gathering of people in a confined space.

Table 1Growth of the Ocean Cruise Line Industry



Source Region of Passengers

Year	North America	Europe	Other	Worldwide Passengers Carried
2017	12,645,600	6,996,000	5,536,400	25,178,000
2018	12,927,800	7,285,100	6,291,700	26,504,600
2019	12,929,200	7,564,900	7,014,800	27,508,900
2020	3,225,500	1,935,300	1,931,800	7,092,600
2021	6,118,596	3,754,580	4,032,711	13,905,900

Vice President of Sea Travel at Celebrity Cruises, Captain Manolis Alevropoulos says: “We look forward to coming back and are very delighted with that. We place great emphasis on the safety and health of both our guests and the crew. We believe that the industry will become stronger by following strict sanitary protocols. "

Over the past year and a half, at least five cruise lines have gone bankrupt, and dozens of functioning vessels have been scrapped.

MSC Cruises’ Executive Chairman and CLIA Chair Pierfrancesco Vago pointed out that the key word today is “safety bubble”. According to him everyone who works on the ship has been verified. “When we reach our destination, in cooperation with the local authorities, we also apply this approach. Our clients ,while visiting attractions, try not to mix with the population. They go by buses, where the driver, the guide – everyone is checked, to the places where every measure is taken to avoid dangerous contacts. " (Gleass, 2021) [10]

The idea is to stay safe by ensuring strict Health& Safety protocols that were developed by the industry. The cruise lines understand that the stakes are high. This year, they cannot afford to repeat the situation of passengers being stuck onboard under the threat of mass infection.

After such drastic measures like closing the ports worldwide, restrictions on the citizens' mobility around the globe, banning cruise tourism in the United States in March 2020, industry representatives and experts are more than confident in the resurrection of cruises. Cypriot authorities are looking to the future with optimism: “We have a very safe entry protocol, - says the Minister of Tourism of Cyprus Savvas Perdios. - You can come with a vaccination certificate or with negative results as well, there is also random testing on arrival. Let people enjoy our island. " (UNWTO, 04.06.2021) [11] Moreover, every cloud has a silver lining. The post-crisis period opened up new opportunities for Cyprus: the American company Royal Caribbean chose one of the ports of the island as a home port.

As voyages are resumed timidly in Europe and the USA, the management and employees of the companies assure that from now on, everything will be done for the complete safety of passengers.

Let’s compare the numbers. Before the pandemic, average passenger growth was about 6.6% per year till March 2020. (Growth of the Ocean Cruise Line Industry, 2021) [9] COVID-19 stagnation for total 15 months made the cruise economy go into a vortex. The crisis has accelerated the retirement process and demolition of cruise vessels as well as expedited the endorsement of an environmentally friendly fleet. According to Cruise Market Watch, 31 ships are going to be out of exploitation worldwide from 2019 to 2021, which will reduce passenger capacity by 49,105. CLIA states that 270 vessels will be projected in 2021 and 20 ones will debut this year. ((CLIA), 2021)[4] Referring to the table below Table 3, by the end of 2021 total ocean cruise passenger capacity will be 581,200 / 323 ships, that is 7.8% decrease comparing to 2019’s capacity. Ocean cruise market share 2021 has reached $23.8 billion so far (Carnival Cruise Line -8.8$ billion/37.1%; Royal Caribbean International- 5$ billion/21.2%; Norwegian Cruise Line -2.9$ billion/12.6%; all other-6.9$ billion/29.2%), that represents 81.8% increase over 2020 and 52.9% decline, comparing to 2019 results. (2021 Worldwide Cruise Line Market Share, 2021) [12]

Table 2Worldwide Cruise Line Market Share 2021

2021 Details					
Parent	Brand	Total Passengers	% of Passengers	Revenue	% of Revenue
Carnival	AIDA	749,300	5.4%	$1,373,710,000	5.8%
	Carnival	2,528,100	18.2%	$1,803,870,000	7.6%
	Costa Cruises	862,400	6.2%	$1,121,190,000	4.7%
	Cunard	99,700	0.7%	$427,110,000	1.8%
	Holland America	384,200	2.8%	$1,095,070,000	4.6%
	P&O Cruises	241,500	1.7%	$466,790,000	2.0%
	P&O Cruises Australia	127,300	0.9%	$134,980,000	0.6%
	Princess	816,300	5.9%	$2,065,350,000	8.7%
	Seabourn	33,800	0.2%	$345,120,000	1.4%
	Total	5,842,600	42.0%	$8,833,190,000	37.1%
RCI	Azamara	31,700	0.2%	$161,530,000	0.7%
	Celebrity	540,000	3.9%	$1,452,300,000	6.1%
	Royal Caribbean	2,657,900	19.1%	$3,048,670,000	12.8%
	Silversea	48,900	0.4%	$391,710,000	1.6%
	Total	3,278,500	23.6%	$5,054,210,000	21.2%
Norwegian	Norwegian	1,200,300	8.6%	$2,057,990,000	8.6%
	Oceania Cruises	71,100	0.5%	$373,140,000	1.6%
	Regent Seven Seas	48,500	0.3%	$565,150,000	2.4%
	Total	1,319,900	9.5%	$2,996,280,000	12.6%
All Other	American Cruise Lines	13,600	0.1%	$37,210,000	0.2%
	Blount Small Ship Advent..	3,900	0.0%	$10,630,000	0.0%
	Celestyal Cruises	64,100	0.5%	$175,440,000	0.7%
	Crystal	40,800	0.3%	$111,640,000	0.5%
	Disney	312,200	2.2%	$653,450,000	2.7%
	Dream Cruises	264,100	1.9%	$723,030,000	3.0%
	Fred Olsen	110,700	0.8%	$303,030,000	1.3%
	Grand Circle Cruise Line	1,900	0.0%	$5,320,000	0.0%
	Hapag Lloyd	48,500	0.3%	$132,910,000	0.6%
	Hebridean Island Cruises	1,900	0.0%	$5,320,000	0.0%
	Hurtigruten	122,300	0.9%	$334,930,000	1.4%
	Lindblad Expeditions	17,500	0.1%	$47,850,000	0.2%
	Marella Cruises	102,900	0.7%	$281,770,000	1.2%
	MSC Cruises	1,414,700	10.2%	$1,539,650,000	6.5%
	Paradise Cruise Line	50,500	0.4%	$138,230,000	0.6%
	Phoenix Reisen	43,700	0.3%	$119,620,000	0.5%
	Ponant/Paul Gauguin Crui..	85,400	0.6%	$233,920,000	1.0%
	Quark Expeditions	15,500	0.1%	$42,420,000	0.2%
	Saga Cruises	38,800	0.3%	$106,220,000	0.4%
	SeaDream Yacht Club	3,900	0.0%	$10,630,000	0.0%
	Star Clippers	11,700	0.1%	$31,900,000	0.1%
	Star Cruises	80,200	0.6%	$219,670,000	0.9%
	TUI Cruises	330,100	2.4%	$903,790,000	3.8%
	Viking Cruises	143,700	1.0%	$393,410,000	1.7%
	Virgin Voyages	111,100	0.8%	$304,100,000	1.3%
	Voyages to Antiquity	7,800	0.1%	$21,270,000	0.1%
	Windstar	23,300	0.2%	$63,800,000	0.3%
	Total	3,464,800	24.9%	$6,951,160,000	29.2%
Grand Total		13,905,800	100.0%	$23,834,840,000	100.0%

The cruise industry has reacted quite quickly to the unfolding crisis of Covid-19. Within 24 hours after WHO declared emergency, CLIA made first changes to the health policy. By mid-March cruise lines have suspended their commercial operations. All the next steps were crucial for the survival of the business and required precise planning, engagement of leading scientists and health experts to make it through. Enhanced Health & Safety protocols have become a lifeline for the industry. Such measures like passenger/crew 100% testing, physical distancing, health evaluations, strict protocol, coordination of destinations along with on-going vaccination made 'phased resumption' possible for cruises. Trial sailings have demonstrated that the protocols work and the cruise world is on the path to resumption. According to polls conducted by CLIA in 2020, 74% of cruisers are willing to cruise in the next couple of years. ((CLIA), 2021) [4]

Table 3Worldwide Cruise Line Passenger Capacity 2021

Parent	Brand	Ship Count	Passenger Capacity
Carnival	Carnival	23	70,700
	Princess	17	45,500
	AIDA	15	36,786
	Costa Cruises	12	35,900
	Holland America	12	20,400
	P&O Cruises	7	16,600
	Seabourn	6	2,818
	Cunard	3	6,700
	P&O Cruises Australia	3	5,000
	Total	98	240,404
Royal Caribbean	Royal Caribbean	24	88,000
	Celebrity	14	28,500
	Silversea	9	3,100
	Azamara	3	2,100
	Total	50	121,700
Norwegian	Norwegian	17	49,800
	Oceania Cruises	6	5,200
	Regent Seven Seas Cruises	5	3,400
	Total	28	58,400
All Other	Ponant/Paul Gauguin Cruises	22	4,400
	MSC Cruises	19	62,700
	Hurtigruten	14	6,300
	Lindblad Expeditions	11	900
	Viking Cruises	8	7,400
	TUI Cruises	7	17,000
	Windstar	6	1,200
	American Cruise Lines	5	700
	Fred Olsen	5	5,700
	Quark Expeditions	5	798
	Disney	4	8,500
	Dream Cruises	4	13,600
	Hapag Lloyd	4	2,500
	Marella Cruises	4	5,300
	Star Cruises	4	4,132
	Crystal	3	2,100
	Phoenix Reisen	3	2,250
	Star Clippers	3	600
	Blount Small Ship Adventures	2	200
	Celestyal Cruises	2	3,300
	Grand Circle Cruise Line	2	100
	Paradise Cruise Line	2	2,600
	Saga Cruises	2	1,998
	SeaDream Yacht Club	2	200
	Virgin Voyages	2	5,720
	Hebridean Island Cruises	1	100
	Voyages to Antiquity	1	400
	Total	147	160,698
Grand Total		323	581,202

There are some positive side effects that were caused by the pandemic. Covid-19 has enabled more responsible tourism, that implies adoption of the latest maritime environmental technologies. New capacities move to 'zero sulfur emissions" and 20% reduction in greenhouse gas emissions. 'Advanced Water Treatment Systems' along with EGCS 'Shore Side Electricity' and other cutting-edge maritime technologies make the cruise industry a leader in eco-friendly tendencies. ((CLIA), 2021)[4]

In the frames of 'phased resumption' cruise lines commence their operation starting March 2021.Table 4.

Table 4-Cruise Lines sailing schedule 2021 (updated June 23,2021)

CRUISE LINE	SAILINGS RESUMES:
AIDA	March 20, 2021
Azamara	August 28, 2021
Carnival	September 1, 2021, except some vessels that will sail in the beginning of July.
Celebrity	June 26, 2021

Celestyal Cruises	June 12, 2021
Crystal Cruises	July 3, 2021
Dream Cruises	Spring of 2021
Holland America Line:	July 24, 2021
Hurtigruten	August 15, 2021
The Majestic Line	May 18 2021
Maple Leaf Adventures	July 1, 2021
MSC Cruises	June 13, 2021
Norwegian Cruise Line	September 2, 2021 except some vessels that will sail in July
NYK Cruises	resumed again on March 26, 2021
Oceania Cruises:	August 29, 2021
P&O Cruises	June 27, 2021
Princess Cruises	July 25, 2021
Regent Seven Seas	September 11, 2021
Royal Caribbean	September 1, 2021, except some in April/June
Saga Cruises	July 26, 2021
Sea Cloud Cruises	August 6, 2021
Seabourn	July 3, 2021
Silversea	beginning of June 2021
Star Clippers	August 3, 2021
Windstar Cruises	March 26, 2021

To mitigate Covid-19 transmission onboard CDC (Center for Disease and Control and Prevention) has developed color-coding system for cruise ships. Basing on a ship color (green, yellow, orange and red), specific preventive measures are required or recommended to take onboard. A cruise ship's color is defined by the criteria listed in Figure 1.

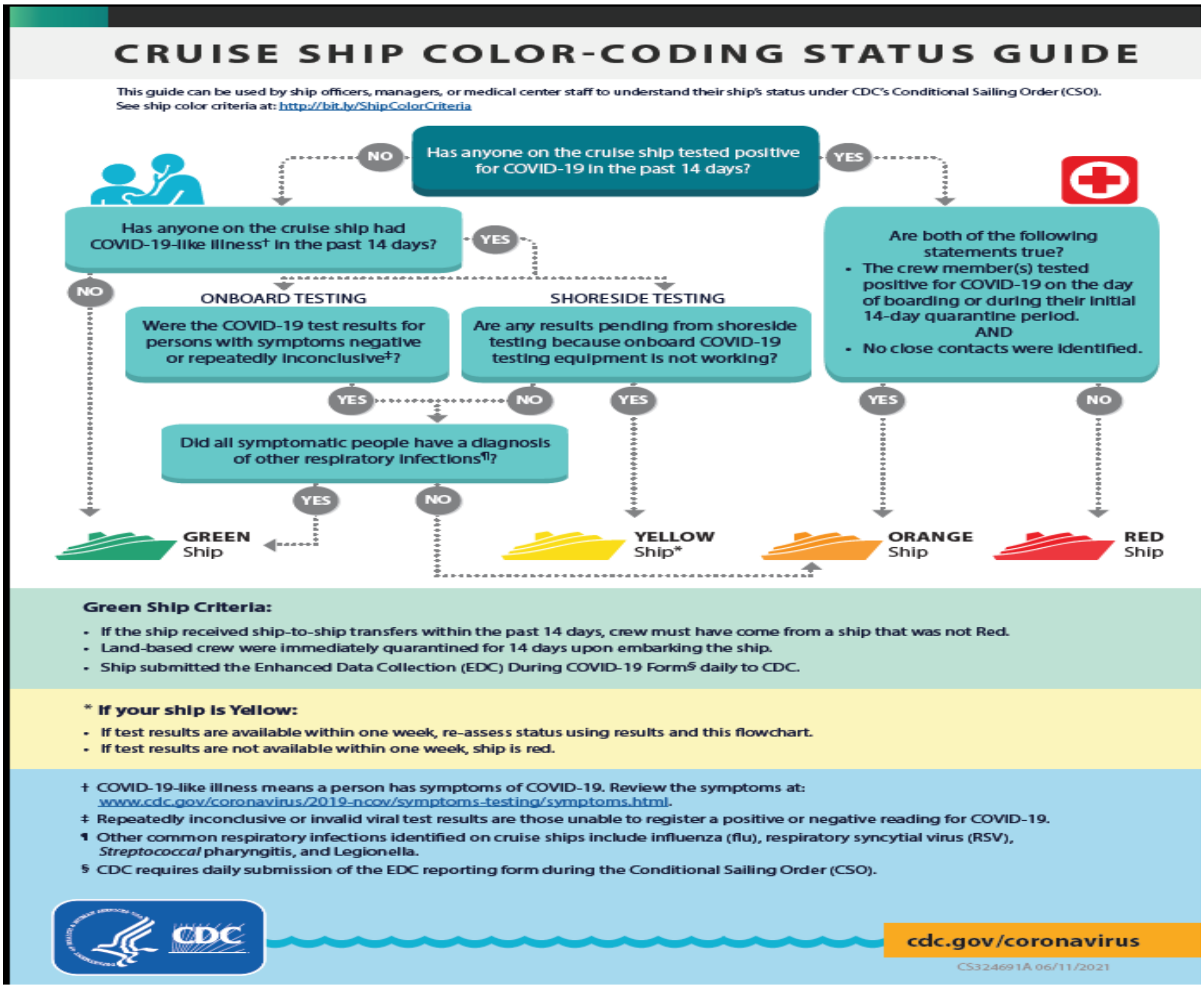


Figure 1Cruise Ship Color-Coding Status Guide

Conclusion

The purpose of this study is to provide an overview of the cruise industry in its resurrection period and evaluate the results of the measures taken by cruise community. To achieve the goal two type of information was gathered and analysed.

The first analysis is focused on statistical data, that showed the depth of the crisis in the industry by 60-80% drops in stock prices of 3 giant cruise companies (Carnival Corporation & PLC, Royal Caribbean Group and Norwegian Cruise Line) (Team, 2020) . Cruise lines have suffered 77$ billion loss of their global economic activity. ((CLIA), 2021)

The second analysis addresses opinions of experts, managers and government representatives, as well as focus groups of passengers and other direct participants of the cruising process. Based on the information collected, the forecasts are more than encouraging. Health & Safety protocols proved to be effective enough to ensure safe operation.

The real pace of industry recovery has exceeded all expectations and forecasts made before. The results obtained so far suggest that 2022 will break the 2019 records of the cruise industry. According to Cruise Industry News Annual Report cruise lines have all the potential to carry 31.7 million passengers in 2022, continuing to grow to and hitting 38.7 million passengers by 2027 (2021 Cruise Industry News Annual Report, 2021) [13]

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Table 1 - Growth of the Ocean Cruise Line Industry, Cruise Market Watch 2021
Table 2-Worldwide Cruise Line Market Share 2021, Cruise Market Watch 2021
Table 3- Worldwide Cruise Line Passenger Capacity, Cruise Market Watch 2021
Table 4- Cruise Lines sailing schedule 2021 , 2021, June 23). *When Are Cruise Lines Around the World Expected To Resume Service?* Retrieved from Cruise Critic
Figure 1-Cruise Ship Color-Coding Status Guide

REMOTE INSTRUCTION: CHALLENGES, INITIATIVES, AND FUTURE DIRECTIONS FOR MARITIME EDUCATION INSTITUTIONS IN A DEVELOPING COUNTRY

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ABSTRACT

The COVID-19 pandemic has caused a shift in pedagogy that has affected the operations of maritime education and training institutions (METIs), the instructors, and the students. This study sheds light on the following topics: (1) Challenges faced by instructors, students, and METIs in implementing remote instruction, (2) METI initiatives to cope with and address these challenges, and (3) Future directions for METIs for effective delivery of remote instruction. Data were collected through a survey and structured interview with 105 instructors, 804 students, and five administrative officers of METIs. Frequency count and percentage were used to analyze the numerical data, while thematic analysis was employed in organizing data from open-ended questions. The results revealed that most of the challenges experienced during the transition from face-to-face to remote mode of instruction stemmed from the "far-from-advanced" technological resources and difficulty in coping with the sudden shift in the METIs' operations, and the instructors' and the students' new academic routines that have affected their physical, mental, and emotional state. Initiatives focused on the academic, financial, human, and technological resources were implemented to cope with the sudden change. Future directions in MET are set on Strengthening IT/Technological Infrastructure, Capitalizing on IT and Research and Development, Academic Calibration for a More Relevant and Responsive Maritime Education and Training, Advancing Instructors' Technical Capacities, Strengthening Parental Engagement, and Building Wider Alliances and External Partnerships.

Keywords: Remote Instruction, Maritime Institutions, Maritime Education and Training, Institutional Initiatives, COVID-19

1. INTRODUCTION

The COVID-19 pandemic has posed challenges for developing countries like the Philippines, particularly in transitioning from in-class to online learning (O'Neill et al., 2020). Maritime institutions have resorted to online, modular, and blended learning modalities. Adjustments had to be made in the MET operations. The pedagogical shift has brought challenges to the instructors -- preparing instructional materials appropriate to each learning modality and conducting virtual classes despite limited internet connectivity. The instructors also had to equip themselves with the necessary IT skills. These initiatives have taken a toll on the institution's financial, technological, and human resources.

As of September 2020, 75% of Filipino households and 44.44% across countries in Southeast Asia have lost their jobs. Eighty-five percent of the Filipinos and 58% across Southeast Asian countries have experienced financial difficulty during the pandemic (Asian Development Bank cited in Basilio, 2021). Over 1.2 billion students worldwide were suddenly out of school (Li & Farah, 2020). Families struggled to survive while forced to provide their children gadgets and internet access to cope with the shift into remote learning.

With the pandemic impacting the academe, maritime education institutions in the Philippines are trying to sustain their academic programs by adopting multiple measures in delivering instruction (*Report of ICS IAMU Virtual Dialogue, September 2020*). The Philippine Association of Maritime Institutions (PAMI), the Maritime Industry Authority (MARINA), the Commission on Higher Education (CHED), and other stakeholders have expressed their optimism in resolving problems that affect the maritime education sector (Pimentel, 2021). A study conducted by van Tatenhove (2021) delved into different ways public authorities and private sectors in the maritime industry in Europe are affected by the COVID-19 pandemic and discovered its pervasive effects on the development of maritime sectors such as transport and shipping, cruise tourism, and fisheries. Earlier studies in the Philippines have explored various academic issues and concerns due to the pandemic (Tria, 2020; Dziuban et al., 2018; Unger & Meiran, 2020). However, gaps in the literature have surfaced, each of them needing further exploration. First, research is limited when evaluating the realities maritime students have experienced because of the shift in the learning modalities. Second, METIs have limited data on how their initiatives could affect the students and the instructors. Lastly, nothing much has been explored on the impact of the COVID-19 pandemic on remote instruction in the context of METIs' financial, technological, structural, and human resources; hence, this paper.

2. OBJECTIVES

This investigation aimed to (1) profile the challenges met by instructors, students, and the administration of METIs in the implementation of remote instruction, (2) discuss the initiatives done by METIs in coping with the situation and in addressing the challenges, and (3) point out future directions for METIs to strengthen their resources for effective delivery of remote instruction.

3. METHODS

A descriptive design using survey and structured interview provided the intellectual machinery for gathering and analyzing the data. An online survey through Google Forms generated substantial data from 105 METI instructors and 804 maritime students. A structured interview with five school administrators and department heads was conducted to get their views from the perspective of the METIs. Frequency count and percentage were used to report and analyze the numerical data. Thematic analysis was employed in organizing and reporting the data from open-ended questions. The results presented are based on the data from the entities who have responded to the survey. An extensive review of related literature and studies conducted in education at the time of the pandemic was done.

4. RESULTS AND DISCUSSIONS

With the pandemic, education has become one of the most affected sectors worldwide, with over 1.5 billion learners in 165 countries being affected by school closures to contain the spread of COVID-19 (UNESCO, 2020). The following discussions summarize the salient findings of this study.

4.1 Challenges Experienced by Students

On top of the challenges experienced by students were Limited Access to a Device and Internet Facilities (f = 659), Excessive Academic Pressure (f = 659), and Mental and Emotional Stress (f = 595).

Limited Access to a Device and Internet Facilities

Twenty percent of the students have stable internet connectivity, 78% have limited connectivity, and 2% do not have access to the internet and have to go to the nearest internet station to get one. Thirty-three percent of the respondents have laptops, 12% have PCs, and the rest have mobile phones to access online learning. Thirty percent experienced difficulties using the Learning Management System and internet signal interruptions. Other problems encountered were slow internet speed, inadequate network coverage, and the high cost of a data package. The findings of this study are corroborated by the study of Ochavillo (2020), which found that 74% of maritime students do not have a computer or laptop for schoolwork purposes, 55% did not have an internet connection, and 80% did not have access to internet shops.

Forty-two percent of the respondents come from low-income and 51% from middle-income classes. Educational inequality in financial and material resources has become more apparent in developing countries because of the pandemic. Ochavillo (2020) reported that 55% of parents have an informal income source; hence, students with parents in this income group are the most vulnerable and most affected by the pandemic.

Online learning highlighted the inequality in educational opportunity. Some students have connectivity concerns or reside in areas where telecom signals are absent. Students from higher socioeconomic status have access to computers, high-end gadgets, and better internet access. This inequality may discourage low-income students from enrolling in schools with well-equipped IT and LMS. Adedoyin and Soykan (2020) pointed out that students who cannot afford broadband connections are most vulnerable to encounter additional challenges in online learning.

Excessive Academic Pressure

Eighty-two percent of the students have voluminous tasks and requirements to perform but hardly get feedback from their instructors, reducing their motivation to perform well. Working in isolation, compounded by family-related struggles in coping with the pandemic, contribute to their academic stress. According to Bedewey and Gabriel (2015), as cited in (Chandra 2020), this perception of academic stress affects their well-being and ability to manage course workload.

Mental and Emotional Stress

Seventy-four percent of the students find online learning more stressful than face-to-face classes as it takes away the benefit of socializing with their classmates (Angdhiri, 2020). Mental and emotional stress may have a detrimental effect on students' learning, and without the physical interactions with their teachers and classmates, their emotional well-being may be compromised. This raises serious concern considering that mental health during the COVID-19 crisis has been associated with suicidal behavior (Sher, 2020; Mukhtar, 2020). Seventeen reported cases of suicides in the Philippines had been linked to these factors (Cervantes, 2020).

4.2 Challenges Experienced by Instructors

The challenges experienced by maritime instructors fall into the following themes: Personal Readiness, ICT Background, Virtual Classroom Management, and Technological Infrastructure.

Personal Readiness

Instructors experienced physical and mental fatigue caused by their multiple roles in delivering online instruction. They also struggled to find time to develop e-learning materials, meet high expectations, and cope with serious personal and financial issues resulting from the implementation of lockdowns and quarantines.

ICT Background

Thirty-two percent of the respondents admitted having weak ICT skills and moderate skills in using the LMS. The older instructors were unfamiliar with online applications for teaching until the pandemic happened and were compelled to learn them overnight. The data revealed that most teachers used online teaching for the first time and have difficulty using the online tools and technology.

Virtual Classroom Management

Students have participated poorly in online class interactions. Most of them turn off their cameras due to poor internet connection that instructors found it hard to monitor their learning. Due to connectivity issues, synchronous virtual classes are held during the first hour, with the rest spent for asynchronous activities. Other challenges were irregular student attendance, unreliable assessment results, and pressure in answering students' queries.

According to Arkorful and Abaidoo (2015), since assessments are carried online, the physical absence of the instructors makes it impossible to control cheating, which affects the credibility of the assessment results. Since students could only work at their own pace, the instructors are overwhelmed responding to their concerns and providing immediate feedback. For instructors handling several classes with close to 40 students each, the pressure could take a toll on their physical and mental state.

Technological Infrastructure

Unstable internet connectivity and inadequate technical support are common problems among instructors. The need for METIs to upgrade their IT infrastructure to facilitate online learning was identified. According to Adedoyin and Soykan (2020), inadequate IT infrastructure and broadband access may negatively impact the instructors' productivity and efficiency.

The Philippines' internet speed improved by 262.70% in 2020, yet it still lags behind its regional peers. As of October 2020, the Philippines ranked 32nd in Asia in terms of broadband speed and 34th in mobile internet speed out of 50 countries in the continent (Domingo, 2020). With online learning as the new norm, the government should prioritize improving the internet infrastructure across the country. Universities also need to train teachers to enhance their online teaching skills to deliver lessons more effectively (Chung et al., 2020).

4.3 Challenges Faced by METIs in the Implementation of Remote Instruction

When COVID-19 became a pandemic, METIs in the Philippines have been pressed to adhere to the orders and guidelines from governing and regulating bodies like the Commission on Higher Education (CHED), Department of Labor and Employment (DOLE), Department of Education (DepEd), and the Inter-Agency Task Force (IATF).

It is on the financial aspect of the operations that the METIs were hit the most. IT infrastructure had to be established and upgraded by subscribing to better bandwidth, creating a multimedia studio, subscription to learning management software, teleconferencing applications, and online library resources. A robust IT infrastructure facilitates better online instruction, improves student outcomes, and reduces dropout rates (Teixeira et al., 2017). This study showed that a significant portion of the budget was spent to capacitate the instructors through a series of training in online instruction, designing e-learning modules, and using the LMS and telecon apps. Moreover, laptops, headsets, and cellphone loads were purchased to support the online delivery of instruction. To adhere to health protocol requirements, the schools purchased thermal scanners, disinfectants, PPEs, construct an isolation room, and install plastic barriers in offices. Substitute instructors had to be assigned for those who were quarantined. The low enrolment turnout due to the pandemic had affected the institutions' financial resources; hence, some schools imposed a cutdown on salary ranging from 80 to 50 percent to sustain operations, while other schools implemented a "no work, no pay" policy.

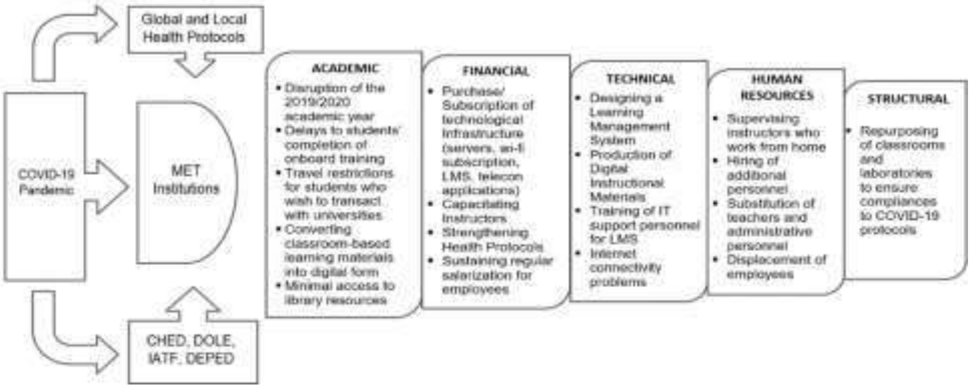

Figure 1. *Thematic Presentation of the Challenges on METI's Operations and Resources*

4.4 Initiatives Done by METIs to Cope with the Situation and to Address the Challenges

Administrative decisions gave much weight to strategic initiatives that address the paradigm shift in education. Figure 2 shows the initiatives taken by METIs to address the challenges of the new normal.

ACADEMICS	FINANCIAL	HUMAN RESOURCE	TECHNICAL	STRUCTURAL
• Adjusted planned schedules and academic calendar • Reduced class sizes to ensure that the academic schedule can be completed as planned and required • Been flexible to any changes in schedules as may be requested by shipping companies • Implemented online//blended approaches and strategies • Revised the curriculum by offering lecture courses first and the laboratory courses next, as soon as controlled FTF classes are allowed by DEPED and CHED • Conducted innovative online activities and games to combat the students' boredom	• Minimized person to person contact by subscribing to various payment avenues for students (banks and remittance centers) • Prepared a business-learning continuity plan that covered the various levels of community quarantine	• Conducted briefings to employees for info and instructions • Provided workshops on alternative instructional methods and approaches • Fast-tracked the training of faculty on the use of LMS • Minimized inter-office mobility of personnel through various undertakings (no face-to-face meetings, use of GC, sending memos in e-copy • Conducted webinars on mental health and stress management for students and employees	• Improved internet connectivity by increasing bandwidth subscription • Installed remote access software so that the simulators can be accessed by the students remotely	• Implemented covid-19 protocols as mandated by DOLE, IATF, CHED, DEPED, and LGU

Figure 2. *Initiatives Taken by METIs in Addressing the Challenges of the New Normal*

4.5 Future Directions for METIs

According to the CHED Chair, Prospero de Vera III, the commission has acknowledged that flexible learning will continue in the school year 2021 and after that. Hence, schools are given the freedom to choose what mode would be effective for them ---online, modular, or blended. He added that flexible learning would be the norm, and there is no going back to the traditional full-packed face-to-face classrooms (Magsambol, 2021). In a structured interview, five selected administrative officers of METIs were asked, "What future directions should maritime institutions be preparing for to efficiently deliver maritime education and training to students while ensuring that they still meet the expected competencies as required?" Maritime institutions have channeled their priorities towards the directions shown in Figure 3 for the years ahead.

Figure 3. *Future Directions for METIs*

Strengthening IT/Technological Infrastructure

The pandemic has exposed the digital connectivity divide. METIs need to ensure affordable internet connectivity to advance learning for all. Improving IT infrastructure is crucial as it positively impacts e-learning systems (Obeng & Coleman, 2020). Enhancing the IT skills of instructors and students, protecting students' right to information, data privacy and protection, familiarity with teleconferencing and remote access software, subscribing to a more robust bandwidth and faster internet speed, and providing e-learning support to instructors during online classes must be considered along this line.

Capitalizing on IT and Research and Development

METIs should invest more in online educational platforms, online library resources, and audio-visual materials accessible to students online or offline. Schools should capitalize on research and development initiatives to encourage technological innovations and address the demand for digital transformation (Iivari et al., 2020). This digital transformation should be part of the strategic plan of METIs, with initiatives focused on people and empowered by technology.

Academic Calibration for a More Relevant and Responsive Maritime Education and Training

Academic calibration is a process of reviewing or revisiting existing academic practices to compare outcomes, maintain and improve educational standards, and promote discussion on good practice in learning and teaching (Rathore, 2019). METIs must reassess their current academic orientations to ensure that they are relevant and responsive to the needs of the times. This calibration may focus on deciding on the best mode of delivery for each subject. Each modality would require a different set of teaching methods and strategies that will redefine the role of teachers. METIs should explore virtual classrooms and simulation, designing digital instructional materials, online tutoring, establishing a reliable grading system, and online feedback mechanisms for assessments.

Advancing Instructors' Technical Capacities and Strengthening Parental Engagement

Rubach and Lazarides (2021) identified six dimensions of basic ICT competence beliefs: information and data literacy, communication and collaboration, digital content creation, safety, and security, problem-solving, and analyzing and reflecting. From this premise, it is essential to advance the instructors' technical capabilities on (1) using various gadgets as instructional delivery tools, (2) discerning what information can be utilized to supplement the topic contents, (3) collaborating with peers in designing and creating digital learning materials, (4) adhering to ethical practices in borrowing learning materials from other sources, (5) ensuring data privacy and respecting intellectual properties, and (6) finding ways to enhance the delivery of instruction using various modalities.

More than half a billion children (Cohen & Kupferschmidt, 2020) have been forced to become virtual-school learners as they shelter in their homes, while family members have taken on the new role of learning facilitators, pseudo-teachers, and coaches. MET leaders have also affirmed the important roles of parents in the holistic development of students in the remote delivery of instruction where the instructors' presence is only virtual. Parental support is crucial in providing students with gadgets to stay connected in their virtual classes. METIs are also realistic when they say that laptops may eventually be required for every student to accommodate the learning materials that will be difficult to view and access on mobile phones.

Building Wider Alliances and External Partnerships

Collaborations between METIs must be strengthened for sharing of resources, best practices, and benchmarking. It may be beneficial to create a committee of researchers at the national and regional level who will be tasked to discuss the common problems, develop intellectual machinery through collaborations, and work on projects intended at improving maritime education and training during the pandemic and for a similar future scenario.

According to Glenn Blackwood, Head of the Policy and Planning Committee of the IAMU, Maritime universities need to maintain a close relationship with the global shipping industry to address the impacts of the COVID-19 pandemic (*Report of ICS IAMU Virtual Dialogue, September 2020*). In the same report, Mr. Tjitso Westra, Chair of ICS Manning and Training Sub-Committee, pointed out that shipowners and operators must pursue a close relationship with MET institutions for a comprehensive revision of the STCW Convention and Code.

5. CONCLUSIONS

The implementation of remote learning during the COVID-19 pandemic has affected

METIs, the instructors, and the students in the Philippines. Most of the challenges experienced during the transition from in-class to remote mode of instruction stemmed from the "far-from-advanced" technological resources, the difficulty in coping with the impact of the sudden shift on METIs' operations, and the change in the instructors' and the students' usual academic routines, impacting their physical, mental, and emotional state. Institutional initiatives have focused on implementing the needed transitions in the academic, financial, human resources, and technical operations to cope with the current situation. Future directions in MET are set on Strengthening IT/Technological Infrastructure, Capitalizing on IT and Research and Development, Academic Calibration for a More Relevant and Responsive Maritime Education and Training, Advancing Instructors' Technical Capacities and Strengthening Parental Engagement, and Building Wider Alliances and External Partnerships.

6. RECOMMENDATIONS

Given the findings, the IAMU may consider future collaborative research projects on developing e-learning materials that IAMU member universities may utilize for free. These materials can be used in virtual classes to augment instruction. Collaboration among peers may also be encouraged in designing learning strategies and materials tailored for hybrid instruction. Strong coordination between the administration, instructors, students, and parents must be established to promote a robust support system. Alternative solutions for students who do not have access to technology must be allowed to lessen the academic divide between those who can and cannot afford it. Extra-curricular programs and activities may be initiated to alleviate fatigue resulting from academic isolation and other difficulties due to the pandemic. A global network for learning may be created by inviting a pool of experts from IAMU member universities or tapping the alumni, industry partners, and the government sector to share information, updates, and current issues in the maritime industry. Lastly, MHEIs should review the entire academic system by revisiting the curriculum, course contents, pedagogy, grading system, and assessment instruments and align them in the context of remote education.

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THE COVID-19 PANDEMIC AND ITS IMPACT ON THE MARITIME SECTOR IN CROATIA AND THE WORLD

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Abstract

The mere fact that more than 90% of global trade is performed by maritime shipping confirms the importance of the maritime industry in the world. During the current Covid-19 pandemic, seafarers still face the risk and mobility obstacles that pose a threat to their existence, and consequently to their physical and mental health. The well-functioning seaborne trade is extremely important for the internal and international markets as it enables delivery of goods worldwide.

However, many seafarers on board cargo vessels sailing across European waters are the third country nationals. Regardless of their citizenship, they should be able to easily travel to ports of embarkation/disembarkation and to return home because this, in addition to other effects, would contribute to mid-term and long-term efficiency of the maritime industry.

In Croatia, there are approximately 20,000 seafarers, 15,184 of whom take part in international and the rest in national navigation. According to the Croatian Ministry of Maritime Affairs, Transport and Infrastructure, the estimated number of seafarers (20,000) makes up merely 0.47% of the total population (4,290,612 according to the 2011 Census), which means that four or five out of a thousand people in Croatia are seafarers. Seafarers make up the same share (0.47%) of the general population in the Philippines, which is considered to be “the land of seafarers”.

The absolute number of Croatian seafarers is not large, but when compared to the population of the country it can be noted that Croatia is one of the countries with the highest incidence of seafaring profession worldwide.

In addition to seafaring, tourism also has an important share in Croatia's GDP, which includes cruise tourism, a branch closely related to the maritime sector.

Both branches of the economy have been heavily hit by the current Covid-19 pandemic. Repatriation and embarkation have become more difficult due to the pandemic. As a result, seafarers remain stuck on board for months following their contract expiry, awaiting possible return home, which is a serious threat to their mental and physical health.

A partial solution to these problems lies in awarding seafarers the key/priority worker status and in implementing priority seafarer vaccination against Covid-19 at the global level.

Key words: seafaring, Covid-19 pandemic, crisis, seaborne trade

Introduction

Maritime transport is amongst the most important modes of shipping worldwide. It has been around for centuries, helping humans to meet their travelling and business needs and requirements. Despite the invention of new modes of transport, maritime transport has not lost its importance. It underpins the global supply chain linkages and economic interdependency with seaborne shipping and ports estimated to handle over 80 per cent of the global merchandise trade by volume and more than 70 per cent by value.

Maritime transport is also a great medium in tourism and can play a crucial role in the development of an economy. Various countries around the globe generate large revenues from tourism via maritime transport. Due to the importance of maritime transport, the associated tourism industry can be considered as a sustainable source of income.

According to the BIMCO manpower report, the global supply of seafarers in 2015 was estimated at 1,647,500 seafarers, of which 774,000 were officers and 873,500 were other crew members [1].

The outbreak of Covid-19 started at the end of 2019 and has, so far, had a devastating impact worldwide, sparing no country. The pandemic, a twenty-first-century global calamity, has been a true reflection of the global economy and global village we live in. It resulted in the shutdown of the world, which lasted for months, with 142,238,073 confirmed cases, 3,032,124 confirmed deaths, and 223 countries, areas or territories reporting positive cases as of 21st April 2021 [2].

The respiratory disease Covid-19 is caused by the new coronavirus, named SARS-CoV-2. The virus was first reported in China at the end of 2019. Since then, it has spread to 224 countries. In 80% of people, Covid-19 is not a severe disease and no hospital treatment is necessary. About 15% of those infected require oxygen and hospital care and additional 5% need intensive care. While people over 60 years of age and/or those with underlying medical conditions are at a higher risk of developing serious illness and requiring additional care, numerous research studies and reports have proved that severe illness can develop in people of any age [3].

Since lockdown measures imposed by countries around the world are still in place, the organisation of crew change is always challenging and often impossible. Despite the UN General Assembly Resolution adopted in December 2020, recognising seafarers as key workers and aiming at facilitating their safe and unhindered movement for embarkation and disembarkation, there are still some seafarers holding Croatian certificates and documents that are due to expire at some point, who are embarked on board vessels with no possibility to organize crew change and their repatriation [4,5].

The impact of COVID 19 pandemic on the global economy and maritime industry

Global shipping relies on about 1,600,000 seafarers worldwide, who make it possible for the clients across the world to receive the goods and products needed for business operations and everyday life [1].

The first half of 2020 was marked by widespread lockdowns, travel restrictions, fast-rising unemployment, government rescue packages and oil and stock market crashes. The second half of the year remained highly uncertain but there was the consensus for full year gross domestic product single digit decline, and expectations for a muted recovery as lockdowns started to be lifted. The performance in 2021 depends on the ability to contain the outbreak, development of the efficient vaccines, the effectiveness of various stimulus packages, the impact on consumer habits, as well as on the government debt-tackling policies [3].

Repatriation and embarkation have become more difficult due to the pandemic. As a result, seafarers remain stuck on board for months following their contract expiry, awaiting possible return home, which is a serious threat to their mental and physical health.

Before the Covid-19 pandemic started, the demand for cruising worldwide increased from 1.8 million passengers in 1980 to 26.75 million in 2017, at an annual growth rate of 7.5%, while the annual growth rate for the land-based tourism was 4.9% over the same (1980-2017) period [4].

Considering the global character of cruising tourism, many organisations and corporations have united in their fight against communicable diseases on cruise ships. Drops in the number of ship calls varied among the different country groupings and economies. This decline also varied with the ship type.

Passenger ships have been affected the most. The nature of the Covid-19 pandemic, the consequent lockdowns in several countries and cities and the reduction in travel, are the major factors behind the temporary suspension of coastal shipping services in many countries. At the same time, cruise shipping ceased operations worldwide. Since April, one in three passenger ship calls was cancelled. As a result, at the end of the second quarter of 2020, the total number of global passenger ship calls were 17 per cent lower than the year before.

The Covid-19 Economic impact barometer that has been developed by the International Association of Ports and Harbors (IAPH) reveals that, at the global level and since Week 12 of 2020, about 45 per cent of the ports faced a drop of more than 5 per cent in the number of container ship calls compared to the situation under normal operating conditions.

Some of the maritime and shipping industry's problems include border restrictions for airlines and port shutdowns, reduced demand for freight, disputes in laytime arbitration, disputes between owners and charterers of such vessels due to lack of time and resources, bankruptcy due to reduced demand and the failure to control the company's finances during this era of decreased demand for shipping and freight [4].

Seafarers and mental health during COVID 19 pandemic

The maritime industry depends heavily on seafarers, i.e. the human resources in shipping. The Covid-19 crisis has posed many challenges to seafarers on board, who now have to extend their contracts because of crew change issues, as well as to those at home, who cannot join their vessels and cope with financial difficulties. Seafarers onboard ships are not only worried about their own health but also about the health of their families and friends back home [6].

A recently published survey about seafarers' experience during the Covid-19 pandemic showed that more than 40% of the participants had experienced symptoms of depression and more than 50% of them reported symptoms of anxiety. Mental health, not only of seafarers but also in general, is now in the spotlight more than ever before.

Situation in Croatia

In Croatia, there are approximately 20,000 seafarers, 15,184 of whom take part in international and the rest in national navigation. According to the Croatian Ministry of Maritime Affairs, Transport and Infrastructure, the estimated number of seafarers (20,000) makes up merely 0.47% of the total population (4,290,612 according to the 2011 Census), which means that four or five out of a thousand people in Croatia are seafarers. Seafarers make up the same share (0.47%) of the general population in the Philippines, which is considered as “the land of seafarers”.

From January to December 2020, there were 48.7 million passengers transported, which is a 42.1% decrease compared to the same period in 2019. Annual data reports reveal that a drop in passenger transport was experienced in all modes of transportation: 33.9% in railway transportation, 44.2% in road liner transportation, 42.1% in deep-sea and coastal navigation, and 70.3% in airline traffic [7].

Since lockdown measures imposed by countries around the world are still in place, the organisation of crew change is always challenging and often impossible. Despite the UN General Assembly Resolution adopted in December 2020, recognising seafarers as key workers and aiming at facilitating their safe and unhindered movement for embarkation and disembarkation, there are still a number of seafarers holding Croatian certificates and documents that are due to expire at some point, who are embarked on board vessels with no possibility to organize crew change and their repatriation [5].

In addition to maritime shipping industry, one of the important items in Croatia’s GDP is tourism. Before the 2019 pandemic, Croatia saw a steady increase in the arrivals and stays of foreign and local tourists for five years in a row. In 2018, there were 89.7 million overnight stays, which was 4% more than the year before. The share of tourism sector in the national GDP amounted to 11.4% in 2016 [7]. However, the share of tourism in GDP considerably fell in 2020 due to the pandemic, revealing a number of shortcomings in tourism trends and in heavy reliance of the national GDP on tourism industry. Expectedly, the least affected tourism branch in Croatia was nautical tourism (due to highest epidemiological safety). Obviously, epidemiologic measures, such as social distancing, are much easier introduced in boating than in cruise shipping industry [8]. It is expected that the tourism industry would grow again 2021, as a result of national and international vaccination programs, lifting of travel restrictions and opening of borders.

Health protection and the role of World Health Organization in Covid-19 pandemic

The World Health Organization (WHO) was established in 1948 as the successor to a century-long legacy of international health cooperation. Created as a coordinating authority on international health work, the WHO enjoys an expansive constitutional mandate and far-reaching powers under international law. As a multilateral agency, the WHO is unique among stakeholders in global health in that it wields the authority to promulgate both binding as well as non-binding agreements. The International Health Regulations (IHR) serve as a particularly noteworthy example of a binding agreement made by the WHO, and have presently been accepted by 196 member countries. The IHR specify the process by which the WHO may formally declare a Public Health Emergency of International Concern (PHEIC). This agreement played a crucial role in directing the WHO’s initial response to the Covid-19 outbreak. Under the IHR, member countries are required to report potential PHEICs occurring in their territories within 24 hours following initial detection. Even though the WHO’s response to the pandemic has fallen short of perfection, the agency has at all times played a necessary and vital role in the battle against the Covid-19 pandemic [9].

Implementation of the anti-epidemic measures in Croatia

As a member of the European Union and the World Health Organization, Croatia has to comply with the guidelines of these institutions. On the 31st of January 2020, the Ministry of Health of the Republic of Croatia established the Civil Protection Headquarters [10] with the purpose of managing and restraining the epidemic of Covid-19 in Croatia. The decision was founded on the *Law on the protection of the population from infectious diseases*, which has been legally in effect for a long time. The Law defines the measures for addressing the epidemic occurrences and outbreaks, which may considerably reduce the freedom and rights of the citizens. The institution in charge of implementing anti-epidemic measures in Croatia is the Croatian Institute of Public Health [11].

From the epidemiological standpoint, these measures are necessary to combat the epidemic and save human lives. For example, this has been clearly effective in Australia and New Zealand. These two countries implemented strict epidemiological measures and managed the crises efficiently. Meanwhile, both countries launched the immunisation process that has ensured the continuity of the good epidemiological situation [2].

No doubt, the most efficient preventative measure against an epidemic is vaccination. In Croatia, the administration of vaccines against Covid-19 started at the end of 2020. After initial problems related to insufficient and irregular vaccine supply over the first quarter of 2021, the mass vaccination started. According to the national register of the vaccinated population (e-Cijepih), 20.9% of Croatia's adults received at least one dose of vaccine against Covid-19 by 30th April 2021 [11]. Seafarers and tourism personnel have been vaccinated, in an organised way, since the end of April / beginning of May 2021.

Preventative and anti-epidemic measures on board ships

Crew members on board should be educated and be familiar with the symptoms of Covid-19 and how to report them to the master. If someone is confirmed as positive or suspect case of Covid-19 on board – there are a few isolation precautions to be followed:

- Single occupancy rooms with private bathrooms, with door closed;
- Persons should wear a face mask anytime they are outside of isolation;
- No direct contact with other persons except for the designated caregivers;
- Caregivers should wear proper personal protective equipment (PPE) and ship companies should always provide adequate PPE. [3,4]

General preventative measures such as physical distancing, washing hands with soap and water or the use of hand sanitiser, good respiratory hygiene, and mask wearing remain the main methods to prevent spreading of Covid-19. The seafarers should resume these practices once vaccinated.

It is very important to preserve mental health. The affected individuals are recommended to talk to people they can trust. Those who are on board are advised to talk to their colleagues and mates, and to contact their friends and family through phone, email and social media. The seafarers are also advised to maintain a healthy lifestyle – including proper diet, sleep, exercise and social contacts with other crew members. It is recommended to not use smoking, alcohol or other drugs to manage emotions.

What next?

The current Covid-19 pandemic situation is changing on a daily basis. The humanity has faced a pandemic of huge proportions. The virus has been constantly mutating, the researchers gain new insights into the nature and dissemination of the virus and its variants, there is a global battle going on against the virus and for the implementation of epidemiologic measures and immunisation. There are many facts yet to be known. Although every country is specific in terms of its administration, demographic, economic, social and geographic features, it has been become clear that the virus SARS-CoV-2 easily passes through all borders and barriers [3,4,12]. This means that the counter-pandemic efforts have to be coordinated at global level, while some of the specific anti-epidemic measures may be designed and introduced locally. This is the current strategy in Croatia as well.

Depending on the type and the way the disease is transmitted, national and international public health authorities may have a range of various preventative and anti-epidemic measures.

It is the irrefutable fact that vaccination is the most efficient preventative measure. Vaccination is a safe, simple and effective way to protect people from a disease before actual exposure to it. A vaccine stimulates the immune system to produce antibodies and other cells that fight the disease, just as if person has been exposed to the disease itself. Many Covid-19 vaccines, authorised for use in different countries, have been reported to be more than 50% and often over 90% efficient in preventing the disease in the vaccinated population. In some cases, the efficacy data have not yet been published. However, all viruses, including SARS-CoV-2, change over time resulting in the emergence of new variants. These variations may cause reduced vaccine efficacy and further complicate the existing situation [2,8].

Research studies show that people who have had Covid-19 may be infected again, and that the immunity after clinical disease may not protect a person against new mutations. Protection gained through vaccination is likely to be broader and people can be vaccinated shortly after recovery from the disease. No testing is necessary. However, due to the limited supply of vaccines, vaccination campaigns may be deferred for a number of months or the vaccination program may be modified [6].

Although Croatia is a country with a strong maritime tradition, the treatment of seafarers as the priority or key population was delayed. Their vaccination started in late April 2021, together with the vaccination of tourism personnel. Unfortunately, in this general turmoil about the pandemic, this category of workforce was not recognised as essential. Due to delayed vaccination, the seafarers experienced a number of administrative hurdles – when joining the ship or when coming back home. Due to restrictions and complications in airline traffic and other modes of transportation, the repatriation of seafarers was difficult, often resulting in the prolonged stay on board. This problem was experienced globally [13,14].

Conclusion

At this moment, the pandemic Covid-19, caused by the virus SARS-Cov-2, continues to present the most serious global public health and safety threat. Almost all countries have re-directed huge resources with the purpose of restraining the pandemic, while trying to preserve their economies.

Future development of the pandemic situation is uncertain and it is hard to anticipate the end of the Covid-19 pandemic. Time and science will provide information and answers to many questions and aspects that are currently unclear. At any rate, according to the available knowledge, insights, research results, references and experience, it is not expected that the causative agent of the Covid-19 disease will be eliminated soon. This is, partly, owing to the fact that animals and RNA as genetic material are involved in the virus life cycle, which results in a highly pronounced ability of mutation, as it can be currently experienced around the world (emergence of UK, South African, Brazilian and other variants). It will probably take a lot of time until the fight against this dangerous disease is over. Meanwhile, humans will have to find ways to resume their life, recover their economies, travel and navigate. It is expected that, in the near future, the Covid-19 will greatly affect the seaborne trade and cruise ship industry, with adverse impacts on the world trade and tourism.

This pandemic has, once again, confirmed that vaccination is the most efficient preventative measure. Increased immunisation of the general population is expected to result in lower rates of infection, hospitalisation and death. When planning and launching the vaccination campaign, it is necessary to define priorities and critical populations: along with the caregivers, chronic patients, old people and other vulnerable groups, seafaring and tourism workforce should be considered as the essential target, owing to their specific professions.

This pandemic has confirmed the importance of the World Health Organisation as the key, global, public health authority that issues relevant documents such as the International Health Regulations referring to the international transport of passengers and commodities.

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THE EFFECT OF COVID-19 ON COASTAL SHIPPING IN MEDITERRANEAN AND BLACK SEA

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Abstract

The aim of this study is to analyze the effect of the COVID-19 pandemic on coastal shipping in the Mediterranean and Black Sea with emphasis on short sea bulk and general cargoes. Semi-structured interviews were with shipowners, and shipbrokers to enhance the qualitiative methodology and to gather more detailed responses. The result of the study shows that in the first quarter of 2020 shipowners and charterers signficantly reduced sailing with some ceasing operations altogether, due to the efect of COVID – 19. Trade stopped, factories shut down, ports slowed down and yet port congestion still occured. Shipyards and scrapyards also faced similar reduction in operations. Freight rates declined to new record lows (for a brief period of time) causing some shipowners to lay-up vessels. Crew change problems were faced and still continuing creatign more disruption in managing the human element of the maritime industry. By the third-quarter of 2020, as demand for raw materials and finished good inventories increased, so did the demand for charters. Fortunately for charterers, the increase in demand also caused an increase in freight rates.

Key words: COVID-19, Coastal shipping, Mediterranean, Black Sea

1. Introduction

The COVID-19 pandemic has wounded the world economy with serious consequences impacting all communities and individuals [1]. In many ways, the pandemic will continue to change our lives in the future. In the first quarter of 2020, the world entered one of the deepest economic crises ever recorded due to Covid -19. UNCTAD reported that since the outbreak of the coronavirus disease, globally, more than 1 million people lost their lives due to the pandemic, and the global economy has contracted by a staggering 4.3 percent in 2020 for the first time since 2008. Millions of jobs were lost, millions of livelihoods are at risk, and an estimated additional 130 million people will be living in extreme poverty if the crisis persists [2]. The contruction of production and consumption due to the spread of COVID-19 [3] affected the entire shipping industry [4]. Passenger sea transport in particular has suffered heavy setbacks in volumes. Ferry services and cruise ships were strongly affected by border closures, cancelations of voyages, and complete ban. Cargo sea transport also faced reduced demand. Container shipping in particular managed to compensate by withdrawing ship capacity to manage the supply while strong consumer demand help the lines to increase prices [5]. While the literature has focused on the effect of COVID-19 on crew, scrapyards and different type of ships, The focus of this study was to investigate the effects of COVID-19 on coastal shipping with emphasis on short sea bulk and general cargoes. Coastal ships are composed of bulk carrier and general cargo ships whose dwt capacity between 2,000 to 10,000 tons. While the size of such vessels operate throughout the world, the focus of this study will be on sailing between the Black Sea and the Mediterranean. The results of this research are important both for practitioners of the industry as well as academics, as it will provide a perspective how coastal shipping markets may react during periods of crisis such as a pandemic. Effects of the results may direct decsision makers how the industry and markets may react during a crisis thereby providing data to assist operations.

The remainder of this paper is organized as follows: Section 2 provides a critical review of the literature on the issue; Section 3 described the methodology and data used; Section 4 concludes on the findings.

2.Literature Review

The literature on the issue of the effects of COVID-19 on different industries is extensive. However, studies related to the effect of COVID-19 on shipping is rather limited. Studies focused particularly on coastal shipping does not exist. In the literature, Nektarious and Melas (2020) examined the the impact of exogenous effects in the shipping industry by employing data from the recent COVID-19 pandemic outbreak and explored the reactions of freight rates for dry bulk, clean, and dirty tankers [6]. Akcacı and Cınarlıoglu (2020) analyzed the effect of the COVID – 19 outbreak on logistics and trade [7]. The Ministry of Transportation and Understructure of Turkey (2020) analyzed the effect of COVID-19 on the effect of the transportation [8]. Notteboom et al. (2021) investigated the temporal and spatial sequences of the supply and demand shocks of COVID-19 on container ports and the container shipping industry by comparing these events to the 2008–2009 financial crisis [9]. Verschuur et al. (2021) analyzed the implementation of large-scale containment measures taken by governments to contain the spread of the COVID-19 virus which has resulted in large impacts to the global economy by using shipping data [10]. Battineni et al. (2021) assessed the awareness and knowledge of seafarers towards the mandatory infection control measures adopted by shipping companies [11]. Yong – Feng et al. (2020) discussed the the transmission mechanism and visual impact of shipping and industry under epidemic condition [12]. Chowdhry et al. (2020) examined the effects of the COVID19 pandemic on international trade and shipping [13]. Arifin (2020) analyzed the impacts of COVID -19 on the maritime industry in Indonesia [14]. March et al. (2021) examined that human activity in the ocean have been radically altered by the COVID-19 pandemic, with reports of port restrictions and changes in consumption patterns impacting multiple maritime sectors, most notably fisheries, passenger ferries and cruise ships [15]. Curovic et al (2021) have studied the Impact of COVID-19 on environmental noise emitted from the port [16]. Rahman et al (2021) analyzed the impact of COVID-19 on ship recycling [17]. Wang et al. (2020) identify the risks of COVID-19 imported by ocean going vessels based on AIS and Infection data [18]. Ventouri (2021) determined that the rapid spread of COVID-19 renders information uncertainty a daunting challenge for shipping companies engaged in global trade [19]. Praharsi et al (2020) addresses that by applying the concepts of Lean-Six Sigma and supply chain resilience, the most suitable continuous improvement method for the maritime industry is developed to maintain a resilient supply chain during COVID-19 [20]. As described earlier in the literature review, several studies have been conducted on the effects of COVID-19 in various aspects in maritime transportation. However, studies focused on the effects of a global crisis on coastal shipping do not exist. As such, the purpose of this study is to close this gap in the maritime transportation literature.

3. Methodology

This study employs a qualitative research in an attampt to explore the Effect of COVID-19 on Coastal Shipping in Mediterranean and Black Sea. Using a qualitative approach provided a deeper insight regarding the issue through responses gathered from those interviewed. In this study, a semistructured interview method was used to provide reliable qualitative data.

3.1. Data Collection

A literature review to explore the Effect of COVID-19 on Shipping has been conducted to compile prompt questions for semi-structured interviews. In addition to the questions regarding the profile of the participants and companies, an interview instrument was created by the authors.

In this study, the same questions were asked to the participants and interviews were conducted either by telephone or a questionnaire was sent to the participants by e-mail. Three telephone and 7 e-mail interviews were conducted and responses were received during April and May 2020 from 7 shipowning, 2 shipbroking, and 1 maritime research company in Turkey (See Table 1 and Table 2 for particiapant and interview details). Participants were recruited by purposive sampling methods. All participants were asked if they were willing to paticipate in a research study and notified of the purpose of the study was publication. Respondents also had the option to not be interviewed and were provided the opportunity to submit anoynmous responses. The study was explained and an oral informed consent was obtained.

During phone interviews, the interviewer transcribed the respondent's responses. In interviews, when the number of interviews reached 10 (7 e-mails and 3 phones), it was reached theoretical saturation which is the point where no new insights are gained and the interwiews were stopped.

Table 1. Profile of Companies and Participants

Type of Firm	Title / Position of participant	Interviewee Code	Age of Participant	Sector Experience of Participant (Years)	Education of Participant
Ship owning	Chartering Manager	A1	47	25	University
Ship owning	Chartering Manager	A2	40	20	University
Ship owning	Operation Manager	A3	40	20	University
Ship owning	Chartering Manager	A4	50	27	University
Ship owning	Chartering Manager	A5	50	27	University
Ship owning	Ship owner	A6	45	23	University
Ship owning	Chartering Manager	A7	44	22	University

Maritime Research	Head researcher	A8	40	21	University
Ship broking	Owner/founder	A9	41	20	University
Ship broking	Owner/founder	A10	41	20	University

Table 2. Details of Interviews

Interviewee Code	**Place of Interview**	**Voice Recording or taking note**
A1	On Phone	Taking note
A2	By e-mail	
A 3	By e-mail	
A4	By e-mail	
A5	By e-mail	
A6	By e-mail	
A7	By e-mail	
A8	By e-mail	
A9	On Phone	Taking note
A10	On Phone	Taking note

In this study, the data collected from the interviews was categorized according to the questions asked to the interviewees. The data collected from respondents was categorized under 13 questions. Findings of the study are presented in the form of relevant quotations from the interviews.

4. Findings

Based on the questions discussed with the participants, the following points have been revealed. The results of the study have been classified according to key findings.

The effect of COVID-19 on the Mediterranean and Black Sea Trade

Before COVID-19 was declared as a pandemic, there was no decrease in the amount of trade. However, after the declaration of pandemic by the World Health Organization, especially between March and September 2020, with the loss of life and the start of closures, production and global trade slowed. Trade came to a standstill, great decreases occured in the freightmarket and almost all of the ships had to wait for cargo and even shipowners, who had the opportunity, went to a short – term lay up solution. However, in September 2020, with the intense demand for raw materials and food, a high trade volume continued and the demand for transportation to meet this high trade volume emerged.

The effect of COVID-19 on shipping markets

In freight market, freight rates declined to new record lows between March and September 2020. However, by the third-quarter of 2020, as demand for raw materials and finished good inventories increased, so did the demand for charters. Fortunately for charterers, the increase in demand also caused an increase in freight rates. In the forth quarter, ISTFIX coaster freight Index based in Istabul reached a historic 748 points with the high seasonal cargo demand, The demand for vessels continued in early first-quarter 2021, with the index point of 662 exceeding 2019 vessel rates.

In the first two quarters of the pandemic, shipyards and scrapyards faced reduction in their operations. Scrap ship purchases ceased altogether in India. After the second quarter, the Aliağa scrapyards in Turkey increased operations. In ship sale and purchase market, most shipowners decided not to sell vessels in order to take advantage of strong increase in freight price and volume. In order to maintain a positive cash-flow, some ship-owners were forced to sell vessels. However, the price of the sold vessels remained relatively stable.

Laying up vessels

Only one ship-owner laid up ships during the March-September 2020 period when freight rates were low. However, almost all of the ship-owners had to operate their ships under running cost in the first two quarters.

The effect of COVID-19 on ports

At first, a 14 day quarantine period was applied in many ports. The ships have not been berthed to the port of arrival within 14 days from the last port of departure.
Therefore, there were delays in some ports. Some slowdown occurred as a result of contractual labor hours in some ports. Yet after some negotiations with labor, in some ports, the density has decreased between 1 and 7 days. Currently, there are no congestion and slowdown at the ports under the study.

The effect of COVID-19 on cash flow

During the period when freight rates were low, some participants faced cash flow problems, but most of the ship-owners did not have a serious cash flow problem. Those who had cash flow problems met the problem through an equity sale.

Crew Changes

It was the seafarers who were most affected by COVID related restrictions. The exchange of seafarers could not be made in many countries. The seafarers had to remain on and continue to work even though their contracts had expired until the ships arrived in the ships home port.

Transformation of corporate operations

Almost all of the ship-owners have started to work remotely from home and they state that they have no difficulty in this situation. As a requirement of the job, employees in ship owning companies state that they adapt very quickly to the new order because they have used telephones and computers outside the company frequently. They stated that they will return to the office once conditions and health authorities allow. Some businesses still apply traditional methods and continue operations from the office. Those respondents were quick to emphasize that all safety precautions were followed in the office such as social distancing, requiring facemasks, emphasizing sanitary protocols, and encouraging employees to remain at home if feeling ill.

Remote working

Almost all businesses have started to work from home. Working in the office has been reduced to a minimum. Communications are mostly done on-line, telephone, What's Up, Skype, and e-mails. Documentation and filing work has decreased and has been digitized. Cloud technologies have started to be used, and increased.

Precautions taken to protect office employees

Necessary precautions were taken in all businesses and office workers were informed about the relevant regulations. Distances were set between the desks in the offices, and information was given on masks and hygiene. Guests and cargo employees were not allowed to enter the office. The temperatures of those who had to enter were taken. In some businesses, office workers were divided into two groups and rotated, and offices were disinfected weekly. However, with the appearance of COVID-19 in employees in some businesses, the works were completely taken home. In some businesses, one person in each department worked at office, while other employees continued to work from home. Some of the businesses receive weekly notifications from occupational safety experts.

COVID -19 and Ship Personnel

Maximum emphasis was given to the training of the ship's personnel throughout all organizations to learn new means of communicating with family. Virtual meeting platforms were provided to help mariners and their families in terms of motivation. While difficult to create the same level of personal connection to families, the objective was to maintain motivation. Even the frequency of communication with families was allowed. In some organizations, the ship's personnel were not permitted to leave ports and, their temperatures were measured very often. The agency and administrative personnel arriving on the ship were greeted with masks and hygiene suits. In some companies, ship personnel are motivated by various on-board social activities and salary increases.

Organizational and office structure

Businesses stated that their organizational structure has not changed, but their business conduct and tracking systems have changed. They stated that some businesses have moved their systems to cloud technology and working with a laptop and internet.

It was stated that generally no change was made in the office structure, only one business was moved to a larger office to be compliant with local health and safety protocols.

Laying - off office employees

Most organizations were able to avoid a reduction in workforce. However, some layoff's did occur in one organization. Still another firm reported that they increased office personnel during the crisis.

Conclusion

The purpose of this study is to analyze the impact of the COVID-19 pandemic on coastal shipping in Mediterranean and Black Sea. The study reveals that in the first two quarter in 2020, freight volume decreased to the lowest level. Many ship owners operated ships with lower margins and net loss. Some ship-owners even forced to lay up vessels. Although there were delays in the ports at the beginning, the congestion later disappeared, while returning due to an increase in global trade. There were significant disruption with crew changes. After the six-month period, trade increased with a strong demand for raw materials and food, and freight volume increased. At the outset of the pandemic, many ship-owners minimized the number of employees in the office and the staff learned to work remotely. Personnel adapted very easily to this new situation as they carry out their activities mostly over the internet and with their phones. Virtual meetings replaced face-to-face. The pandemic did necessitate the need for organizations to digitize their operations. In order to create any sort of semblance to normalcy, crews were taught how to use more technology on-board vessels in order to help more on-line talks were made with their families, and salary increases were made in some enterprises.

Overall, the study found that many changes occurred for maritime organizations to properly function during a pandemic. A significant portion of office work was conducted remotely and a virtual environment replaced the personal interactions from face-to-face meetings.

The effect of the pandemic on operations mentioned above was also found to be a limitation of this study. Accessing the appropriate participants to take part in the study continued to be challenge as many ship owners, were unavailable and unable to provide information. As such, managers of ships, ship brokers, and ship agents were relied on for much of the collected data.

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WHAT IS AFTER COVID-19? : CHANGING ECONOMIES OF THE SHIPPING INDUSTRIES AND MARITIME EDUCATION INSTITUTIONS

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Abstract

Most of the people in the world are struggling to ensure their presence and livelihood activities during this pandemic period. Achieving the third Sustainable Development Goal: “Ensure Healthy Lives and promote Well-being for all at all ages” since the end of 2019 is a big question mark to most of the economies. The first Case of Covid-19 was found in China during the mid of November 2019, still now there is no proper medicine and vaccine were found to cure fully. The vaccination availed after one year also not resulting 100% and the modern medicine there is no satisfactory effective therapy available to cure the Covid-19 infection due to the less genetic information regarding the mutation of this virus. World Health Organization suggested to implement Lock downs to handle this pandemic. Upto the end of first month of this decade more than 100 million people were infected and more than 2 million people were lost their lives. This pandemic severely affected most economic sectors of the world without any partiality. This attempt was made to analyze the impact of Covid-19 pandemic on the Maritime Education sector and Shipping Industry. For the study purpose detailed survey was conducted among the Maritime students, educators, sailors and practitioners in the different parts of the world. Collection of qualitative data for this study is quite difficult due to pandemic. So present study adopts descriptive cum analytical research design was adopted for the study. Totally 1094 respondents of the 16 countries were approached for the study purpose and received the responses from 857 respondents were responded to the survey and results were documented here to understand the future of the Maritime industry. The results of the study are interesting and highlighted the present mentality and economic status of mariners and future of the students. Mariners reported that they have less sailing opportunities compared to the past. Many of the respondents were worried that this economic slowdown due to pandemic had a huge impact on the industry is terms of less Liner schedules and reduced employment opportunities and poor practical exposure. Maritime Students highlighted that they were unable to get the practical exposures to meet out the challenges and virtual education system gave less chances to learn the practical aspects. Maritime educators pointed that less interaction between the students resulted in terms of adverse results. Meanwhile few of them responded that this pandemic helps them in terms of increased business growth in absence of Air Cargos. This study suggests that both public and private sector should take initiatives to meet out the challenges of this changes in the Maritime sector. Maritime Education institutions have to revise their mandatory policies to meet out the changing trends in education sector. It concludes that both positive and negative aspects of this pandemic resulted the tremendous changes in the Maritime sector hugely in reduced possibilities in the economies of the maritime business ventures. Further, this study suggests future researchers to carry out the segment specific both qualitative and analytical studies to handle the pandemic situation to effectively meet out the needs of the sector for the sustainability.

Keywords: Covid-19, Maritime Education, Mariners, Shipping industry.

Introduction

World Health Organization (WHO) officially announced the discovery of Coronavirus (SARS-Covid-2) on 9th January 2020. It was found in the unknown origin of the Wuhan, China during the 2019 December. Earlier the people were told that it's a viral pneumonia until the announcement made from the WHO. Initially people were not worried about the issue and many of them believe that this is the kind of marketing trick used by the medicine and medical equipment producers to increase the artificial demand and increase the price until it reached to their neighborhood. All the myths and believes were gone nothing in front of novel Covd-19. Without partiality it hits most of the places. In this situation no one told that they are having immunity, world power or medically sustainable. There is a two kind of news we have one is by the Chinese government says that this virus spread by the animals and the rest of the world says that this was created in the virology laboratory and that hits the many of the people in the world. World health Organization declared this as a pandemic on 11th March 2020 when 205 countries reported that they were found the infections among their people and later rest of the world. Later, many countries reported that 1000s of positive cases every day and few countries reported more than 100000 cases in every day. To avoid the critical condition World Health Organization (WHO) Suggested Lockdown in most of the countries. Lockdown due to pandemic is totally new to the modern world. Governments and public were not taken any precautionary or prefatory measures to handle the situation. Primary and health care sector alone permitted to function and control the pandemic situation and rest were muted their activities. According to UNESCO majority (89.4%) of the total enrolled students in the world were not able to attend their schools and higher education institutions in the 185 countries. This situation affected a lot to the Maritime Education sector, where, most of the courses were practical oriented. In this juncture the study on "What is after covid-19? : Changing economies of the shipping industries and maritime education institutions" will helps to picture about the realty of the maritime industry and education sector.

Literature Review

The survey conducted by International Association of universities in the title "The Impact of Covid-19 on Higher Education around the World" reported that majority (59%) of them were closed their education institution to reduce the effect of the pandemic. More than three fourth (80%) of them were reported that this lockdown cost huge in the enrolments in both local and international admissions. This survey highlighted that this pandemic converted the education system into the remote learning and students and teachers were encouraged to access the virtual and distance more of education which reduced the importance of learner/teacher centric approach of education system. According to UNCTAD findings responses to this pandemic varied from sector to sector, place to place, people to people and country to country in terms of operational adjustments, financial/economical adjustments, sanitary protocols and processes and adjustments to working practices and organizational aspects to handle the situation and overcome the issues and challenges and highlights that maritime trade will plunge by 4.1% in 2020. It revealed that the waves of pandemic further disturb the supply chain economies might cause a deeper decline. The study found that clear negative impact of COVID-19 related school and public transport closure cost huge (Verschuur J, Koks EE & Hall JW 2021). Literature shows that covid-19 pandemic affected the most of the economic sectors in the world. Hence the literature proves that there is an impact of Covid-19 pandemic on the maritime industry in all the aspects. This study tries to provide the empirical evidence on this impact.

Statement of the Problem

China is the one of the fast growing economy of the world and fostering multifold growth with their effective production process. They are contributing the most of the economies with their cheapest products. More than two third of the countries involving foreign trade were importing the goods from China. Most of the gadgets we are using recent past were manufactured or using the spare parts from the Chinese products until the third quarter of the 2019. By the end of 2019 most of the countries were closed their gates for China due to Covid-19 Pandemic. During the first quarter of 2020 countries were closed their gates for other countries and later in the beginning of second quarter entire world were imposed lock down due to this pandemic and this cost huge in terms of economic slowdown, medical emergencies and food scarcity. Due to closure of gates many of the countries were not able to function as usual. Due to less productivity of goods the shipping industry also facing the problem in terms of reduced liner schedules. Studies in the area of effect of covd-19 pandemic on the marine education and institutions are rather limited. Hence this study tries to find out the major impact of Covd-19 pandemic on the shipping industry to find out what is after Covid-19 pandemic to the pillars of the maritime industry such as maritime education, maritime sector and warehouses and other stakeholders by collecting information from maritime students, teachers, sailors and practitioners from various parts of the world.

Objectives of the Study

The following objectives were framed to fulfill the aim of the of the study are

- To study the impact of Covid-19 pandemic on maritime industry
- To understand the economic issues faced by the maritime industry
- To analyze the psychological issues and challenges faced by the people in maritime industry

- To suggest suitable measures to handle the pandemic situation by marine industry

Methodology of the Study

The design for the study is descriptive cum analytical in nature. It is the design which describes the different characteristics of the social phenomena under this there is no emphasis on the theory formation only the facts and character were gathered also it presents the view regard to predict future trends which finds out the relationship between the variables and further analyzing the phenomena with suitable statistical tools. According to this study maritime student, maritime educators, sailors, mariners and practitioners were employed as respondents to understand the current station. Totally 1094 samples from 16 countries were approached for the study purpose and 857 respondents were responded to the survey and results were documented here to understand the future of the Maritime industry. This study adopted purposive sampling used to collect the necessary information respondents. The researcher used a structured self prepared interview schedule for collection of data. The interview schedule formulated by researcher is based on the aims and objectives of the study covering the aspects of social, psychological, economical and professional impact of Covid-19 pandemic on the marine industry. The source of data was primary and it was obtained from the maritime student, maritime educators, sailors, seafarers and practitioners from India, UAE, Malawi, Zambia, Canada, England, Australia, Tanzania, Sri Lanka, Singapore, Malaysia, Japan, South Korea, Sultanate Oman, Bangladesh and Ethiopia. The researcher called the 1094 respondents from April 2020 to June 2020 and 857 were spending their valuable time to respond the questions included in the interview schedule. Since the researcher had conducted a telephonic interview has doubled the work in terms of getting their appointment and then conducting the telephonic interview. Marine practitioners used in this study are both the people engaged in the sailing of ships as well as port and warehouse activities. Descriptive statistics, Garrett's Ranking, Chi-Square test and factor analysis were used to understand the scenario.

Results and Discussion

Collected information was grouped and presents in this chapter:

- India (34%), UAE (8%), Malawi (7%), Zambia (6%), Canada(4%), England (4%), Australia (4%), Tanzania (4%), Sri Lanka(4%), Singapore(4%), Malaysia (4%), Japan (4%), South Korea (4%), Sultanate Oman (3%), Bangladesh (3%) and Ethiopia (3%) of the respondents were responded to the study;
- Maritime students (30%), maritime educators (27%), shipping practitioners (24%) seafarers (14%) and sailors (5%) of the respondents were responded from the study area;
- Majority (83%) of the respondents were male and remaining (17%) are female were responded;
- 51.1 percent of the respondents were above 30 years age group and remaining 49.9 percent were below 30 years age group
- Majority (74 %) of them were reported that they have less opportunities compared to the past.
- Majority (84%) Maritime students and Maritime educators (92%) reported that students practical exposure got reduced due to Covd-19 Pandemic lockdown and highlight that absence of physical interaction is the major problem.

Garrett's Ranking Technique for major problems faced with pandemic

This Garrett's ranking technique is used to understand the different responses of the maritime practitioners in their order to understand the problems faced by the mariners. The following formula has been used to obtain the rank under the Garrett Ranking technique to rank the problems faced by the marine practitioners in the different parts of the world.

$$\text{Percentage Position} = \frac{100 (R_{ij} - 0.5)}{Nj}$$

R_{ij} = Rank given for the i^{th} item or scheme by the j^{th} individual

j = Number of schemes ranked by the j^{th} individual

The percentage position of each (problems with Covd-19 pandemic) rank thus obtained was converted into scores by referring to the ranking table given by Garrett. The ranking was done according to the average score obtained from the marine practitioners. In the following table, the ranks obtained from the marine students, educators and practitioners were converted in to scores by applying Garrett scoring technique and finally the average values of the obtained scores were ranked. The problems listed by the marine and shipping practitioners were ranked accordingly in the below table.

Table 1

Garrett's ranking for Problems of Covid-19 pandemic

S. No.	Reason	Total Score	Average Score	Rank
1.	Poor practical interaction	33397	38.97	**VI**
2.	Absence of face to face interaction	35779	41.75	**V**
3.	Reduced employment opportunities	53322	62.22	**II**
4.	Increased cost of Living	48411	56.49	**III**
5.	Psychological imbalance	41898	49.89	**IV**
6.	No recreation activities	26575	31.01	**VII**
7.	Reduced business opportunities	57136	66.67	**I**

Source: Computed from field data

The results of the Garrett ranking test reveals that, problem faced by the marine practitioners by the responses obtained from the different category of respondents. Ranking average score were rounded with nearest two decimals. From the view of the marine practitioners as defined in this study found that, reduced business opportunities for shipping industry, reduced employment opportunities to close down of the entry points of the host countries and lock down imposed by the home countries, increased cost of living due to the lack of production and less choice of products in the local market, psychological imbalance of stay home without actual payment of salary and new living practice of stay within the door, absence of face to face interactions were reported by the most of the students and teachers, poor practical interaction were reported by many of them and they were revealed that lack of practical interaction may lead to the future generation with less exposure and absence of recreation facilities. Thus, it is concluded that the covid-19 pandemic changed the life style of the respondents selected for this study purpose.

Chi square Test for age group Vs Reduced income

The chi-square test was applied to find out the significance of association between the age group and reduced income due to covid-19 pandemic.

Chi-square value was derived by using the following formula:

$$\chi 2 = \sum \left(\frac{(O - E)^2}{E} \right)$$

O = Observed Frequency

E = Expected Frequency

The expected frequency is calculated by using the formula:

$$\text{Expected frequency} = \frac{\text{Row total x Column total}}{\text{Grand total}}$$

Degrees of freedom (r – 1) (c – 1)

Chi square for age group and reduced level of income due to covid-19 pandemic situation for the analytical purpose age group was divided into below 30 and above 30 years were presented hereunder table 2.

Table 2

Age Group Vs Reduced Income

S. No.	Income reduced due to Covid-19 pandemic	Age group		Total
		Below 30 years	Above 30 years	
1.	Yes	298	333	**631**
2.	No	130	96	**226**
Total		**428**	**429**	**857**

Source: Computed from field data

Table 3

Chi- Square for Age group Vs Reduced Income

Test Statistics	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.236	1	.022
Likelihood Ratio	5.246	1	.022
Linear-by-Linear Association	5.230	1	.022

From the Chi-square test output, it is clear that, a significance level of 0.022 has been achieved and calculated chi-square value is 5.236 which, is greater than the table value 3.84 at 1 degree of freedom. Hence, it reveals that the chi square test is showing a difference between two variables at 95% confidence level. It can be concluded that, there is a significant difference in the income of the respondents of the study due to covid-19 pandemic situation.

Factor Analysis on Opinion of Marine Practitioners about Covid-19 Pandemic lockdown

Factor analysis is used to find factors among observed variables. In other words, factor analysis to reduce the number of variables from many variables. Factor analysis groups variables with similar characteristics together. It produces a small number of factors from a large number of variables which is capable of explaining the observed variance in the larger number of variables. The reduced factors can also be used for further analysis. There are three stages in factor analysis:

1. First, a correlation matrix is generated for all the variables. A correlation matrix is a rectangular array of the correlation coefficients of the variables with each other;
2. Second, factors are extracted from the correlation matrix based on the correlation coefficients of the variables; and
3. Third, the factors are rotated in order to maximize the relationship between the variables and some of the factors.

Totally sixteen variables have been identified and test the impact of lockdown on the livelihood activities of the marine practitioners. Opinion of the marine practitioners about the selected variables has been collected in order to identify the factors have more impact.

In this context, factor analysis would give the underlying pattern of relationship among the opinion of the marine practitioners about how their livelihood activities were changed. Through factor analysis, the opinion of the marine practitioners was converted into number of factors. The rationale behind this is to identify sum total of high impact factor on their livelihood. The factor analysis was run in SPSS (Statistical Package for Social Sciences) using principle component extraction method with Varimax rotation as these measures had unique advantage of simplifying interpretation by maximizing the variances of the variable loadings on each factor.

The factor analysis has yielded six factors based on Eigen values and percentage of variance accounted for each factor. The results are presented in Table.

Table 4

Factor loadings on Opinion towards Impact of Covid-19 Pandemic Lockdown on the Marine Practitioners livelihood

Factors	Eigen values	Percentage of variance	Cumulative percent of variance
Factor I	3.217	20.104	20.104
Factor II	1.389	8.684	28.788

Factor III	1.355	8.469	37.257
Factor IV	1.212	7.576	44.833
Factor V	1.158	7.237	52.070
Factor VI	1.016	6.347	58.417

Source: Computed from field data

The components having Eigen values greater than ‘1’ were converged as factors. The first factor accounted for 20.104 percent of the variance followed by other factors accounting for 8.684 percent, 8.469 percent, 7.576 percent, 7.237 percent and 6.347 percent respectively. Together, these six factors accounted for 58.417 percent of variation in the opinion of the impact of Covd-19 pandemic lockdown to their livelihood practices and their lifestyles.

The opinion with larger factor loadings under each factor is presented in table. There were three factors having significant loadings on factor I named as economic factor. They were reduced salary (0.909), increased medical expenses (0.896) and increased cost of living (0.865) in the descending order of factor loadings. Factor II named as career opportunities consisted of two opinions with higher factor loadings. They were providing reduced job opportunities (0.841) and Job insecurity (0.723). Factor III named as psychological factor and had bounded inside the home (0.697), afraid about future (0.602) and addicted with gadgets (0.509) higher factor loadings.

Table 5

Factor loadings for Opinion towards Impact of Covid-19 Pandemic Lockdown on the Marine Practitioners livelihood

Opinion	**Factor Loadings**
Factor I (Economic Factor)	
Reduced salary	0.909
Increased medical expenses	0.896
Increased cost of Living	0.865
Factor II (Employment factor)	
Reduced employment opportunities	0.841
Job insecurity	0.723
Factor III (Psychological factors)	

Bounded inside the home	0.697
Afraid about the future	0.602
Addicted with gadgets	0.509
Factor IV (Ship operations)	
Less ship operations	0.736
Increased cost of shipment	0.702
Factor V (Procedures)	
Protocol for Onboard	0.759
Delay in online procedure	0.547
Changes in the customs procedure	0.518
Factor VI (interaction)	
Recreation and interaction	0.855

Source: Computed from field data

Factor IV Liners consisted of two variables with higher factor loadings. They were less ship operations (0.736) and increased cost of shipment (0.702). Factor V procedures consisted of three variables with higher factor loadings. They were protocol for onboard (0.759), delay n online procedure (0.547) and changes n the customs procedure (0.518) and recreation and interaction (0.855) was having high factor loadings at Factor VI.

The rotated factor matrix of the selected variables along with its rank has been presented in Table 5.

Table 5

Rotated Component Matrix

V. No.	Practice	Factor Loadings	Variable Rank
X1	Changes in customs procedure	.518	XIII
X2	Afraid about the future	.602	XI
X3	Addicted with gadgets	.509	XIV
X4	Protocol for onboard	.759	VI
X5	Less ship operations	.736	VII
X6	Recreation and interaction	.855	IV
X7	Job insecurity	.723	VIII
X9	Increased medical expenses	.896	II
X10	Increased cost of shipment	.702	IX
X11	Reduced employment opportunities	.841	V
X12	Reduced salary	.909	I

X13	Increased cost of living	.865	III
X14	Delay in online procedure	.547	XII
X15	Bounded inside the home	.697	X

Source: Computed from field data

Based on the component loadings, the variables can be ranked for its importance. Out of 16 variables, 14 have been grouped into 6 factors and have been assigned ranks from 1 to 14. The two variables X8 and X16 have not been grouped into any factor and the variance explained by these variables has reported minimum, so they have not been ranked. It also reveals that except these two variables other fourteen variables are most important to test the impact of covid-19 pandemic lockdown on the marine practitioner's livelihood.

Recommendations

The following recommendations were made based on the survey results and suggestions given by the respondents of the study:

- Marne Education institutions must provide advanced skill training to their educators to handle the future changes in the maritime industry;
- Marine and shipping course syllabus and curriculum must be upgraded in line wth the future trends to prepare the potential manpower for the industry;
- Marine students must understand the situation and have to prepare themselves to meet the future needs of online world by learning the application of artificial intelligence for the ships and shipping industry to fulfill the future requirements;
- Marine students must learn about the practical aspects and they have to feels that training events are take part in the institution and have to undergo all the practices as scheduled in their institutions;
- Marine and Shipping educators must prepare their modules in the practical mode to experiment all the aspects in detail by the virtual mode and that should provide varied possibilities;
- Maritime education institutions and educators have to prepare the well competent students to meet the online world;

- Shipping companies in maritime industry should ensure the job security to their employees and provide proper online psychological counseling to them for handling this pandemic era; and
- Education institutions in collaboration with shipping companies should conduct the elaborate research on handling this situation, future trends of maritime industry and moderation of the industry.

Conclusion

Maritime industry is evergreen industry providing opportunities to the stakeholders by its varied possibilities. Entire world is suffering with Covid-19 Pandemic lockdown and struggled to come out from the situation. Hence, this study tries to find out the impact of covid-19 pandemic lockdown and what's after that. The results of the study are interesting and highlighted the present mentality and economic status of mariners and future of the students. Mariners reported that they have less sailing opportunities compared to the past. Many of the respondents were worried that this economic slowdown due to pandemic had a huge impact on the industry is terms of less Liner schedules and reduced employment opportunities and poor practical exposure. Maritime Students highlighted that they were unable to get the practical exposures to meet out the challenges and virtual education system gave less chances to learn the practical aspects. Maritime educators pointed that less interaction between the students resulted in terms of adverse results. Meanwhile few of them responded that this pandemic helps them in terms of increased business growth in absence of Air Cargos. This study suggests that both public and private sector should take initiatives to meet out the challenges of these changes in the Maritime sector. Maritime Education institutions have to revise their mandatory policies to meet out the changing trends in education sector. It concludes that both positive and negative aspects of this pandemic resulted the tremendous changes in the Maritime sector hugely in reduced possibilities in the economies of the maritime business ventures. Future economic prosperity of the world is purely depends on the maritime industry and going to contribute the maximum sustainability of the world. Further, this study suggests the future researchers to carry out the segment specific both qualitative and analytical studies to be carried out to handle the pandemic situation to effectively meet out the needs of the sector for the sustainability.

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Proceedings

GMP Applications and Human Capacity Building in Maritime Affairs

GLOBAL MARITIME PROFESSIONAL: UNIVERSITY COURSE OF RISK ASSESSMENT - CASE STUDY OF CADETS ACADEMIC PERFORMANCE BASED ON BLOOM'S TAXONOMY

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Abstract

The International Association of Maritime Universities (IAMU) in 2019 submitted to IMO its publication under the title of «Global Maritime Professional: Body of Knowledge» [1], which proposes the implementation of structured approach to education and training of seafarers based on well-known Bloom's taxonomy. There is no doubt that the term Global Maritime Professional (GMP), which by its meaning is a powerful social, political and academic driver, gives the great cumulative significance and sense for developing the profession of seafarer.

Along with the rapid changing in industry, new trends and mainstreams, reflecting in development of new standards, new threats, hazards and risks appear that were not predictable before and to which seafarers must be professionally ready to respond adequately and sometimes immediately. All of this requires well timed management of changing in education and training process of seafarers based on research of up-to-date reality and trends to find the ways for development of new normal, keeping in line with such time-honored rule of seafarers as "safety first".

Risk Assessment is the core component of all STCW'78 standards intended to ensure safety at sea, against which prospective officers are to be trained and which should be implemented onboard as per ISM Code provisions. It is the basis for achieving the adequate level of situation awareness and decision making onboard ship in a lot of critical situations and the use of Bloom's taxonomy can be one of the keys to make the educational course of Risk Assessment more effective.

The paper presents some case study preliminary findings of cadet academic performance in perception and mastering the university course of "Risk Assessment in Seafaring" (RAS) delivered at the Faculty of Navigation and Communication of AMSU-MIS.

The study identifies difficulties cadets face in the process of learning the RAS course to follow each Bloom's level. It also outlines the relationship among Bloom's levels in cognitive domain and steps of hazard analysis SWIFT, «Structured What If Technique» [2-3] used for risk assessment and gives recommendations for improvement the course.

Keywords: safety, risk assessment in seafaring, Bloom's taxonomy.

Introduction

The GMP publication, designed by IAMU, is timely and relevant guidelines that encourage the use of Bloom's taxonomy in the MET field and intended to ensure the designing the educational trajectories and more efficient mastery of knowledge and skills required primarily for career development at sea. It additionally includes consideration of possible other career paths that can be promoted by MET institutions for shipping industry. The issue provides flexible recommendations that may exceed the running STCW'78 Convention standards but they are justified by contemporary trends in industry, signaling the need of review of STCW' 78 Convention and Code.

The nuances of application of action verbs recommended in Bloom's taxonomy for the educational process depend on the working language used for teaching and learning the subject, but there are a fairly large number of action verbs that could be accurately interpreted to a specific field of knowledge in any language.

The IAMU publication proposes the hierarchy of training levels for seafarers based on STCW 78 certificates of competency and aligned with academic degrees. The proposed hierarchy could not directly be embedded in all national standards for MET purposes and STCW certification process, but it could be easily adaptable. As per the Russian Federation standards, the AMSU-MIS graduates are awarded by the national academic degree of an "Engineer in Navigation", which is roughly equivalent to Master of Science and also they are issued the STCW Certificate of Competency at operational level. The graduation thesis contains a mandatory research part. So, the learning outcomes of graduates can be positioned between Tiers “A” and “C” by GMP classification.

Principally, the university RAS course curriculum was built on the same Bloom's taxonomy ideas, but they exist implicitly in it. The main task of the case study is to highlight these levels in the course and evaluate the consistency of its learning objectives are in line with Bloom's taxonomy [4-6].

The Course “Risk of Assessment in Seafaring”

The main seafaring motto «safety first» is to be included in each professional competence of seafarer. Maritime safety is a serious concern for shipping industry, that is why the risk assessment is the key part of all core STCW competencies. The incorporation of risk assessment in the STCW Code by the Manila amendments could be considered as an effective and wise decision of the maritime community, aimed to have a significant impact on enhancing the performance of ships' officers and strengthen the safety at sea that is completely in line with safety concept of ISM Code.

Risk onboard is assessed by seafarer and his/her foremost proficiency in this process is the ability to identify and analyze hazards for safe planning of forthcoming shipboard operations. At the same time it should be noted that rising implementation of new technologies creates the new hazards that were previously unknown to seafarers.

Adequate risk perception, knowledge and understanding of risk assessment and management algorithms, as well as adequate projection of the impact of associated hazards on safety of forthcoming shipboard operations positively influence the seafarers' level of situation awareness, helping to focus their attention on core points and find effective solutions in critical circumstances. Risk assessment is one of the disciplines included in the IAMU GMP publication.

The course of "Risk Assessment in Seafaring", which is one of the academic subjects taught at Navigation & Communication faculty of the AMSU-MIS, is built on the concept of Formal Safety Assessment (FSA) and includes the SWIFT methodology (Structured What If Technique, SWIFT) [2-3].

The chronology of mastering the Bloom's taxonomy for the RAS course was as follows: having consultations with shipping companies, we came to the conclusion that SWIFT, as a expert evaluation and analysis method, could be used not only for hazards identification and developing risk assessment forms, but it is also an efficient tool for conducting educational workshops for cadets on risk assessment in ship operations. Later, it became clear that Bloom's taxonomy fits well with the SWIFT process for setting the structure of workshops, and we began to implement it by default.

The combination of SWIFT algorithm and Bloom's Taxonomy in the RAS course for conducting the workshops and the nomination of cadets to roles of acting experts during this workshops significantly encouraged their activity, motivation and interest to the course. Then it was decided to carry out some study with the target group of cadets to understand the degree of presence and impact of Bloom’s ideas on the theoretical learning objectives of the RAS course.

The Bloom's levels, which were included in SWIFT consequent steps for conducting the RAS workshops, are presented in Fig.1. The following notations are used here: Re (Remembering), Un (Understanding), Ap (Applying), An (Analyzing), Ev (Evaluating), Cr (Creating).

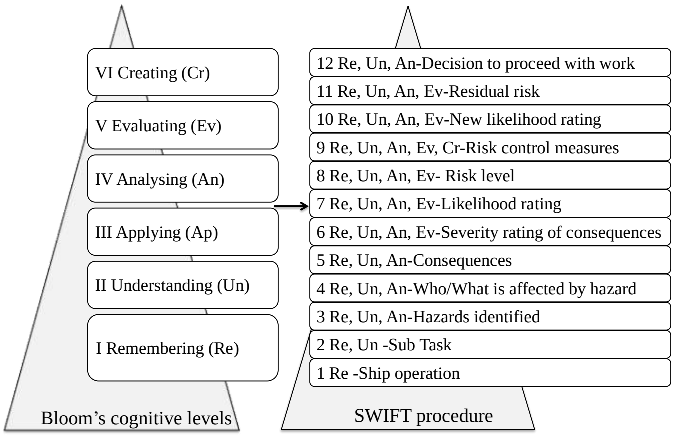


Figure 1. Links of Bloom's taxonomy levels with SWIFT algorithm steps

Then it was decided to carry out the empirical study with the target group of cadets to check if the theoretical learning objectives of the RAS course are in line with Bloom's levels recommendations in cognitive domain.

The inclusion of Bloom's cognitive domain levels in the RAS course based on FSA and SWIFT algorithms gave the opportunity to outline and understand the weak points of it and allowed to work out the original structured approach to delivering the course.

The course content has the following sections:

1. The general concept of risk in seafaring: likelihood and consequences of accidents. Requirements of the international instruments for risk assessment in ship operations.
2. Qualitative, quantitative and hybrid approaches to risk assessment onboard ship: terms and methods.
3. Classification of risk types assessed onboard ship. Ship's forms of risk assessment.
4. Hazard analysis and mathematical modeling of ships collisions likelihood.
5. Hazard analysis and mathematical modeling of ship groundings likelihood.
6. Heinrich's Law and investigation in onboard near misses as per ISM Code.
7. Assessment of the total risk from accidents using fault tree/event tree techniques.
8. IMO Formal Safety Assessment (FSA) overview.
9. Analysis and assignment of tasks in FSA process.
10. Incorporation of Human Reliability Analysis (HRA) into the FSA process.
11. Managing and reducing the risk of fatigue at sea.
12. Hazard Identification technique.
13. Risk control measures and risk control options.
14. Cost-benefit assessment of risk control measures and options.
15. Recommendation for decision-making in ship operations.
16. The overview of IMO FSA studies.

The competency as per the RAS course curriculum covers a wide range of KUPs'[1] requirements, including those necessary to:

- know the general approaches and algorithms of risk assessment and management and those implemented in seafaring to ensure the safe ship operations;
- know and implement the hazard identification, risk assessment and risk control measures techniques and also be aware with principles of analyzing and ranking the potential hazards related to ship operations;
- be familiar with implementing the risk-based procedures of decision-making, ensuring the proper level of the situation awareness;
- be familiar with implementing the methods of elementary research in the field of risk assessment.

The RAS course causes certain difficulties for cadets in achieving the educational objectives. The reasons for the difficulties arise from the very concept of the term "risk", which is based

[1] Knowledge, Understanding and Proficiency

on the probabilistic analysis of information, including a large number of associated uncertainties and various interpretations of the basic concept [7-10], as well due to a wide option of data analysis methods [11].

Uncertainties arise due to inaccuracy and incompleteness of data, their absence or redundancy, which is not always adequately perceived by cadets, precisely for solving practical tasks of risk assessment in ship operations. This is compounded by the lack of verification technique at the time of risk assessment and the use the a priori data. All of this motivates the instructor to adapt the methodology for delivering the educational material in order to increase the efficiency of the course mastering by cadets using clear structuring educational objectives.

Description and results of the case study

As mentioned above, the Bloom's levels are not reflected in the curriculum of the RAS course directly. The purpose of the study is to understand if they implicitly exist in the course and can be extracted for evaluation of achievement of educational objectives.

To carry out the study two types of assessments were developed:

1. Cadets' self-assessment test reflecting level of difficulty that cadets faced with in learning the RAS course. Results are shown in Figure 2, where the number of responses is shown in black and the percentage of the total number of responses in gray. Total results are presented in Figure 3.
2. In addition to self- assessment test, a written survey was conducted on the RAS course, the total results of which are shown in Fig. 4. Cadets were asked 30 questions on the course, which were structured by Bloom's levels. Each level included 5 questions using appropriate action verbs. The target group consisted of 52 participants.

The cadets preliminary were introduced to the modified Bloom's taxonomy and they were asked to answer anonymously to questionnaire of a 5-point Likert scale to clarify the difficulties they faced in mastering the course in terms of Bloom cognitive levels (see Table 1). Difficulties were interpreted as hazards, which could lead to the failure of exam. Levels of difficulty as per Likert scale were as follows: 1 – very difficult, 2 – difficult, 3 – neutral, 4 – easy, 5 – very easy. Before the test the target group of cadets completed their assignment under the title "Assessing the risk of failure the exam", using their individual statistic data.

Sample questions were presented to cadets to clarify links with Bloom's levels to assess the individual level of difficulty.

Table 1. Bloom’s levels and types of sample questions concerning the course content

Bloom’s levels	Sample questions
Remembering	Define the term «risk» used in seafaring.
Understanding	Can the risks from two types of accidents in different shipboard operations be equal, if the likelihood of these accidents varies?
Applying	What decision should be made on planning the ship mooring operation if the risk of mooring lines break is assessed in the ALARP zone of the risk matrix?
Analyzing	Decompose the processes of risk assessment and control in the form of a consistent algorithm of actions.
Evaluating	Under which circumstances the second iteration cycle might be required in assessing the risk of a shipboard operation?
Creating	Suggest the ways, which can reduce the impact of uncertainties in risk assessment process.

Self-assessment test results can be seen in Figure 2 below.

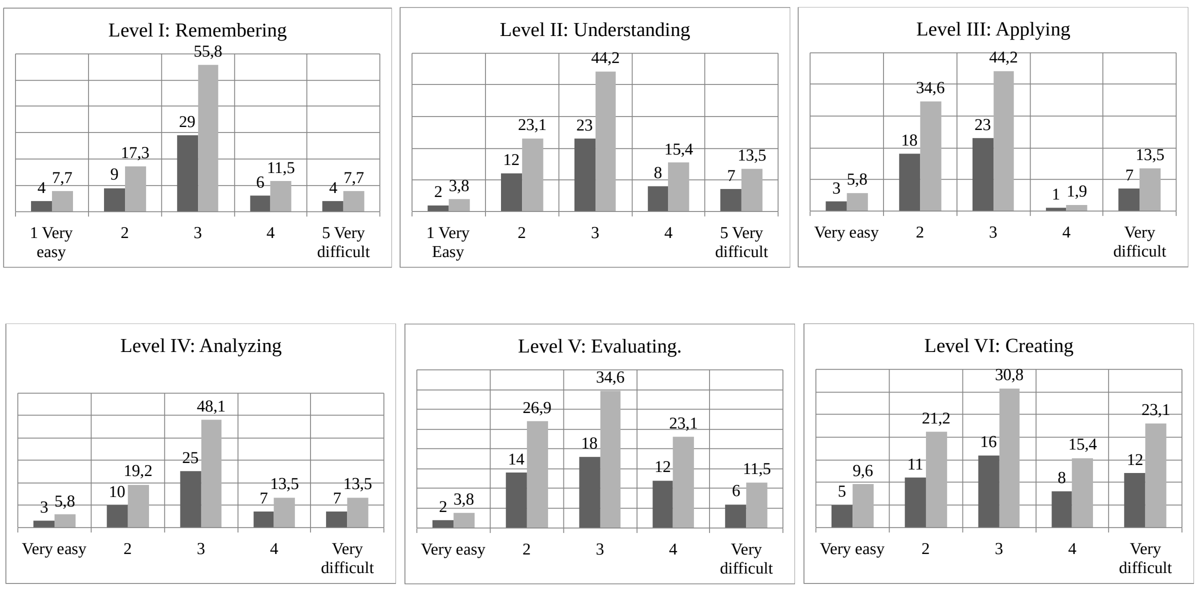
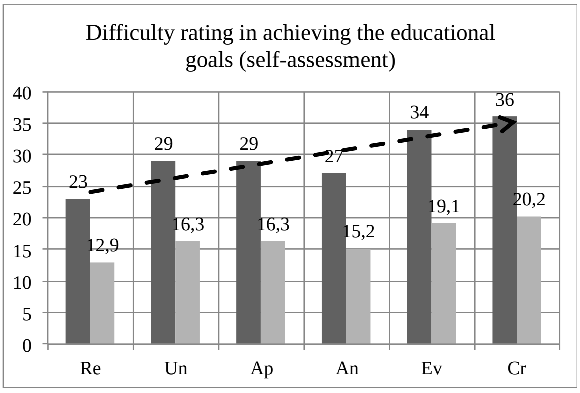


Figure 2. Difficulties of the RAS course mastering: the results of self-assessment test as per Bloom’s levels

The summation of self-assessment and written review results are shown in Figures 3-4.

Figure 3 represents the sum of self-assessment results in number of responses (points) on each Bloom's level as per data that shown on Fig. 2. The number of points is interpreted as a degree of difficulty to master the Bloom's level. The neutral responses were excluded. So, the less points, the more easy to master a Bloom's level.



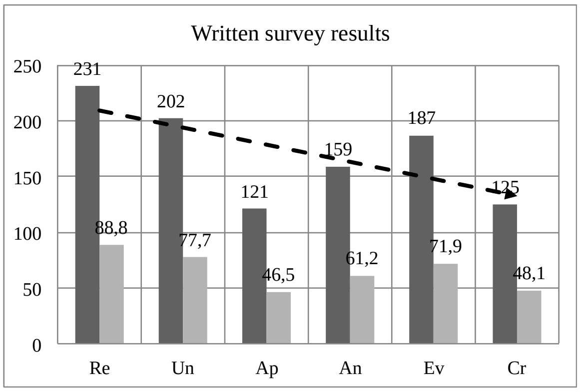


Figure 3. Summation of self-assessment results

Figure 4. Written survey accepted results

Discussion

Self-assessment test

The results of cadets' self-assessment are quite obvious. As can be seen from all 6 graphs in Figure 2, the highest percentage of responses for each category shows their neutral self-assessment position in terms of the degree of difficulty of learning, as it is easier to be justified psychologically. All of this also reveals the uncertainty in responding the questions at all Bloom's levels.

If to take the average value of the results as an expression of a certain degree of difficulty in forming the student's opinion, then the sum of the results for difficulties with Likert indices 4-5 for all levels of Bloom's taxonomy clearly exceeds the sum for difficulties with indices 1-2.

Written survey

As can be seen from the total written survey results, cadets experienced the least difficulty is observed in mastering Bloom's levels I-II (Re-Un) and the greatest difficulty, when working at levels III-VI (Ap-Cr) that is similar to self-assessment test findings.

The written survey results show that of the target group: 11,2% have difficulties in *remembering* the material, 22,3% - in *understanding*, 53,5% - in *applying*, 38,8% - in *analyzing*, 48,1% - in *evaluating* and 51,9% - in *creating* new ideas based on the material studied. Total outcomes are as follows: the largest number of accepted answers relates to the level of *remembering*. Here the level of *understanding* of the course is lower than the level of r*emembering*, which is quite evident, as to remember the material in a lot of cases is more easy than to understand it.

Totally, the worst results were obtained at the Bloom's level of *applying*. The level of *evaluating* is higher compared to the levels of *analyzing* and *creating*, but everywhere the level *creating*, showing the creativity of cadets, is quite low. It should be borne in mind that any cadets' suggestions on new ideas, even fantastic or absurd ones, were accepted to encourage their creative activity.

This generalized self-assessment and the written survey results revealed that Bloom's ideas were used implicitly in delivered RAS course. However, these results are the clear signal for the educator to improve the methodology of the educational process to be in line with educational objectives. The foregoing undoubtedly has an impact on the process of forming cadets' individual competencies, as prospective officers.

Comparison of the results of self-assessment and the written survey confirms the intuitive idea that the degree of difficulty in mastering the learning material by cadets increases in accordance with the hierarchical order of Bloom's levels.

Conclusion

The combination of SWIFT algorithm and Bloom's Taxonomy in the RAS course for conducting the workshops and the nomination of cadets to roles of acting experts during these workshops significantly encourage their activity, motivation and interest to the course.

There is an obvious inverse relationship among the levels of Bloom's educational objectives in cognitive domain and the degree of difficulty in their mastering by cadets, which grows in a hierarchical order of Bloom's levels. This suggests that developing the curriculum, it would be appropriate to pay more attention to Bloom's levels II-VI to make the course more efficient, taking into account that the RAS course is the applied one and the risk assessment is a forming part practically of all seafarer competencies that regulated by the STCW 78 Convention provisions and also by appropriate procedures onboard ship as per the International Safety Management Code.

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Marine student's information literacy skills- a case study of marine engineer's bachelor thesis at Chalmers University of Technology

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Abstract

What do the marine engineer students remember from their library instruction sessions in information literacy (IL) when it is time for them to write their bachelor thesis? The need for IL in the education is important due to the students coming work life. The skills to be an engineer are so much more than just technical knowledge. To state this, we have worked with integrated learning sequences and development due to the Conceive Design Implement Operate (CDIO) concept. Within in this specific subject we will highlight the need of writing and IL. CDIO main goals can be closely connected to IL especially about how to lead the operation of processes and understand research impact and development of the society (Crawley et al., 2014).

During the autumn semester in 2017 we asked the marine engineers to fill in a one-minute paper to reflect over the library lecture. In the spring of 2021, the students wrote their bachelor thesis and we wanted to look at how much they remember from their previous lecture. With a short survey after they finished their theses we wanted to find out if they had used their information literacy skills during these years as students.

Keywords information literacy, active learning, marine engineers, CDIO

Introduction

This paper describes and reviews the information literacy and writing process of the BSc Marine Engineering (ME) Program at Chalmers University of Technology. The goal of this has been until their last year with the thesis as sum-up of the education program. The program has several overviewed outcomes to fulfil as a Maritime Education. By this said the program shall comply with the requirements set out in the Higher Education Ordinance, the Swedish Transport Agency's regulations and the International Convention on Training, Certification and

Watchkeeping for Seafarers (STCW Convention) and the local degree regulations at Chalmers University of Technology.
During the years of 2017-2021 a developed information and writing process was implemented in the program, and it aimed to give the student better skills due to the report writing and the B.Sc. thesis and to prepare them for their coming career as engineers.

The department Communication and Learning in Science (CLS) functions as a pedagogical hub at Chalmers University of Technology (2020). *The Division for Language and Communication* teach among other things scientific writing and technical communication. At CLS you also find the Chalmers library and the division *Information Literacy for Learning and Research*, that is responsible for the IL-instructions. The two divisions are involved in the process of almost all academic theses within the university of Chalmers and offers a different range of course elements in IL.

Chalmers Marine Engineering program

Chalmers University of Technology in Sweden conducts education in and research in several different areas within the spectrum of natural sciences. Out of 11, 000 students approx. 800 students are enrolled to the Maritime Educations.

The Marine Engineering program at Chalmers is a four years education (270 ECTS) and it all ends with a B.Sc. degree in Marine Engineering. The title Marine Engineer was added during the 1950s and the main labor market for marine engineers has been as a engineer on board the merchant navy and as an engineer in the "shipping industry". Furthermore, marine engineers form an important part of Sweden's maritime cluster for both Swedish-flagged vessels and Swedish shipping companies in an international market. The change that has taken place in recent years is that several other industries outside the "shipping industry" have aroused interest in graduates from the program and see them as well prepared for other engineering jobs.

Conceive Design Implement Operate (CDIO)

The CDIO approach to engineering education was introduced in the early 2000’s. It started as a cooperation between Chalmers University of Technology, The Royal Institute of Technology (KTH), Linköping University in Sweden and Massachusetts Institute of Technology to reform engineering educations. The cooperation has now grown to an international network with about 150 educational institutions from all parts of the world (Crawley et al., 2014).

The concept of CDIO consist of two main parts, a description of the professional role as engineer with generic goal descriptions and a systematic way of developing and work. The other main part of the concept is to create conditions for a clear progression in the program and general engineering skills that needs to be trained. Some example of skills are communication, teamwork and project management can be actively trained through integration into courses and projects. Also, the learning environment is important due to the CDIO and it will improve students to work in a more collaborative way. One, out of many, parts that can be achieved from the CDIO concept we have used the perspective of *"Integrating learning of professional skills such as teamwork and communication"*(Worldwide CDIO Initiative, n.d.). Due to the concept it is important for engineers to fulfill and understand the role out over the technical "problem solving".

Education plan

The courses at Chalmers are formed into educational programs and the ME program and consist of 27 mandatory courses and six electable courses. The electable courses are the internship courses and the practical workshop courses, in total they are of 90 ECTS. If the students fulfil the degree of BS.C and the electable courses they will be able to apply for a certificate as second engineer. During the program we have strived to foster the student in several skills out over the traditional engineering skills. Through the education, the student is given good conditions for the development of personal qualities and attitudes. See appendix 1 for detailed information of an overview of each year in the program.

Program learning outcomes

The outcome of the program's degree BS.C is described in Swedish Degree Ordinance (Högskoleförordning [Higher Education Ordinance], 1993) as well as in the *Local Qualifications Framework for Chalmers University of Technology* (2020a) The IMO regulations are controlled by the Swedish Transport Agency but are not stated in the Swedish Degree Ordinance. Therefore, all the specified objectives at Chalmers are develop by the program management to explain how we do this at Chalmers and to make it more clear to stakeholders of the educations. In this article we will just highlight the program outcomes that relate to the communication outcomes.

The program description (Chalmers University of Technology, 2020b) has in total eleven learning outcomes and the seventh of that includes the following:

> **(7) demonstrate the ability to present and discuss information, problems and solutions in dialogue with different groups orally and in writing in different national and international contexts by:**
> (7.1) present information in writing and orally in Swedish and English
> (7.2) be able to reflect and discuss problems and solutions with sea captains, shipping staff and authorities

Out over the formal program outcomes the program has developed an agreement with the department CLS of what should be done in the courses.

Academic and information literacy

Students in higher education need to be prepared both for their upcoming student years but also for their future work life. Academic literacy, to understand academic texts, writing and reading skills is needed for them to success in both. Reading and writing abilities can be seen as core strategies for students to be able to learn new subjects and develop their knowledge (Wollscheid et al., 2020). In the Norwegian study *Prepared for higher education? Staff and student perceptions of academic literacy dimensions across disciplines* (Wollscheid et al., 2020) explores beginner students' perspectives of study preparedness across higher education. And students are *"apparently not used to working hard... struggling to read large text amounts, showing a lack of academic writing and reading skills"* (p. 20). They look at both hard and soft disciplines, for example natural science and engineering or humanities and social sciences. They argue for the importance of discipline-specific writing skills to prepare them for academic achievement. They write that engineering students as a hard discipline need to learn to write and understand structured reports in a technical language. Maritime students have the same needs. At Chalmers the maritime engineers' students writes a lot of lab reports, internships reports etc. But in some courses, they write more academic texts where they must back their claims with facts. They must find peer reviewed scholarly articles and cite them correctly. And then, besides academic literacy, they need information literacy (IL). One engineer student in Wollscheid et al's study responds that *"I know what I'm searching…I just screen the text, and* *when I find something which is relevant, I use it…"* (p. 33). This cherry-picking approach to finding information is for the novice learner but a more experienced learner understands that you need to seek deeper and not take the first best hit in your search list. According to the American Library Association (ACRL, 2016) Information literacy is:

> "Information literacy is the set of integrated abilities encompassing the reflective discovery of information, the understanding of how information is produced and valued, and the use of information in creating new knowledge and participating ethically in communities of learning."

When we teach IL at Chalmers, we follow the *Framework for Information Literacy for Higher Education* (ACRL, 2016). The framework is organized into six frames, each consisting of a concept central to information literacy, a set of knowledge practices and set of dispositions. For example, how to seek information, valuating and use the information ethically according to academic honesty. The six frames are research as inquiry, scholarship as conversation, authority is constructed and contextual, information creation as a process, information has value, searching as strategic exploration.

There is not that much research about maritime students and their ability to find information and need of information, but a Turkish study look at how maritime students search for information on the web and their commitment strategies (Topal & Süner, 2020, p.1). They write *"For students preparing for a life at sea, it is important to establish and determine the appropriate strategies for accessing and interpreting information on the web, as their ability to perform such tasks quickly and effectively is vital for their success in this particular sector."* The shipping industry needs sea farers that are up to date and know about the latest technical equipment. For example, about energy efficiency so that they can reduce greenhouse gas emission or find information about global economy for smother operations (p.2).

Faculty librarian collaboration

Just as reading and writing are seen as a core strategy even IL is recognized as a core competence (Junisbai et al., 2016; Kastner & Cheng, 2019). Junisbai et al, (2016) writes that faculty often thinks that their students have poor skills in locating and evaluating scholarly information but there is an ambivalence on how to teach it. In their study they look at collaboration between faculty and librarians and how to best integrate IL in the curriculum. With conversations about clear goals and learning outcomes that the teaching librarian can put her input on and how she can complement the faculty. Findings from the study shows that greatest gains come from when librarians provide moderate input into the syllabus and assignments, followed by a few strategically placed hands on library sessions.

In Brierton Granruth & Pashkova-Balkenhol's (2018) study that also looks at the benefits of collaboration between faculty and librarians. They have developed a new model to integrate information literacy to strengthens social students writing skills. The students were positive with the combined expertise from the faculty teacher, the librarian and also the writing tutor. The authors got the insight that students need interactive, hands-on and just in time teaching (Brierton Granruth & Pashkova-Balkenhol, 2018, p. 459) And Kastner and Cheng (2019) highly recommends a collaboration between faculty and librarians is the best way to help first years engineering students to develop critical information literacy skills and it should be in the beginning of their academic journey (p. 4).

Active learning at Chalmers library

The library, that serve the marine students and faculty at Chalmers, reopened as a Learning Commons in 2017 (Chalmers University of Technology, 2017). In conjunction with the new premises the librarians changed the library instruction sessions in information literacy from mainly passive lectures in computer labs to more active workshops in ALC (active learning classroom) inspired classrooms. Active learning shifts focus from the teacher to the student and this learner-centered approach place more responsibility on the students (Felder & Brent, 2016). And for some students this can be hard, but the advantages of active learning have been confirmed by many scholars, among others, by Freeman (Freeman et al., 2014).

Over the years we have meet the student in different courses and at different times during their study years, depending on what would best for the students, see fig 1 and 2. But usually we offer a so-called one-shot lecture where we introduce the students to our library resources, focusing mainly on the discovery service, databases and our so called libguides. We have a libguide for the maritime students were we have gathered important resources in the subject of shipping and maritime studies https://guides.lib.chalmers.se/Shipping.

Figure 1. Class start 2017

Year	Library activity	Information literacy	Writing assignment
1	Library introduction, one- shot lecture	Library resources, information seeking, references	No academic writing, only a lab report
2	One- shot lecture	Source criticism, avoid plagiarism, peer review, citations	Argumentative text
4	One- shot lecture, online module, dropin sessions and tutoring	Academic honesty, source criticism, avoid plagiarism, peer review, citations	Bachelor thesis

Figure 2. Class start 2020

Year	Library activity	Information literacy	Writing assignment
1	Short introduction to the library (and the librarian), quiz in canvas (sea-web)	Library resources	No academic writing
2	Library introduction one- shot lecture	Information seeking, references	Argumentative text
4	One- shot lecture, online module, dropin sessions and tutoring	Academic honesty, source criticism, avoid plagiarism, peer review, citations	Bachelor thesis

We go through the process of seeking information and evaluating what they find. And we introduce them to the reference style commonly used in their program, APA7th ed (American Psychological Association). The librarian holds a shorter introduction, gives the students an assignment that they work on in smaller groups and that they must reflect on in whole class. When students periodically get something to do that requires using recently presented information, their working memories have a chance to rehearse that information and being stored in the long-term memory (Felder & Brent, 2016, p.117). They also write about the win-win situation that *"academically weak students get the benefit of being tutored by stronger classmates, and stronger students get the deep understanding that comes from teaching someone else"* (p.119).

We meet them in class again when they start working on their bachelor theses. And now with progression in mind. In consultation with teachers we have set up a suitable package with focus on academic integrity. We have a mandatory one-shot lecture and the students also have to do our online module Chalmers Library Education Online (CLEO) in academic integrity that focus on plagiarism, scholarly communication and copyright (Nordfeldt & Wernbro, 2017). We also offer drop in and tutoring sessions.

Method

That first semester in 2017 with active learning we asked all the students from different programs we meet in class to fill in a one-minute paper to reflect over the lecture. One-minute papers is a good way to receive formative assessments. We asked; What have you learned today that can be helpful for your further studies? What did you think about todays lecture? And an open-ended question for other comments.

We received 46 answers from the marine engineers student in year one and two. The students that 2017 were the first-year students were now writing the bachelor thesis in the spring 2021 and we sent out an survey. We wanted to know what they remembered from the library instruction. Has it been of any help? The survey was sent out to the class by mail, and it was performed in Google forms. The survey was in Swedish and the questions where both closed and open form. The questions will be found in appendix 2. The participation was voluntary and the survey where sent out to 23 students and 12 of them responded. A reminder was sent out after a week. The response rate was 52% which we considered good even if it is a small group of respondents. According to (Denscombe, 2014, p.54) there's no benchmark figure for what is considered an acceptable response rate.

Results

A lot of the comments from the one-minute paper in 2017 mentions that they learned about information seeking, how to write correct references but also were to search and they seemed to understand the importance of information literacy. Some students wrote that learned (translated from Swedish):

> *Future essay writing, the use of the library/school's "research database".*
>
> *Where I can search for information. Who can I turn to in case of problems.*
>
> *I have gained a deeper understanding of how references work and what resources I have available.*

The students liked the active learning and were positive to the lecture, the majority thought it was “good” (54,3%) or “very good” (37%). They also mentioned that it was good that they had the library instruction early in the course, that they learned a lot and that they liked the “live” teaching. But they also said that it was short on time, our one-shot lectures are 1 hour 45 minutes and a lot need to be covered in that time.

The first year they didn’t have a written assignment but in their second year the librarian meet them again as mentioned earlier in fig 1 and now they had to write an argumentative text based on scholarly articles. Since this was the first time, they actually needed to find information and cite it correctly, the library session was more needed and the perception from the librarian was that the students didn’t really remembered that much from year one.

Results from the survey from the fourth year when the students wrote their bachelor thesis show that they were still positive to the library sessions and that information literacy is important, even if that is a term used by librarians and some students said that they haven’t heard it before. But they defined it as “the ability to find, understand and sort out relevant information on a topic, and to be able to be source critical to assertations/statements” and *“a skill to mediate information”* which is an important skill in the maritime sector. We asked how information literacy and academic writing has been beneficial for them during their education and also if they see how it will be of importance in their coming work life. The majority said that it was beneficial for the bachelor thesis but only a few could see the importance of information literacy in the workplace. One student summed up *“only for the bachelor thesis, my program is not that academic so for my future career is it completely unnecessary. However, for my personal development and general education is it very useful…”*. And then on the other side some students responded that it is useful for the career, *“I’ll certainly write reports and manuals at work so gaining this knowledge is priceless”*. We also asked if the student thought that information literacy and writing skills should be integrated earlier in the program and it was a 50/50 response on yes; it should be integrated earlier and keep it as today. None wanted it to come later in the course. *“It would have been good to be more prepared for information seeking and referencing earlier in the program so that you don’t need to develop that knowledge during the writing process. However, if you asked me three years ago, I would have said that it was totally unnecessary and that it would have been better to focus on current studies”*. Interesting is that the library sessions in year one was as previously stated appreciated and that they learned how to seek information and cite correctly. But now in the survey when we asked what they remembered they responded; *"not much, a little about how to search…"* and one even wrote that they didn't had any library education instruction in year one.

Conclusion

This is just a small case study and it's hard to draw any final conclusions. The students appreciate the active learning, but the library instruction need to be right on time with clear learning outcomes. As Junisbai et al, (2016) writes that the library sessions should be strategically placed in the right courses were information literacy is a goal. And that it is better to have shorter elements were the library just introduces our services than have unnecessary one-shot lectures without a cause. Already back in 2017 we realized that the one-shot library lecture we had for that class in year one when they didn't have an academic writing assignment wasn't suitable. The year after with discussion between faculty and librarian it was decided to just have a short introduction in the course *Introduction to marine engineering* so that the students got to know the library as a place and also "their" librarian. In the course we also integrated a quiz in canvas, were the students would find information about ships and engines in Sea-Web that was connected to the course, se fig 2. Based on the feedback from the students and from the literature the librarian will be present during the whole education and IL should be embedded in the curriculum from the start and it's important with progression.

The results also give us that this is a very fruitful way of working with the skills of communication and we will strengthen and develop the learning sequence of this for the coming educational year.

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Appendix 1 Overview of the Program plan

In the first year, students develop their knowledge in basic engineering skills, mathematics, marine and mechanical engineering and electrical and logical control systems. The introduction to the maritime subject is given as a part in all courses. All courses contain workshops/ laboratory work / or exercises in an engine room simulator. The course also includes writing / Maritime English communication (SMCP) and other generic skill, the first year is to see as a toolbox for the coming years.

The second year starts with courses in the natural sciences with communication tasks that are integrated in the courses. The Steams and refrigeration course has integrated elements with the Marine English, to prepare for progression in communication education in the program. During the spring semester, the practical courses in workshop training given.

During year three, the education is broadened and mainly at the management level due to Marine Engineering skills. This prepares for the future role of as leader and chief engineer. The course Maintenance Technology includes a part in communication / English with an example of a real type of report for a marine engineer.

During the fourth year, main part of the tasks in the program are written and there several guest lectures as wells a study visit included in the courses. All of them are examined by written reports with a standardized template that shall be used. The template is a “short version” of the B.Sc. thesis that the students performs during the spring semester. In parallel with the thesis that are two courses given than can be electable within the portfolio of Chalmers course but in general the students choose the curses that are included in the program.

Appendix 2 Survey questions

What is information literacy for you?

In what way have you benefited from reference handling and academic writing during the education?

What do you remember of the library introduction during year 1?

In what way do you see that you will benefit from information literacy and academic writing in your coming career?

When you have written your bachelor thesis, how did you find the instruction from the library and the division for language and communication?

When do you think writing should be integrated in the program?

As today	
Earlier	
Later	

Follow-up question, why do you think that?

Do you you think that it should be more teaching in information literacy and referencing in the program?

Yes	
No	
Maybe	

Anything else you like to add?

Methodological Basis for Training Cadets/Professionals and Developing the Risks Management System in Maritime Shipping and Industrial Fishery

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Abstract

Activity in the field of the industrial fishery is associated with risks determined by the state of the environment. In this regard the development of methodological approaches to the design of risk management systems in industrial fishery is relevant. The paper presents an approach to develop a concept of the risk management system for industrial fishery including catching biological resources of the World Ocean and transportation of raw materials. The suggested concept consists of four stages. The paper presents a structure of the adaptive processing model of risk management. This model reflects the processes and their relationships by means of which the risk management is carried out. The formation of the risk management system structure can be realized in three variants. The paper demonstrates an example of such an organizational structure (the state structure of the Russian Federation).

Keywords: Risk management, Industrial fishery, Shipping, Training, Methodology

Introduction

The theory of risks in various spheres of human activity has received significant development in recent years [1,2,3,12,13]. Since the 70s of the last century, much attention has been paid to the development of scientific tools and technological support for the theory of risks [12].

As the analysis of scientific and educational literature of the last decades devoted to security and risk issues has shown there is a certain substantive focus in this problem. It is the assessment of financial, economic, environmental, natural and technological, social and political risks.

Activities in the field of the industrial fishery are associated with risks determined by the state of the environment. It is very often characterized by extreme conditions (hurricanes, storms, fogs, cramped conditions, etc.).

However, it is important to consider not only the risk assessment issues but also the matters its management. It has become in many key areas of activity including human activities at sea. In particular, these issues are not considered/investigated towards the field of industrial fishery.

Due to the fact the development of methodological approaches to the design of risk management systems in industrial fishery is relevant.

It should be noted that there is an opinion [5] that it is incorrect to speak about risk management, because "… cannot control that is not under control". But, the "risk management" provides just the "controlled" risk.

The concept of risk management in industrial fishery

Stages of developing the concept

The approach of developing the concept of the system of risk management in industrial fishery including catching biological resources of the World Ocean and transportation of raw materials consists of four stages.

The first stage includes defining the mission and goals of the system; the safety policy in the field of shipping and industrial fishery and formation of a monitoring subsystem and a database of the accident rate, fishing accidents, extreme phenomena of nature, etc.

The second stage consists of an analysis of factors affecting human activities at sea and identification of risk factors; an analysis of cause-effect relationships and defining risk indicators, criteria of their significance, determination of the possible level of damage and the allowable amount of losses.

The third stage includes: identification of the mechanism and resources for the effective risk management; development of scientific tools and methods to predict or reduce the level of risks; creation of regulatory support of the risk management system.

At the fourth stage training professionals for the risk management, formation of organizational risk management structures for all levels of the hierarchy, creation of a rational and effective mechanism to control functioning of the risk management system are carried out.

A conceptual model of the system of the risk management in industrial fishery during fishing and transportation of raw materials is presented in Figure 1.

The purpose of creating the risk management system is to increase the safety level of these processes, including by managing risks and reducing their negative impact on human activities at sea.

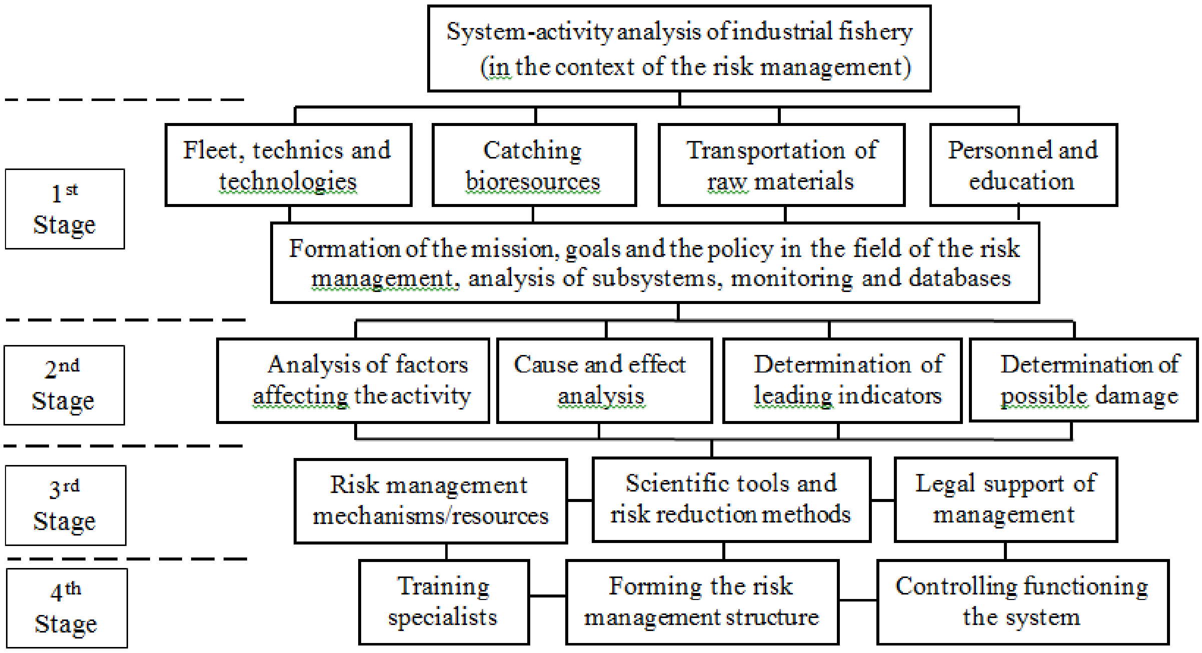

Figure 1. Model of the general concept of the formation of a risk management system in industrial fishery

The methodological basis for designing a risk management system is the system approach. In this regard, first of all, it is necessary to determine which activities and tasks have to be solved in the designed system and by what processes these activities (tasks) will be implemented.

When the design goals and objectives have been defined it is necessary to develop a process model of the future risk management system.

The main tasks of the designed system are: organization of monitoring the fleet work in the context of the its safety; an analysis of the accident rate and determination of the cause-effect relationships; elaborating scenarios for the development of emergency situations based on retrospective data; formation of time series (the statistics on accidents) and the calculation of the expectation/average estimates of the frequency of accidents by type of vessels, seasons, areas; development of plans and the content of advanced training maritime professionals; solving practice-oriented tasks of risk assessment and management; the organization of rescue operations and an advisory assistance to crew of ships in distress (if necessary), etc.

A process model of the risk management system

The solution of practice-oriented tasks of the risk assessment and management includes the following operations [1,3,6,9,10]: identification of risks; assessment of the level and the cost of risk; determination of the acceptable level of the risk; development of measures to reduce the level of risk (if necessary); calculation of the effectiveness and the cost of activities; making management decisions; implementing decisions and its controlling.

Elaborating the process model of the risk management system supposes identifying the main processes that need to “start” realization of the risk management tasks:

– organizational–managerial processes to provide the organization of the implementation of the whole complex of works and the management of the main and auxiliary processes;

– informational processes to collect/systematize data and to provide the system work with the necessary information;

– monitoring processes to provide continuous observation of the fleet operation, collecting information on the accidents rate, the state of the internal and external environment, and registration of parameters of the observed objects, data systematization and evaluation by selected criteria;

– analytical processes to evaluate data and retrospective scenarios on accidents and the impact of factors of the different nature on fishing and transportation of raw materials and identification, calculations, forecasting, assessment, pricing the risks, etc.;

– designing and planning processes to provide organizational and technical measures for safety of vessels, development of projects for fishing/transport-logistic systems for servicing fishing vessels at fishing grounds and planning of trips;

– consulting processes and participating in the organization of rescue operations in cases of accidents and other emergencies;

– educational processes in order to determine the content of training/professional development of specialists [6,7].

An integral part of designing and planning of the fleet operations is the calculation of predictive risk assessments and comparing them with an acceptable level. A project/plan of measures is developed if the prognostic risk estimates exceed or are close to the acceptable level of the risk.

Let us to consider the presented processes in the terms: “an input – a process – an output”. The main and auxiliary processes can be selected in any systems. The main processes in the risk management system are organizational and managerial, that include the risks identification; designing and planning measures for ensuring the safety of a vessel's trip. The auxiliary processes include monitoring, information and analytical processes, financial-economic, including calculations of the risk price and the effectiveness of measures to reduce the level of the risk.

The structure of the adaptive processing model of the risk management is presented in Figure 2. This model reflects the processes and their relationships by means of which the risk management is carried out.

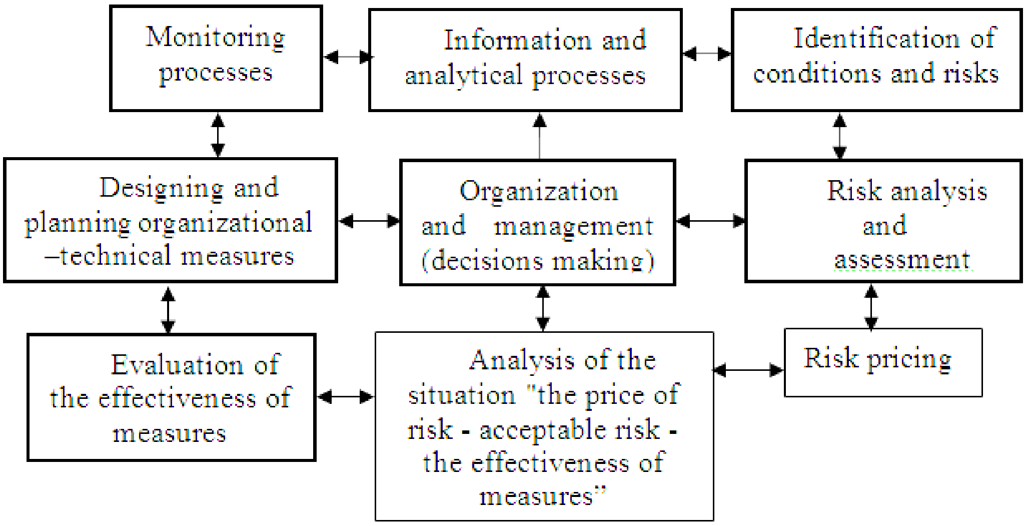

Figure 2. Adaptive process model of the system of assessment and risk management in industrial fishery and transportation of raw materials

The process representation of the management system allows:

– to organize the risk management work without creating additional administrative structures in small fishing and transport companies;

– to create adaptive risk management systems in large fishing and transport companies with a minimum of expenses for maintaining such a specialized structure;

– to create adaptive risk management systems in the central state structures (the Russian Federal Fishing Agency, for example) as well as in specialized regional information–analytical logistic centers.

The main requirement for the designed system can be formulate as the following: the risk management system has to adapt quickly to negative changes of the external environment and prevent such serious consequences of environmental factors as the loss of vessels, accidents, failures of machinery, fishing gear, stopping catching and manufacturing fish products, etc.

The need to take into account changes of the external environment in conditions of the uncertainty leads to the use of adaptive models. An adaptive adjustment of the formal model is made according to the current and predicted information about the input and output variables.

The feature of adaptation is realized in the proposed process model of the risk assessment and management system on the basis of the principles of diversity, duality and feedback.

The diversity principle states that the diversity of the control system should be no less than the diversity of the control object (the control object is the risk in the given case).

The essence of the duality principle is that impossible to carry out effective management without knowing the characteristics of the controlled system/object on the one hand but on the others these characteristics can be studied during the management process and thereby to improve the management quality [6]. These cases the control actions are dual in nature: they are means of both active study, cognition of the controlled system/risks for the future and direct control at the current time [1].

The essence of the feedback principle is that the characteristics of a controlled object are measured and reactions that are expressed as control actions are developed with the help of the feedback [7,11].

An analysis of the structure and characteristics of the process model shown in Figure 2 suggests that the designed model of the risk management system satisfies to all characteristics and principles of the adaptive system. There is the possibility to adapt the risk management system to changing conditions using the basic modules.

Risk indicators

A fishing company is a complex dynamic system that implements many functions. The activities of the company and its fishing and transport vessels can be characterized by many indicators. Each of indicators represents particular information relating to the object of the management. The information presented by various indicators is used to solve various problems. Therefore, it is necessary to separate out the most significant indicators from the array of information in order to solve a different class of problems.

In particular, the following information is needed for risk management tasks:

– technical state of vessels and their operational characteristics;

– frequency of technical equipment failures;

– technical data of the hydroacoustic equipment;

– casualties and fishing accidents;
– characteristics of stability and floodability of vessels;
– crew qualifications;
– hydrological and meteorological characteristics of navigation areas and fishing grounds;
– physical and chemical features of the cargo (for example, fish meal), etc.

An analysis of the dynamics of changes of these indicators, their relationships and sustainability will allow to assess (at least qualitatively) the degree of risk and the presence of risk factors. Thus, indicators containing information about threats to navigation, fishing or other activities are called as "risk indicators".

The use of the risk indicators has the purpose of informing the company's management about the current situation and possible threats in the foreseeable future. A risk indicator reflects the presence and characterization of a particular risk factor. In this regard the special interest has so called "advanced indicators of risk" i.e. they indicate the presence of risk factors before the occurrence of the risk events.

The effective risk management has to be based on complete and reliable information, the structure and content of which are satisfied to the conditions of minimality and sufficiency.

Formation of the structure of the risk management system

An example of such an organizational structure of the adaptive risk management system (the state structure of the Russian Federation) is demonstrated in Figure 3. The formation of the risk management system structure can be realized in three variants.

The first option is creation the conditionally-permanent risk assessment and management team in the concrete fishing company and supposes:

– the company has at least one highly qualified specialist who is trained in the risk management;
– availability and permanent updating of the database on accidents and risks;
– availability of methods for assessing and managing risks as well as calculating their acceptable level.

The second option means delegating functions of the risk management to an outsourcing structure (for example, to the regional information–analytical logistics centre). This case the company has to:

– get rid of the need to perform complex actions for the risk management, database formation, monitoring, etc.;

– save the cost, because the implementation of certain functions by own staff can be more expensive (for example, the formation of databases);

Internet technologies allow to organize efficiently the execution of relevant functions, as well as remote accessing and transferring of large amounts of data.

The third option is a mixed version of two first options.

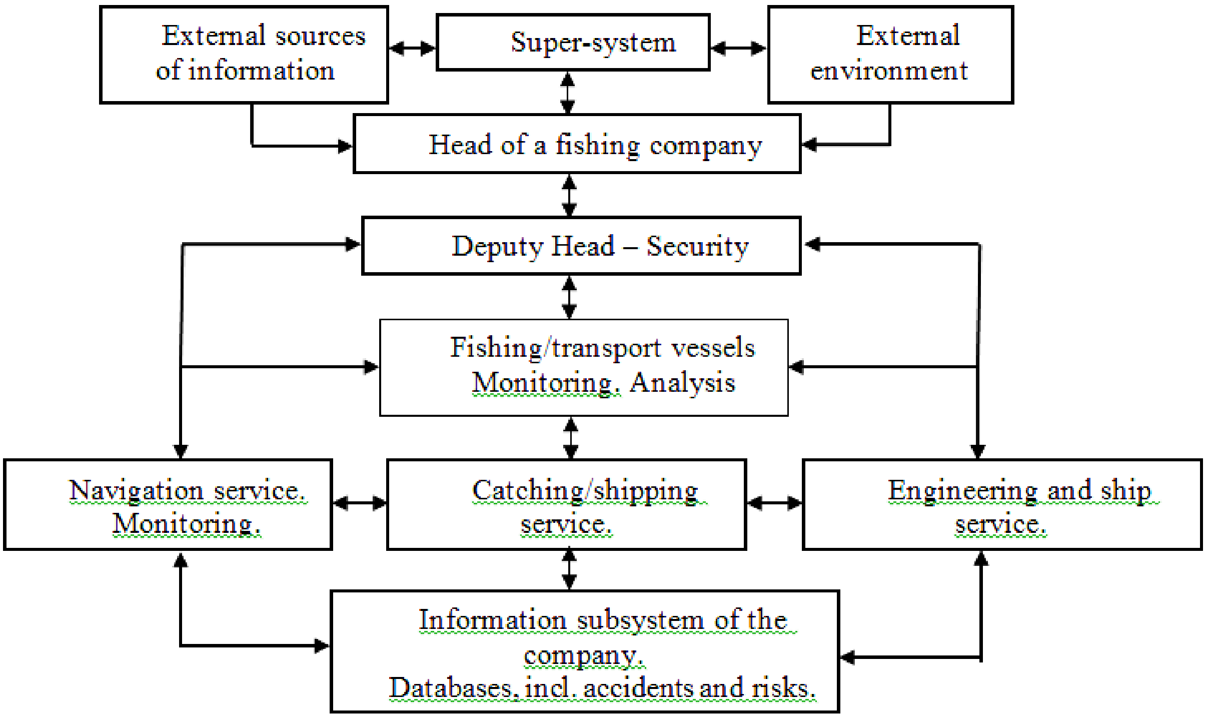

Figure 3. Organizational structure of the risk management system of a fishing company on the principle of conditionally-permanent functional cooperation

The "Super-system" is here the Federal Agency for Fishery is a hierarchically superior management structure that performs the functions of an "ideologist" and a controlling body, on the one hand. On the other hand, the functions of the "Super-system" should include the provision of the methodological and resource assistance to fishing companies in the organization of work on the risk assessment and management.

The "External environment" is the set of objects and entities which can interact directly or indirectly with the fishing company, fishing and transport vessels. The "External environment" can have both positive and negative effects on fishing and transport vessels and companies. The influence of the "External environment" factors should be studied and taken into account for the risk assessment and management. "External sources of information" are any sources external to the considered object. The information can be very useful for solving both production problems and the navigation safety and the risk management. The head of the fishing company, as the person responsible for the activities of the company as a whole, exercises the general management.

The scheme of functioning of the risk assessment and management system is presented in Figure. 4.

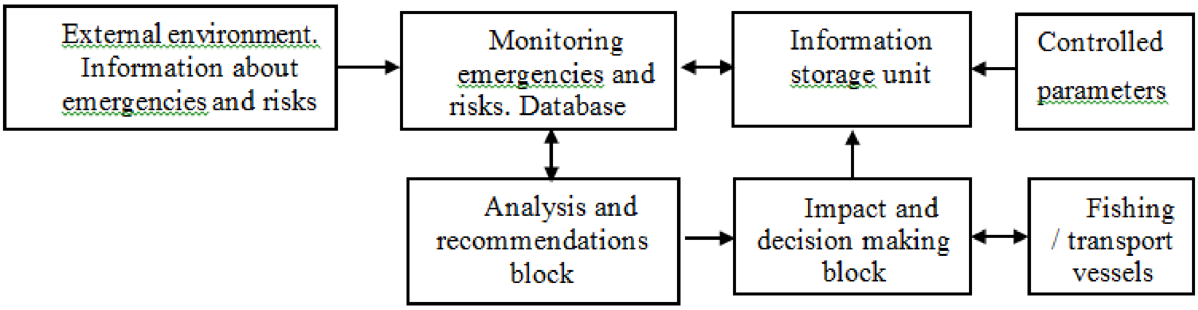

Figure 4. Main elements of the risk management system

Information support of the risk assessment and management system

Information relating to the following types of risks is primarily important in the context of the risk management:

– natural risks which include risks associated with the elemental forces of nature;

– transport risks are risks associated with the carriage of goods by sea transport, in particular navigational risks of vessels collisions, grounding, damages of the propeller-steering group, berths and vessels during mooring, etc.;

– risks of loss/damage of cargo during transportation;

– fishing risks associated with industrial fishery;

– anthropogenic risks;

– ecological risks.

The calculation of probabilistic assessments of the occurrence of emergency situations and the risk realization is based on the use of expert assessments and statistical data on accidents, losses of catch, cargo, causing any damage. In order to use the accident statistics it is necessary to reflect in the investigation of accidents: the type and purpose of the vessel; time and place of the accident/emergency, season and environmental conditions; what actions were taken to avoid and/or reduce damage. As a result, it is necessary to clearly define the chain "conditions - causes – effect". It is advisable to describe the scenario of an emergency. Scenario analysis will help to obtain information that will be useful in the future.

Information on accidents and other emergencies will have the greatest practical importance if there is the presence of a representative sample. Data should be differentiated by fishing grounds, navigation areas, types and purpose of vessels, the season. It is necessary to have data on the number of vessels at the fishery or the navigation area to calculate probabilistic risk assessments. It will allows to calculate the frequency or expectation of the occurrence of the emergency/risk.

It becomes necessary to create integrated databases because the sample has to be representative for calculating probabilistic estimates based on retrospective statistical data. Such databases can be created at the level of large fishing companies, regional information and analytical centres, governmental and international structures. At the same time databases of the lower levels has to be integrated into the databases of the upper level. It opens up real opportunities for creating a representative database and using past experience for solving practical problems, studying and researching it and using statistics to calculate probabilistic assessments of risk situations, identifying risk, studying cause-effect relationships, etc.

Conclusion

The risk management in the industrial fishery is closely related to managing the safety of catching, towing fishing gear, interacting with other vessels, transporting raw materials and fish products. The risk management system on the fishing fleet is a set of interrelated processes and operations aimed at achieving a single goal: the risk reduction.

The most important processes and operations in the risk management system are: monitoring fleet operating conditions and risks that occur or may be possible; risk identification; risk analysis; development and planning of measures to eliminate or reduce the level of risks; organization and control over the implementation of measures to eliminate or reduce the level of risks; an analysis of the effectiveness of planned activities and their remote consequences; an analysis of already implemented activities; generating files of positive achievements and negative experiences; a factor analysis of risks based on retrospective data and expert estimates; training specialists for the risk management.

Thus, the risk management system allows fishing companies to predict the occurrence of risks and assess their consequences, to plan transportation taking into account possible risks, developing measures to reduce risks, to monitor risks at all levels and make rational decisions in case of an emergency.

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Prediction of the Potential Human Errors Probability of Critical Safety Tasks

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Abstract

Safety operations onboard ships and onshore terminals in hazardous processes required the human element to be aware of the operational risks. Since the concept of human error has exposed ample arguments. An overview of the human element's failure is essential because the major provenance of accidents is human errors even there are many conventions and codes to reduce the petition errors. Human Reliability Assessment (HRA) techniques is a theoretical framework to assess human actions for predicting the potential human error probability (probability of failure) of a certain given task or operations' scenario. Accordingly, surveillance of the human performance through an operation "task steps and sub-steps" is vital. The Cognitive Reliability and Error Analysis Method (CREAM) tool is the second generation of HRA which offers a practical approach to both performance analysis and error prediction. CREAM essentially deals with the difficulties of human attention during an action control in the context of human organizational and technological issues under the impact of cognition (competence).

This paper reveals the importance of predicting human errors for keeping lives, by applying the HRA CREAM tool to critical safety tasks onboard ships (lifeboat drilling process). In addition to introducing a newly developed software based on CREAM tool "prospective phase" for monitoring the human performance during the task steps and sub-steps to enhance and expect the human failure points during the process by collecting the expert's opinions and utilizing the software then acquires the process quantitative and qualitative results.

Keywords: HRA – CREAM – CPCs – HEP.

1- Introduction

Seas play a crucial role in dominating history, registering both the destiny of nations as well as the societies in the world's most populated and economically vibrant regions. Thus the significance of the seas in the development of societies and economies of regions is immense. Seas also acted as a duct for several events that dramatically altered the socio-economic development in several regions throughout history.

The shipping industry system is four times riskier than air transport causing. Over the last four decades, the shipping industry has focused on developing ship structure and the dependability of ship systems in order to decrease the rate of accidents and increase proficiency and productivity. Human elements are contributing in all life times of most technical systems, from design, construction, operation, management, conservation, and system upgrade. Humans have a tendency to make mistakes and it is repeatedly said: "to err is human" (French et al, 2009).

It is obvious that accidents and shipping causalities have been strongly influenced by human errors, as either unintentional or intentional breaking of the rules that have the potential to lead to catastrophic failures. The International Maritime Organization (IMO) has a glorious role in reducing human errors. This occurs by implementing the International Safety Management (ISM) code, and its required procedures, Standard Training, Certification and Watchkeeping (STCW) convention, and other related conventions. Conversely, the annual Overview of Marine Casualties, incidents by European Maritime Safety agency (EMSA), and the statistics of the International Union of Marine Insurance (IUMI) revealed that there are sever maritime casualties, still occurring, that causes loss of lives and properties.

Since the human factor is one of the main concerns of total safety standards, the HRA could be applied to improve an inclusive understanding of human action in context as required in the shipping industry domain. Moreover, it is the way to recognize how reliable the operator to achieve a given action without failure and estimate the probability of human errors for a certain task or operation. Applying the HRA is considered a sophisticated tool to minimize human errors particularly for a maritime high-risk, critical, operation that evolves causalities, pollution, and loss of lives (Rashed, 2019).

As it is necessary to account for reliability in relation to cognition rather than manual action. Some extent may be reasonable to describe the likelihood that a manual operation will succeed or fail in the same way that a first-generation HRA does.

CREAM is what so-called second-generation human reliability tool that offers a practical approach to both act analysis and error prediction. In this tool, human error is not considered to be arbitrary but formed by different issues such as the context of the task, "physical/psychological situation of the human operation and time of day".

This paper reveals the fundamental of the CREAM tool, propose a model based on CREAM, created software, and apply the model on an example of critical safety operation task utilizing qualitative method (Delphi Method) in collecting the expert opinion for both versions of the CREAM tool.

2- Background

CREAM is initially established from the Cognitive Control Model (CoCoM), and offers an applied approach to both performance assessment and error likelihood. Moreover, it is used as retrospective and prospective assessment method and it distinguishes between actions (Phenotype) and possible causes (Genotype) (Hollnagel, 2005).

HRA tool CREAM has been developed by Hollnagel (1998). It represents a second-generation HRA tools with developed applicability and accuracy compared to most of the first generation tools. HRA was comprehensively studied in recent years by many researchers. Hollnagel et al. (2004) have defined the development of the basic screening version in CREAM, whereby a rating of the performance circumstances can be used to calculate a Mean Failure Rate directly without appealing the concept of human error. The method is to derive the failure probability directly from a description of the context in the form of Common Performance Conditions (CPC).

Yoshimura et al. (2014) introduced research that used CREAM, a retrospective phase to clarify how ample the influence conditions have on the human acts and the dependencies between CPCs, even these conditions change across domains, the CPCs will apply differently to domains other than the nuclear industry.

The authors compared the nuclear industry and the maritime industry, there are significant differences in the influence the work environment has on behaviour and human performance. Therefore, the dependencies between CPCs and priority are now evaluated according to the expert judgment of each domain and questionnaire survey for the Officers of the Watch (OOWs), including OOWs on training ships in cooperation with the National Institute for Sea Training, Japan.

De Felice et al. (2013) presented modeling application for the CREAM tool which is a very promising tools in order to manage the “human factors” in production process; considering that most of the production processes are made by the combination of man and machine.

On the other hand, Jianxing et al, 2014 presented in their paper CREAM tool taken into account the characteristics of shipping operations and introduced weight analysis of modified CPCs that suitable for shipping operation then developed quantitative model based on CREAM tool and apply it to case study of analyzing the human reliability of the crew on board of an ocean going dry bulk carrier.

Akyuz et al. (2015) introduced in two studies application of the mentioned HRA tool for a type of maritime operations. The basic and extended versions of HRA CREAM tool, furthermore, Akyuz et al, (2015) answered the question “why used CREAM?” The results of the study showed the real performance reliability.

However, the used CREAM was in a narrow sector in addition to applied the tool to only single operation, and the authors did not created modifications for the use of the tool to reduce the time of applying it. While, Shuen- Tai Ung (2015) illustrated a new CREAM tool utilizing Fuzzy logic and introduced a modified framework capable to resolve difficulties based on under the classification of rule-based approaches of traditional way.

Shuen (2015) presented new adaptive model for using CREAM by fuzzy logic for dealing with human failures on board vessels where technological, environmental and social factors are emerged. The usage of CREAM in maritime domain is still disclosed and weaken the applicability of such an approach. The results acquired are consistent with the principles evolved from the axioms since the outcomes are sensitive to the minor alterations of input data and weights.

In addition to the proving that CREAM tool is capable to produce reliable risk outcomes once applied in different fields in which the probability intervals may vary due to its flexibility, it seems promising that the CREAM tool can be applied to other industries with confidence.

Akyuz and Celik (2015) used the results of De Felice et al, (2013) and Jianxing et al, (2014) then introduced a research of a very critical, potential hazards operation “loading Liquefied Petroleum Gases (LPG) tanker” during these process stages, human reliability (operation without failure) plays a crucial role in maintainable transportation of such type of cargo.

Sana et al. (2017) introduced CREAM as one of the second-generation HRA tools used to evaluate human reliability; they illustrated how it has a strong, detailed theoretical background that focuses on the important cognitive features of human behavior. The study revealed the significance of CPCs, woke environment, and the time available for work were among the most important factors that reduced occupational performance.

Zhou et al (2017) presented risk assessment study of spill accidents of LNG carriers handling operation based on fault tree assessment and CREAM HRA tool taking into account various uncertainties caused by lack of data in human reliability quantification.

Hogenboom (2018) presented a comparison research of human reliability analysis methods.

Zhou et al (2018) proposed a quantitative HRA model based on fuzzy logic theory, Bayesian network, and CREAM for the tanker shipping industry. The CPCs in conventional CREAM approach are custom-modified to better capture the salient aspects of the situations and conditions for on-board tanker work. Human Error Probability (HEP) is obtained from memberships of the control modes and the results of Bayesian network reasoning.

Rashed (2019) proposed a model based on CREAM used for predicting HEP in shipboard a safety critical operation utilizing a created software.

3- The Concept of CREAM Tool

CREAM inspects the environmental context in which humans operate and evaluate actions utilizing a difference between competence and control (competence discusses what a person can do, while control refers to how competence is applied). There are two versions of CREAM to calculate human error probability basic version and extended version. Basic version offers a primary screening of human error, to realize the probability of error. While extended version uses the outcomes of basic version to obtain the detailed value of the probability of error. CREAM introduced nine CPCs.

CPCs constructed the basis of identifying the condition of likely performance. The features of the different conditions were revealed by four control modes (Scrambled, Opportunistic, Tactical, and Strategic).

The assessors use to find out the score of CPCs for a certain task by counting the number of reduce, not significant, and improve performance reliability which is stated by

$$\sum_{\text{reduce}},\ \sum_{\text{not significant}},\ \text{and}\ \sum_{\text{improve}}.$$

The Context Influence Index (CII) which is equal to $\sum_{\text{reduce minus}} \sum_{\text{improv}}$e of CPCs scores

$$\text{CII} = \sum_{\textbf{reduce}} - \sum_{\textbf{improve}} \quad \text{(Akyuz, 2015).}$$

The values of CII indicate the control modes through using table (1),and graphically Fig(1), if the score of CPCs is not significant, i.e. there is no effect upon human performance reliability, so it can be discounted and ignored.

Table (1) CREAM Control Modes and its values

Control modes	HEP Interval	CII values	Control modes descriptions
Strategic	0.00005< HEP<0.01	-7 to -4	The strategic mode provides a more efficient and robust act and may consequently seem the ideal to strive for.
Tactical	0.001 < HEP < 0.1	-3 to 1	Performance typically follows planned procedures while some definite deviations are probable.
Opportunistic	0.01 < HEP< 0.5	2 to 5	The person does very little planning or anticipation, perhaps because the context is not clearly understood or because time is too constrained.
Scrambled	0.1 < HEP < 1.0	6 to 9	In scrambled control the choice of next action is in practice irregular or arbitrary. Scrambled control illustrates a situation where there is slight or no thinking involved in selecting what to do.

Source: NASA, 2006 & Akyuz, 2015

3.1- CREAM Basic Version

The CREAM tool basic version is utilized to evaluate the overall human acts reliability. Its outcome is a generic appraisal of CPCs probability for the whole task, this result is used in the extended version estimation, if the probability of error is not accepted, to take a closer look at the parts of the task that should be inspected more specifically, in order to provide a probabilistic estimation. The basic version of CREAM divided to three main steps:

- Identify the task
- CPCs Evaluation
- Find the control mode error interval determination

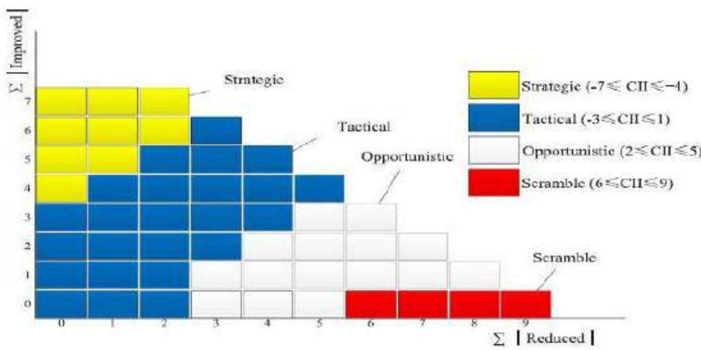

Fig (1) The relationship of each CPC and COCOM.
Source: (Xuhong et al, 2008) (Rashed, 2016)

3.2- CREAM Extended Version

The extended version of CREAM recognizes Error Modes of the four cognitive functions (observation, interpretation, planning, and execution). Extended version of CREAM is essential in cases where the general action probability of the basic method is unacceptably or when the uncertainty is large and intolerable (Hollnagel, 1998).

In the extended version, the task requires to divided the Task into sub-tasks or sub-steps each sub-step can be matched to one of fifteen pre-specified cognitive activities and identify Cognitive Failure Probability (CFP) type for each sub-task, then use the following equation to quantify it.

$$\mathbf{CII} = \sum_{i=1}^{9} \mathbf{PII} \text{-----------------------------} \mathbf{(1)}$$

PII of CPCs, which must have adjusted by expert judgement,

$$\mathbf{CFP} = \mathbf{CFP_0} \times \mathbf{10}^{\mathbf{0.26.CII}} \text{--------------} \mathbf{(2)}\ \text{(Akyuz, 2015)}$$

The extended version contains the following steps:

- **Cognitive Profile Construction**: Finding the values of Performance Influence Index PII, then construct a table include the CPCs and the values of PII for each main step of the task count on the results of Basic Version before utilizing equation (1)
- **Finding Human Error Probability:** Identify the cognitive activities, generic failures type related to the cognitive functions, which selected from a list of failures, CII for each main step of the task has been found, so using equation (2) using nominal CFP_0 to find the adjusted CFP. The main purpose of this step is to state the Cognitive Profile considering the dependences between cognitive activities and Contextual Control Model (COCOM) (De Felice et al, 2013).
- **Finding HEP:** It will be beneficial to construct a table collect the assessment task's sub-steps elements (sub-step – cognitive activity – cognitive function – generic failure type – nominal CFP or CFP_0 – $CFP_{adjusted}$) of the extended version. To use the tool, it is essential to follow the proposed diagram illustrated in Fig. (2) box diagram

4- CREAM MHEP Assessor Software.

To use the CREAM HRA tool with the explained procedures framework (model) it takes a long time and exerted effort to assess operation task for estimating HEPs for decision making. Therefore, it is essential to create a software as an assistance in prediction of HEPs, and to ease the procedures in practical usage.

CREAM MHEP Assessor Software is built using programing code "Node.js" and modules directly from browser and also use web technologies, rapid prototyping solution for user interface design. Node.js is a framework for building desktop applications with HTML, and JavaScript. The CREAM supporting software tool is based on CREAM HRA tool "prospective phase" with CPCs suitable for shipping industry domains. It contains the basic version and extended version of CREAM tool.

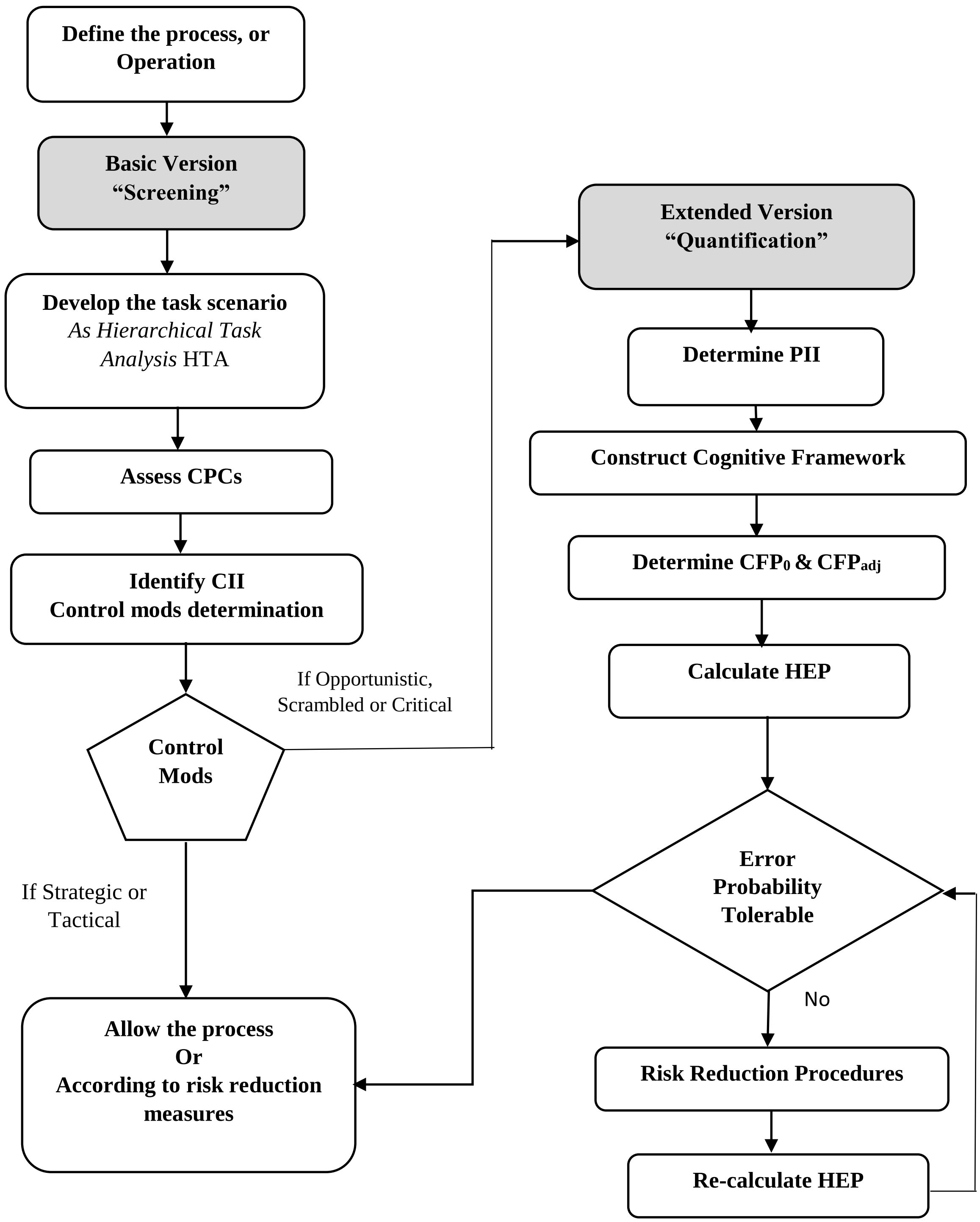

Fig (2) CREAM tool model

Source: Rashed (2019)

4.1- The Limitation of the MHEP Software

The CREAM MHEP Software is designed mainly to utilize with shipping industry domain working environment particularly safety and ship board critical operations, if required to use with another domain it needs a further re-adjustment.

5- Application Based on CREAM Tool Utilizing MHEP Software.

5.1- Lifeboat Drilling Task

Ship crew members training for abandon ship using life boats attached to gravity davits, and lowering the boat for a specific job under normal circumstances and good weather condition which changed to moderate with light swell when recovering the boat on day time drill. Table (2) contains accidents with significant impact of life boat fall during routine drill which have results of severe injury or loss of lives.

Table (2) Life boats drill accidents

Ship Name	Ship Type	Ship Flag	Accident Causes	Accident Date	Result
Harmony of the sea	Passengers	Bahamas,	Recovery of lifeboat During boat drill	Sep 2016	1 died
Norwegian Breakaway	Passengers	Bahamas,	Recovery of lifeboat Routine rescue drill	July 2016	1 died 3 injured
Nagato	Reefer	Panama	Life boat Recovery Abandon ship drill	Apr 2014	1 injured
Thomson Majesty	Passengers	Panama	Recovery of lifeboat During boat drill	Feb 2013	5 died
Saga Sapphire	Passengers	Malta	Recovery of lifeboat During lifeboat drill	March 2012	2 injured
Tombarra	RO-RO Car Carrier,	UK	Rescue Boat Recovery Fall. Stop of electronic proximity switch during monthly regular launching drill	Feb 2011	1 died
Velox	General Cargo	Isle of Man (UK)	Boat Fall During regular launching drill	Sep 2009	2 injured
Stena Britannica	RO-RO Passengers	UK	Life boat Recovery Abandon ship drill	May 2007	1 injured
St. Rognvald	Dry cargo	UK	Recovery of lifeboat.	Oct 2003	5 injured

Source : MAIB (2018)

Table (2) also reveals the significance of the operation task, even with different type of vessels and different flags. The task is prepared according to Hierarchical Tasks Analysis (HTA).

The Task Main Steps and Sub-steps in (HTA)

AS1 Prepare to abandon ship

1.1 Switch on the alarm.
1.2 Start announcement for abandon ship.
1.3 Report the situation to the crew.

AS2 Gathering at muster station.

2.1 Check that all crew gathered at muster station.
2.2 Check that all crew put on lifejackets correctly.
2.3 Announce a short brief all to crew for abandon ship procedures.
2.4 Confirm that crew fully understand the procedures.

AS3 Launch the Lifeboat.

3.1 Start the boat engine, close the drain plug, and put the boat ruder to the seaside.
3.2 Check that the painter is rigged in a correct manner.
3.3 Check that the harbor pins are out.
3.4 The gripes should be slipped and any triggers checked to see that they are clear.
3.5 Winch man lowers the boat down to the embarkation deck.
3.6 Check that the over side is clear, then lower away by lifting the brake handle.
3.7 The bowsing in tackles should be rigged in such a manner that the downhaul is secured in the boat.
3.8 The two men in the boat slip the tricing pendants once both ends of the boat are securely bowsed in.
3.9 Embark the Crew, and seated as low as possible in the boat.
3.10 Ease out on the bowsing in tackles to allow the boat to come away from the ship’s side.
3.11 Let go the tackles from inside the boat and throw them clear.
3.12 Winch man lower the boat with a run.
3.13 Release the boat from the lifting hooks and clear the ship.

AS4 Boat Recovery.

4.1 Secure a wire pendant to an accessible point on the davit arms.
4.2 Take extreme care to ensure that the strop and the wire Pendant with any shackles used, are of sufficient strength.
4.3 Put nylon strop on lifting hook of the boat.
4.4 Retrieve the boat falls at deck level and nylon rope strops shackled to the linkage from the floating blocks.
4.5 Fit both nylon strops over the lifting hooks, fore and aft in the boat.
4.6 Hoist the boat clear of the water until the floating blocks are ‘block on block’ with the davit head.
4.7 Cut away or work free the nylon strop when the strop becomes slack.
4.8 Walk back on the fall and secure linkage over the wire pendant on to lifting hook.
4.9 Detach pendant at davit head.

4.10 Make a check to the boat, davit wires, total links before secure (Seamanship Techniques).

6- The Results of Basic Version

Contain results summary of estimated weights of CPCs collected by expert's judgment opinionnaire during the interview and processed by CREAM MHEP Software, for the operation task's four main steps. Fig. (3) (graphically fig 4) contains relationship between the four main steps and the calculated results of CII values, control modes, and HEP intervals of the four main steps based on the CPCs levels collected by expert's judgment opinions that were entered into the software after the compilation.

NO	MAIN STEP	Σ IMPROVED	Σ REDUCED	CII	CII VALUES	CONTROL MODES	HEP INTERVAL
AS.1	Prepare to abandon ship	-3	1	-2	-3 to 1	Tactical	0.001<HEP<0.1
AS.2	Gathering at muster station	-3	1	-2	-3 to 1	Tactical	0.001<HEP<0.1
AS.3	Launch the Lifeboat	-3	1	-2	-3 to 1	Tactical	0.001<HEP<0.1
AS.4	Boat Recovery	-3	1	-2	-3 to 1	Tactical	0.001<HEP<0.1

Fig (3) The Results of Basic Version.

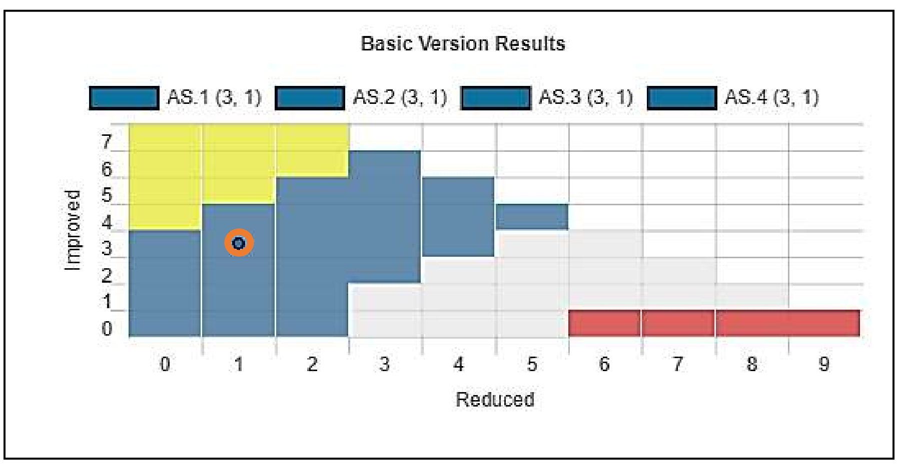

Fig (4) Graphical screening of the basic version results.

The results of basic version of the task four steps are “Tactical” control modes. The control modes HEP intervals is (0.001<HEP< 0.1), as shown in Fig. (3), and according to Table(1) this means “the performance more or less follows planned procedures, but some variation is still possible also the task is of critical grade that means it needs a deep analysis.

7- The Results of Extended Version

The extended version results are shown in Fig. (5) which illustrates the value of four main steps CII according to equations (1&2), the all steps relations and dependences collected by expert’s judgment opinion. The table shows HEPs for the four steps, and the potential HEP of the whole operation task.

CODE	MAIN STEP	CII	RELATION	DEPENDENCE	RULE	HEP
AS1	Prepare to abandon ship	-2.6	Serial Relation	Low Dependency	$1 - \prod (1 - value_i)$	1.4E-3
AS2	Gathering at muster station	-2.6	Serial Relation	High Dependency	Maximum Value	4.2E-2
AS3	Launch the Lifeboat	-2.6	Serial Relation	High Dependency	Maximum Value	4.2E-2
AS4	Boat Recovery	-2.6	Serial Relation	High Dependency	Maximum Value	4.2E-2
Potential Human Error Probability			Serial Relation	High Dependency	Maximum Value	4.2E-2

Main Steps HEP

Fig. (5): The Results of Extended Version.

The following Figs (6), (7), (8), and (9) show each main steps of the task and its sub-steps HEP values as curves after assessment by the software.

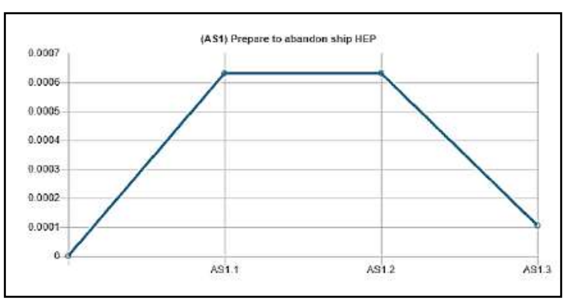

Fig (6) Main step AS1 and its sub-steps

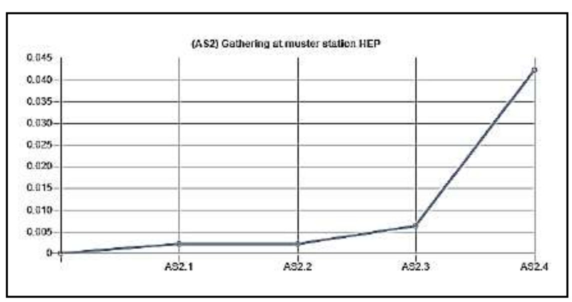

Fig (7) Main step AS2 and its sub-steps

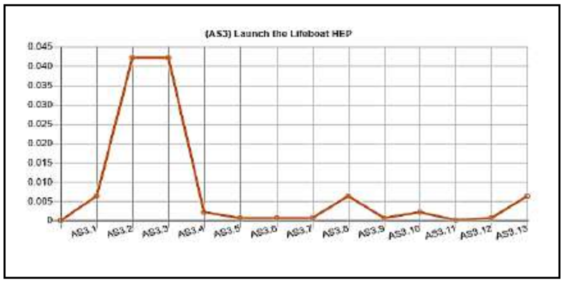

Fig (8) Main step AS3 and its sub-steps

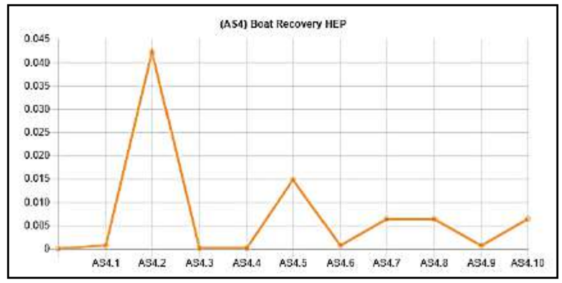

Fig (9) Main step AS4 and its sub-steps

8- The Task Results analysis

In the view of calculated HEP values, Fig. (5) reveals the potential HEP value of the whole operation task (extended version) is 4.2E-2, the software graphic result shows that the first main step (AS1) is comparatively low HEP, in comparison with the others steps, because there is less contribution of human elements in the preparation to boat drill, this makes the human error is less and serial relation between the main step (AS1) and its sub-steps with low dependence.

On the other hand, the other three main steps are equal in the potential HEPs and comparatively high as the number of crew members involved is greater in addition to the crew duties particularly the operation task at day time i.e. the human errors expected is higher than main step (AS1).

Fig. (6) shows the relation between the sub-steps and its HEP values of the main step AS1 that contains sub-steps (AS1.1) Switch on the alarm, and (AS1.2) "Start announcement for abandon ship". Both steps look comparatively higher HEP values, but th**e** HEP of its Main step is low.

Fig (7) illustrates main step AS2 "Gathering at muster station"; it is important for the operation to ensure that the crew understand the operation procedures to complete the operation with satisfactory level. For this reason, the expected human failure and HEP of sub-step (AS2.4) is drastically increase and skill based errors are expected. On the other hand, the other three sub-steps (AS2.1), (AS2.2), (AS2.3) HEP are law.

Fig (8) shows the main step (AS3) "Launch the Lifeboat" it is important step because the correct and safe procedure to launch the lifeboat is the core of whole operation that is why the expected HEP is nearer to the value of operation task HEP. The sub-step (3.2)

“Check that the painter is rigged in a correct manner.” and sub-step (3.3) “Check that the harbor pins are out” those two steps pertaining to the boat safety lowering process as a result Knowledge-Based Mistakes and Skill-Based Errors expected that’s why the HEP expected to be higher than the rest sub-steps HEPs.

Table (3) and Fig (10) conclude the sub-steps which have higher HEPs, and the sub-steps (AS2.4, AS3.2, AS3.3, AS4.2, and AS4.5) are more critical because the values of HEP of each is approximately equal to whole HEP of the whole task, that mean the probability of the task failure are confined in these five steps.

Also Fig (9) which illustrates main step (AS4) during the boat recovery, there is very important sub-step (AS 4.2) “taking extreme care to ensure that the strop and the wire pendant with any shackles used, are of sufficient strength”; there are many accidents of boat fall caused by unsuitable shackles, and the expected HEP of this sub-step is equal (4.2E-2) the same value of the excepted operation task HEP.

The table (2) reveals that the majority of lifeboat drilling fall accidents during boat recovery, specifically sub-step (4.2) ‘‘Take extreme care to ensure that the strop and the wire Pendant with any shackles used, are of sufficient strength”, and sub-step (4.5) “Fit nylon strops over both lifting hooks, fore and aft in the boat”. (even its HEP is comparatively low in and sub-step 4.5). The boat falls accidents of M/V Thomson Majesty, and M/V Harmony of sea occurred as a result of the mentioned two sub-steps (MAIB, 2018).

Table (3) Sub-steps with comparatively high HEPs

Sub-steps codes	Sub-steps	HEPs
AS2.4	Confirm that crew fully understand the procedures.	4.2E-2
AS3.2	Check that the painter is rigged in a correct manner.	4.2E-2
AS3.3	Check that the harbor pins are out.	4.2E-2
AS4.2	Take extreme care to ensure that the strop and the wire Pendant with any shackles used, are of sufficient strength.	4.2E-2
AS4.5	Fit nylon strops over both lifting hooks, fore and aft in the boat.	1.5E-2

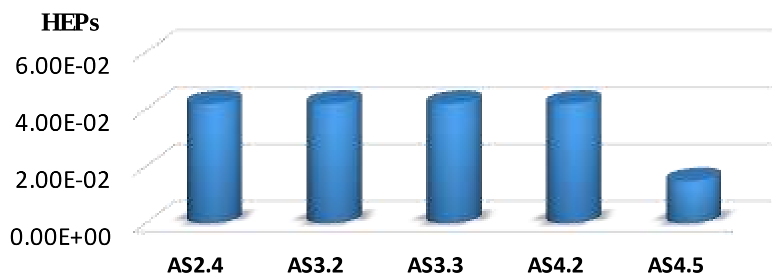

Fig (10) Sub-steps with comparatively high HEPs

By studying the causes and final flag state reports of the ships in table it was found that the majority of accidents occurred through sub-step (4.5) and sub-step (4.2) illustrates in the table (3) as comparatively high HEP results from the assessment of the task through the expert's judgement opinionnaire.

The whole results of the task revealed that the assessment can improve the level of safety training courses as well since studying the most critical steps or sub-steps of safety or shipboard operations tasks that require mitigation is very essential to modify such courses. Moreover, The CREAM HRA tool presents additional standards for safety procedures, awareness, and skills to build the safety culture and shipping organization safety strategies. The CREAM HRA tool is a prospective way for predicting the potential errors before commencing a critical safety task or scenario.

Conclusion

Human errors still the major causation of the ships accidents with the fast rate of development of the shipping industry and the technology of operations, and there is no database even national or regional counting the human errors in a suitable taxonomy. HRA has been used to update safety and risk-based decision-making in many industries for years, and a variety of tools have been accepted it remains a divisive area, it would deliver a practical power, and resource-efficient tool to the assessment and improvement of human reliability.

The CREAM HRA tool presents additional standards for safety procedures, awareness, and skills to build the safety culture and shipping organization safety strategies. The model Based on CREAM provides benefits to ship operators as an indicator for crew performance reliability and human error reduction tool onboard ships. Furthermore, the model is developed in a sequence that provides an integrated approach to increase the safety and effectiveness of safety and shipboard operations. The paper illustrated the utilization of the introduced model through CREAM MHEP Assessor software by applying it to the lifeboat drill process as a safety-critical shipboard operation task.

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Sustainable Development in Maritime Education and Training (SDiMET) Towards Global Maritime Professionals (GMP) Development

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ABSTRACT

Sustainable Development **(SD)** in Maritime Education and Training **(SDiMET**) can be seen as an innovative approach towards global maritime professionals (GMP) development. This IAMU funded study primarily reveals the perspectives of maritime representatives (i.e., presidents, administrative officers, leaders, and teachers) and maritime students on various areas of sustainability**.** The study looked into the conception and attitude towards **SD**, the awareness and commitment to **SD,** institutional measures to address **SD,** research and innovation of the Institution related to **SD,** and prioritization of **SD** in the maritime higher education institutions (MHEIs). A mixed-method approach to research was carried out with data obtained from the 73 institutional representatives and 405 students (from 31 IAMU members from 17 countries) involved in the study. Results suggest **SD** implementation in maritime higher educational institutions (MHEIs) are less than ideal and therefore needs improvement. Nevertheless, **SD** is of significant importance and has a place of high priority for MHEIs. However, barriers to the optimal implementation of **SD** principles in maritime higher educational institutions need to be strategically and committedly addressed**.** Using the **S-D-I-M-E-T** acronym for easy recall, MHEIS are encouraged to: **S**- Supervise campus by institutionalizing SD**; D-** Develop a team culture of Men and Women for sustainability roles; **I-** Incentivize or provide incentives to people's SD initiatives; **M-** Mix or integrate SD principles into disciplines, policies, procedures, curriculum, and practices ; **E**- Execute and **E**valuate sustainable initiatives & projects; and **T-**Train people for sustainability. The paper ends with conclusions and other recommended actions in navigating the future of MET for sustainability and GMP development.

Keywords: Global Maritime Professional (GMP), Maritime education and training (MET), Maritime higher education institutes (MHEI), Sustainable Development, Sustainable Development Goals (SDGs)

INTRODUCTION

In general, sustainable development (SD) is defined as a development that provides for the needs of the present while considering the ability of future generations to meet their own. Today's buzzword as the United Nations promulgated its 17-point Sustainable Development Goals (SDGs) primarily for poverty eradication, environmental protection, and prosperity assurance for all. Sustainability is a learning process that encourages transformative learning, the capacity to challenge existing patterns and worldviews, construct new knowledge collectively, rethink current practice, and critique and examine sustainability issues (Sterling, 2001 as cited by Cebrian et al. (2013). It is supported by three (3) pillars: economic, environmental, and social. Economic sustainability promotes financial capacity and quality of life improvements thru activities such as job generation and enhancement of business enterprises. Environmental sustainability deals with the capability of an institution to exist within the means of natural resources. Social sustainability is the ability of an organization to continually achieve excellent social well-being by ensuring the protection and promotion of human rights, gender equality, health, good governance, and others.

All sectors of society, including the educational sector, cannot thrive without keeping sustainable development in mind. **Education for Sustainable Development** has been an emerging research area, where much research has been conducted in integrating sustainable development in education (Barth & Rieckmann, 2016; Barth & Timm, 2010). However, in their analysis of higher education for sustainable development (HESD), Barth & Rieckmann (2016), concluded that HESD research is predominantly descriptive and only partly meets high-quality research standards. Moreover, integrating sustainability into higher education needs a re-orientation of teaching, learning and traditional approaches. Also, it is essential to advance innovative case studies to move higher education for sustainability forward to address the many changes in different disciplinary and cultural settings (Barth & Rieckmann, 2016). In a similar conclusion, Prylipko (2013) stated that the application of the sustainable development paradigm in the maritime sector seems to be problematic as there is no consensus among maritime experts on how it should be defined. She added that SD in maritime education and training (MET) needs re-orientation, resource allocation, and capacity building to implement **sustainable maritime development**.

Seafarers in the shipping industry are required to be in a continual state of education and training to ensure that they are up-to-date and well-versed in the current trends surrounding their duties and responsibilities aboard ships plying international waters. With this continual growth mind-set, **professional development** in the shipping industry is continually pursued. Seafarers are continuously required to hone their knowledge, skills and attitudes to have a positive outlook and perform their jobs more effectively and efficiently. Maritime higher education institutes (MHEIs), therefore, play a significant role in providing the shipping industry with the competitive and excellent maritime professionals that are to form the backbone of the maritime field. In this context, the International Association of Maritime Universities (IAMU) has recently (July, 2019) launched its leading initiative in maritime education and training, the **Global Maritime Professional - Body of Knowledge (GMP-BoK)**. The aim of the GMP-BoK is to provide MHEIs worldwide with an outcome-based approach to maritime higher education which, while meeting the needs of a rapidly advancing maritime industry, also recognizes the jurisdictional and social context of each individual university. The GMP-BoK ultimately aims to produce maritime graduates who remain current, vibrant, adaptable, professional and forward-looking so that they can continuously perform their roles successfully despite the rapid advancements in technology and the everyday disruptions in social and economic aspects. The following description is provided for a Global Maritime Professional (GMP).

> An individual who is a professional in the maritime industry and who is equipped with all the relevant technical competencies relevant to their specific operational role in the industry and as required by international requirements with high level academic skills including logical and critical thinking and who – in addition to their technical competency – exhibits a high level of <u>professionalism</u> and <u>ethical behaviour</u>, <u>human relations skills</u>,

emotional intelligence and multicultural/diversity awareness and sensitivity. Such an individual exhibits significant leadership skill and is able to optimally work with teams and also take personal initiative. They additionally exhibit a high sense of environmental consciousness and the need for **sustainable practices** and have an excellent grasp of contemporary issues affecting the maritime industry (IAMU, 2019).

From the above description, It can easily be noted that the concept of a GMP is strongly related to the notion of SD. Note the underlined words and phrases. Furthermore, the GMP-BoK outlines 28 focus areas that underline the knowledge, skills and attitudes (KSAs) required in a GMP. Focus area number 21 is titled "*Sustainable Development"* with a number of other focus areas closely pertaining to SD; e.g. Cultural/diversity awareness and sensitivity; Progressive mindset and lifelong learning; Environmental awareness, sustainability and stewardship; Professionalism and ethical responsibility… etc.

The same year the GMP-BoK was launched another closely related IAMU funded joint project was also concluded; the SDiMET joint research project which aimed to explore the landscape of sustainable development in maritime higher education. SDiMET involved four IAMU member universities; the World Maritime University **(WMU-Sweden**) as project leader, the Maritime Academy of Asia and the Pacific **(MAAP-Philippines),** the Arab Academy for Science, Technology and Maritime Transport (**AASTMT-Egypt)**, the University of Polytechnic Catalunya **(UPC-Spain)** with an independent researcher Ms. Alina Prylipko (WMU Report, 2019)**.**

The SDiMET research project primarily aimed to describe the perspectives of maritime representatives such as administrative officers, leaders, and teachers on various areas of sustainable development (SD). Also, the views of the students on similar concerns were sought. In addition, the study looked into the conception and attitude towards SD, the perceived commitment of the Institution to SD, measures or efforts taken by the Institution to address SD, awareness, and commitment of faculty/staff and students to SD, research, and innovation of the Institution related to SD, use of SD in learning, prioritization of SD in the maritime higher education institutions (MHEIs) and other feedback on SD.

The implications of the findings of the SDiMET project to GMP development are paramount. This study, therefore, provides maritime higher education institutions (MHEIs) with research-based information (extracted from the SDiMET project) relevant to making the wise decisions needed for the sustainable development of campuses and to further inform MHEIs in their quest to develop innovative plans, programs and curricula as required for the development of future GMPs.

METHODS

This research employs a mixed-method approach that involves quantitative and qualitative research techniques, methods, approaches, and concepts (Johnson and Onwuegbuzie, 2004). This method frees the research from extreme Durkheimian positivism restrictions, which tend to focus exclusively on objectified quantitative information, or Weberian *'Verstehen,"* which leans towards focusing exclusively on subjective meaning (Manuel, 2011). Like qualitative research, this study focuses on gaining deep understandings of social phenomena. Quantitatively, the research obtained numerical data treated with descriptive statistical methods.

The research instruments were developed from a comprehensive literature review on sustainable development (SD) in general and integrating SD in maritime higher education institutions (MHEI). The researchers came up with themes and categories, which were then used for further exploration through surveys and interviews. First, a survey for IAMU institutional representatives was formulated about various SD-related topics and how their institutions are immersed in these topics. Then, a second survey was carried out for students of the same IAMU member universities. The student survey was similar in structure to the first survey but had more student-specific questions. Finally, for a more holistic picture of the situation in the sampled institutions, a semi-structured interview of institutional representatives was done on-site and online due to the COVID-19 pandemic.

The survey questionnaires were completed by the respondents online. The research involved 73 institutional representatives such as lecturers, professors, directors, rectors, managers, chief operating officers, deans, principals, and presidents. The 73 responses gave a 47% response rate from the 31 IAMU member universities involved in the study.

For the student survey, 405 respondents from 29 institutions in 17 countries were involved in the final analysis. The group consists of 83% males and 15% females. About 49% came from Europe and Africa, 39% from Asia, Pacific and Oceania, 6% from the Americas, and the other 6% were special members. For academic program level, 59% are Bachelor, 15% Diploma, 15% Master, and two percent (2%) Doctoral. Most 64% have no seagoing experience, while the other 36% have already worked onboard ships.

All statistical analyses were done using SPSS Version 26.For research ethics, the research participants were assured that all information is analysed and presented in aggregates, and their data were used strictly for research reports/publications.

RESULTS and DISCUSSION

The following are results extracted from the two SDiMET surveys involving institutional representatives and students, along with the results of the interview of the a number of institutional representatives.

Dimensions of Sustainable Development (SD)

As for the definition of SD, responds mostly coalesce around the definition used in the 1987 Brundtland Commission Report; i.e., "sustainable development meets the needs of current generations without compromising the ability of future generations to meet their own needs."

It is, interesting to note that when queried for their opinion on the importance of the three different dimensions of sustainable development; both the institutional representatives and the students ranked "*environment"* first, "*social"* second, and "*economics"* third. While SD is a paradigm for thinking about a future with a balanced consideration of the environment, society, and economy to pursue advancement and improved quality of life, respondents have shown a bias towards the environment. While educational institutions may be primarily concerned with the social dimension given their nature and mandate, the environmental dimension gained primacy. Prylipko (2013) argued that SD, as a paradigm, is jeopardized by mistakenly considering its three pillars equally important instead of considering that the economy is a system within society, which depends on the environment.

On the other hand, Zeeger & Clark (2014) found that despite undergoing a pedagogical approach that challenged views through discussion, debate, and reflection and provided a balanced view of sustainability, many students still leaned towards environmentally focused perspective sustainability. However, Fisher & McAdams (2015) stated that though students, in general, emphasize the environmental aspects of sustainability, they also have an increasing grasp of the other dimensions of sustainability. Sustainable development, rightly understood, provides a better perspective on the any profession and its relation to society, environment and economy. Thus, ultimately paving the way for the concept of Global Professionals.

Implementation of SD

A majority of institutional representatives (64%) reported that their institutions were required to consider SD in their general operations. Almost 70% also claimed that they are required to somehow consider SD in their curriculum. The majority (83%) indicated that their institutions have vision and mission statements and accreditation/certification related to SD. However, only 42% have SD policies and only 53% with institutional social responsibility policies. Only 11% have signed an SD declaration.

As for students, more than 76% of respondents had a positive commitment to SD and 94% were of view that inclusion of SD issues in education was quite important. Nonetheless, only 37% were aware of the presence of any practices or initiatives related to SD on campus.

Sustainable Approaches to Institutional Governance and Facilities

On average, the institutions involved in the study lean towards having no concrete governance issues and facilities for sustainable development. For example, on a scale of 0-10 (0 being of "not present" and 10 being "fully present"), a formal sustainability office or position obtained a mean of 4.77 (with a standard deviation of 3.81) while a formal working group on sustainability had a mean of 4.67 and a standard deviation of 3.62. Likewise, incentives for staff and students to work on sustainability were at 4.66 and 4.52 respectively. are not fully present at the time of the research.

Institutional representatives, on average, tend to agree on various governance issues and facilities for sustainable development. They tend to believe that facilities on campus are designed and built based on SD principles. Using a 1-5 Likert Response Format (Strongly Disagree to Strongly Agree), the highest mean rating of 3.94 (with a standard deviation of 0.93) was provided on this concern, followed by having clear rules for waste management in the Institution's facilities. On the other hand, the institutional representatives have neutral views concerning having incentives for faculty and staff to operate sustainably (mean = 3.24, standard deviation = 0.98), having incentives for students to work sustainably (mean = 3.28, standard deviation = 0.90), the Institution's operations leaving only a small carbon footprint (mean = 3.38, standard deviation = 0.99), and the waste being recycled in the Institution (mean = 3.38, standard deviation = 1.09)

The students' views on the Institution's commitment to SD through various governance issues and facilities tend to be positive. On the other hand, the institutional representatives' views on use of renewable energy sources at the respective institutions was limited; only 41% of the 73 respondents reported their institutions using renewable energy sources, while 29% stated that they are not yet using such energy sources, and 27% are unsure.

Institutional Measures to address SD in MHEI Operations

Possible institutional measures to address elements of operational sustainable development include efficient use of water, the greening of institutional campuses, reduction of water, reduction of carbon footprint, energy-efficient buildings, and effective waste recycling. These measures topped the list of institutional representatives. However, these actions are not as prevalent as may be desired.

On a scale of 0 to 10, institutional representatives are a bit neutral on their responses regarding the effectiveness of their institutional measures to address elements of operational SD. The top mean of 6.58 (with a standard deviation of 2.03) is on efficient use of water, followed by the greening of institutional campuses with a mean of 6.28 (with a standard deviation of 2.97). In contrast, institutions have none or almost no measures for vehicles powered from renewable sources, and mechanisms tracing the institutional carbon footprints.

Though results are rather similar, students have slightly higher regard towards the institutional measures to address elements of operational SD. The top mean of 6.72 (with a standard deviation of 2.96) is on effective waste recycling, followed by water reduction (mean=6.63, standard deviation=2.82). Like the institutional representatives, the students provided their lowest mean ratings on vehicles powered from renewable sources (mean=4.49, standard deviation=3.56) and mechanisms for tracking the institutional carbon footprints (mean=4.84, standard deviation=3.40).

For both groups, an extreme need for improvement can be vigorously pursued using vehicles powered by renewable sources and mechanisms for tracking the institutional carbon footprints. Moore (2005) promulgated infusing sustainability into all university decisions, promoting and practicing collaboration and transdisciplinarity, and focusing on personal and social sustainability. She also recommended integrating sustainability in university plans, decision-making structures, evaluative measures, research, services, and teaching components.

As for the presence of policies and institutional procedures on sustainable development, the top institutional measure, “conferences on SD”, was confirmed by only 32% of respondents.

"Continuous professional development of human resources on SD" followed by 22% and only 16% confirmed having "guidance on integrating SD in their institutional operations".

Faculty, Staff, and Students' Awareness and Commitment to SD

Results suggest that faculty, staff, and students are not as aware of and committed to SD issues as may be considered ideal with less than optimal means. While awareness of faculty and staff seems slightly higher than that of students, direct inspection of mean ratings (5.67 compared to 5.61 as ranked by institutional representatives) suggests that overall awareness of both groups is quite comparable. The same may, also, be said about commitment to SD (5.50 compared to 5.46 as ranked by institutional representatives).

This result supports the finding of Barth and Timm (2011), wherein a high rate of commitment among the undergraduate students and a sophisticated understanding of the concept of sustainability towards an innovative approach to educational change was evident.

SD Research and Innovation

The institutional representatives consider research and innovation on SD at their institutions to be reasonable with mean ratings ranging from 3.47 to 4.04 on a 5-point Likert Response scale. However, results of surveys for both institutional representatives and students indicate less than ideal institutional support to research and, therefore, certainly need improvement, especially on researches that focus on social, economic, and environmental dimensions of sustainable development.

The most favored statement, "research at the institution is interdisciplinary", obtained a mean of 4.04 (with a standard deviation of 0.81). The lowest mean of 3.47 (with a standard deviation of 1.01), indicating a neutral rating, is on the Institution's support through funding research on sustainability.

On the other hand, students placed the highest regard on the importance of SD knowledge for their future professional performance (mean = 4.29, standard deviation = 0.78). In contrast, they gave the lowest mean rating of 3.37 (with a standard deviation of 1.15) on their personal involvement in sustainable community projects; a result that clearly indicates much room for institutions to improve on this area. Hence, the notion of integrating sustainability into higher education not only needs a re-orientation of teaching and learning and traditional approaches. It, also, is necessary to advance innovative case studies to move higher education for sustainability forward so that the many changes in different disciplinary and cultural settings can be addressed (Barth & Rieckmann, 2016).

Integration of SD in the Educational Curriculum.

When asked for their views on the integration of SD in the educational curriculum of their institutions, institutional representatives, 42% agreed that their institutions integrate SD elements, to some extent, in existing subjects. For example, certain principles of SD and environmental conservation may be reflected in existing subjects such as in Marine Pollution.

Only 13% of respondents indicated providing a stand-alone SD subject in their programs. Approximately 12% offer a Bachelor's program in SD, while only 10% offer a Master's program. Additionally, both institutional representatives and students had a moderate view on the degree of sustainability of the materials used for student learning activities with both rating sustainability of materials at approximately 6.26 (on a scale of 1 to 10).

It is evident that SD is not yet pervasively integrated into the curriculum of the institutions involved in the study. This result coincides with the findings of Amador et al. (2015) that there is an increasing number of higher education institutions engaged in integrating SD into their curricula; however, this has not yet been infused into all disciplines. Also, Fisher & McAdams (2015) recommended that sustainability programs incorporate a course or series of courses that expose students to a wide variety of scholarly approaches to sustainability early in the curriculum. Greater attention should be paid to fully integrated programs emphasizing typical descriptors of effective sustainability education.

Prioritization of SD in Operations, Curriculum, and Learning Outcomes.

Compared to other aspects of SD, prioritization in terms of operations, curriculum, and student learning outcomes are quite highly favored; with a mean rating of 8.11 given by institutional representatives and a mean rating of 7.73 by students. This finding supports Prylipko's (2013) study, which promotes education as the most powerful tool to consider to meet the United Nation's vision of meeting the needs of the present without compromising the ability of future generations to meet their own. She added that SD in MET needs re-orientation, resource allocation, and capacity building to implement sustainable maritime development.

With this in mind, it is interesting to note that only a handful of the institutions involved in the study have already signed a declaration as part of a network related to SD. About 58% reported being unsure if their institutions are willing to do it, while 37% expressed a positive response to this SD involvement.

Sustainability development in education should be advanced with the involvement of every member of the Institution, especially the senior officers. Students may be eager to engage in SD activities, but it is also crucially important that leading administrators provide top-down support. Communication is key. It is also essential that the Institution's accountability is linked with campus sustainability, e.g., greening the campus as part of corporate social responsibility or societal development involvement (Müller-Christ et al., 2014).

Overall Implications to GMP Development

The GMP-BoK includes, inter alia, sustainable development, cultural/diversity awareness and sensitivity, progressive mindset and lifelong learning, environmental awareness, sustainability, and stewardship, as soft professional elements that maritime students should develop to be successful global maritime professionals (IAMU, 2019).

Results of the SDiMET project prove that the inclusion of sustainable development, along with the above-mentioned SD-related elements, as necessary focus areas to the development of Global Maritime Professionals (GMPs) is far from arbitrary. Sustainable development, as the results show, is perceived by both institutional representatives and students to be of high importance. Yet, SD implementation in maritime higher educational institutions (MHEIs) is less than ideal and needs improvement. The SDiMET project helps shed the light on the intricacies of SD in MHEIs; therefore, proving quite important to the GMP initiative.

For one, MHEI students are not only willing, but are eager to learn about and practice SD. They understand the importance of SD to their future whether it be on a personal scale or professionally. For most focus areas of the GMP-BoK, working on the affective domain may not be a simple task. However, results of the SDiMET study show that when it comes to SD students are already "*affectively*" on track. Oddly, it is the cognitive domain that requires more attention when it comes to students embracement of SD principles. Students already embrace the importance of SD. They just need to learn more about it. This by no means implies that the affective domain may be neglected. In order to reach higher levels of achievement within the affective domain, students need also to engage in sustainable practices and activities both on campus and outside.

Secondly, students' perception of SD mainly revolves around the "environment". However, they seem to lack a good understanding of the remaining two pillars, "society" and "economy". Therefore, as MHEIs seek to create GMPs, some attention may need to be devoted to these two areas of SD; especially taking into account the very economic and social nature of the maritime industry.

Thirdly, the GMP-BoK aims to integrate SD principles in the curricula of MHEIs. With "internationalism" as one of its two guiding principles, the GMP-BoK does not specify how this should be achieved. MHEIs are free to introduce SD principles into their existing curricula or otherwise create a whole new course dedicated to SD. Though, the first approach may seem more simple and effective, the latter approach may be more comprehensive. By creating a dedicated SD course, students of MHEIs will surely get a universal sense of what SD means. They will be able to take a glimpse into the seventeen Sustainable Development Goals, thus, broadening their understanding of SD. The course should of course, during its later stages, focus on the unique nature of the maritime industry thus working towards the idea of GMPs.

Finally, in order to produce GMPs who embrace sustainability, students not only need to be educated on SD; they need to observe, feel and breathe SD. They need to see sustainability being practiced in every corner of their educational institution; in the curricula; in the conduct of staff and faculty; and in the institution's facilities including energy-efficient buildings, the greening of campuses, efficient use of water, reduction of carbon footprint, effective waste recycling, etc. Without a whole-institution approach to SD, truly realizing GMPs may become a challenge.

CONCLUSIONS AND RECOMMENDATIONS

Results suggest that sustainable development is perceived to be of high importance, with environmental dimension as the most essential, followed by societal and economic aspects, in that order. Furthermore, the respondents have a fairly high level of understanding of the concept of sustainability. It can be surmised from the results that sustainability does not simply require an “add on” to existing structures and curricula, rather, it implies a change of belief in the respondents (faculty, staff and students) culture, thinking and practices.

Generally, SD implementation in maritime higher educational institutions (MHEIs) is less than ideal and needs improvement. However, institutional awareness and commitment can be harnessed to prioritize SD for research, innovation, operations, and curricula.

In navigating the future of MET for sustainability, this study recommends the following **action plans for implementation of MHEIS** using the **S-D-i-M-E-T** acronym for easy recall.

- **S**upervise campus by institutionalizing SD in short and long-term plans, including technology, renewable energy, and other green sustainability practices.
- **D**evelop a team culture of professionals (GMPs) for sustainability roles.
- **I**nvolve and **i**ncentivize faculty, staff and students (future GMPs) whose activities contribute to sustainability.
- **M**ix or integrate SD principles into disciplines, VMGOs, policies, strategies, university plans, decision-making structures, evaluative measures, research, services, and teaching components including courses, programs and curricula.
- **E**xecute and evaluate initiatives & projects for sustainability and workforce development.
- **T**rain faculty, staff and students (future GMPs) for sustainability.

It is, also, worth noting the IAMU Tokyo Statement, which requires member universities to "*engage in sustainable university operations and to educate a future generation aware of and working toward sustainable development in a socially peaceful context, emphasizing the attainment of global goals such as the current 2030 UN Sustainable Development Goals and optimal stewardship of the pla*net." In the light of these realities, the research recommends that IAMU proactively promote the integration of SD principles among member institutions and that member university programs and curricula reflect this commitment; an IAMU sponsored SD declaration perhaps.

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The Application of the Global Maritime Professional Framework on an MET Program: A Case Study

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Abstract

This paper delineates an attempt to apply the framework of the Global Maritime Professional (GMP) as it has been articulated in the *2019 Body of Knowledge* (BoK) to an existing program in order to asses that program, and also to test the navigability of the tables – to see what may be problematic, and to see how both the program and the BoK could be adapted to address the future needs of the maritime world. It was hypothesized that the Marine Transportation Program of CSUMA – embedded as it is within a very large American system of higher education with many externally-required provisions for general education and other knowledge acquisitions outside of maritime training – would align quite positively with the criteria and the levels of achievement stated in the BoK.

By describing the process of mapping an academic program onto the GMP framework it is hoped that such an endeavor will inform other institutions that are likewise engaged (or considering engagement) with this project. Furthermore, recommendations will be identified for improvement of the program under scrutiny, the mapping process, and, perhaps, the framework itself for continuous future improvement of the educational development of the maritime professional.

Keywords: Global Maritime Professional, Maritime Education and Training

1. Introduction

One of the International Association of Maritime Universities' foundational and fundamental goals was to provide a universal, coherent, international curriculum for maritime education and training. [1] The past two decades have seen several iterative but aborted attempts to deliver on this goal. A few studies are cited in the Book of Knowledge itself – "The Harmonization of European Maritime education and Training Skills (METHAR), the Thematic Network on Maritime Education, Training and Mobility of Seafarers (METNET), and The Skills and Competences Development of Future Transportation Professionals at All Levels (SKILLFUL) – but there have been several IAMU articles and presentations on this topic as well [2]. Work on this objective began to coalesce around an outcomes-based notion of what, collectively, we seek in the maritime community. Instead of focusing on the near-impossible task of aligning curricula across diverse institutions with different governing bodies and myriad local, national, and regional accrediting agencies, the orientation shifted toward identifying the characteristics of a "Global Maritime Professional." This would be "an individual who is not only equipped with all the relevant technical competencies" but also exhibits a "high level of professionalism and ethical behavior," has "high-level academic skills," is able to "optimally work with teams and take personal initiative," and "exhibits a high sense of environmental consciousness and has an excellent grasp of contemporary issues affecting the maritime industry" [3].

The notion of re-orienting the attempt to universalize MET – moving from model courses, standardized curricula, modules, exams, etc. toward outcomes-based or competency-based educational models – is not necessarily new (see El Ashmawy, Weintrit, Benton) [4]. However, the breadth and sophistication of the model articulated in the BoK builds upon past theorizations and postulations to ultimately create something substantive and actionable. The inclusion of database tools, integrated rubrics and tables, and specific benchmarks across different cognitive, affective, and psychomotor domains is designed not to be a scholarly artifact, but a living workbook whereby maritime universities may assess and evaluate their programs against a prescribed model with a vetted methodology – something which should hopefully gain traction across all maritime institutions.

This paper delineates the attempt to apply this framework to an existing program in order to not only asses that program in light of the global parameters set forth in the Body of Knowledge, but also to test the navigability of the tables – to see what may be problematic, and to see how both the program and the BoK could be adapted to address the future needs of the maritime world. The Bachelor of Science in Marine Transportation at the California State University Maritime was assessed as a "GMP Tier B" program across the cognitive, affective, and psychomotor domains, with the understanding that other institutional programs would be assessed later. It was the hypothesis that Cal Maritime's program, because it is embedded within a very large American system of higher education with many externally-required provisions for general education and other curricular considerations outside of maritime training, would align quite positively with the criteria and the levels of achievement articulated in the BoK.

Part of the elegance and usefulness of the GMP model rests in its orientation to outcomes-based education (OBE). This, as Roy Killen notes, can be seen as a "theory or philosophy of education in the sense that it embodies and expresses a certain set of beliefs and assumptions about learning, teaching, and the system structures within these that activities take place" [5]. This involves moving away from the type of assessment based on test results and completion rates and moving toward a transformational OBE which is less tangible and "is usually expressed in terms of what students know, are able to do, or are like as a result of their education" [6]. An additional distinction of outcomes-based education is its principle of "designing back." Instead of a orientation wherein a program is constructed from course design and instructor input, "the starting point for all curriculum design [in transformational OBE] must be a clear definition of the significant learning that students are able to achieve by the end of their formal education. All instructional decisions are then made by tracing back from this "desired end result" and identifying the building blocks of learning that student must achieve in order to reach the long-term outcomes" [7]. Such a design principle circumvents the thorny and complex issue of attempting to standardized curriculum or courses or modules that fail the test of translation from one university (or country) to another. Thus, while there is slippage in the nomenclature of "outcomes-based education" and "competency-based education," the central point is to understand how this informs the GMP Book of Knowledge, and how this can work towards the implementation of a globalized platform for MET.

2. CSUMA and the Program in Marine Transportation

As noted in Section 4.3.2 of the *Global Maritime Professional Book of Knowledge*, this inaugural version "is targeted at ship operators (onboard or remote). This is in line with the criteria for membership of the IAMU. However, it is recognized that many of the member universities do not exclusively educate and train seafarers and their educational offering include a range of competencies in the maritime industry defined in wider terms than technical ship operation. It is envisaged that future version of the BoK will include and specifically address this wider scope" [8]. The California State University Maritime Academy is such an institution, with degree programs in International Business and Logistics, Facilities Engineering, Global Studies and Maritime Affairs, Oceanography, and Transportation and Engineering Management, among others. More will be said about these programs and the possibility of further editions of the BoK in the conclusion of this essay, but in line with the initial intent of the BoK, the initial program under scrutiny is Cal Maritime's bachelor's of science in Marine Transportation (MT). This major provides the broadest maritime industry training possible consistent with officer licensing requirements. Through the wide array of professional skills taught, the MT program is designed to prepare students to take the U.S. Coast Guard STCW licensing exam for Third Mate and Officer in Charge of the Navigational Watch. Passing this examination, which results in the issuance of a Third Mate's license, is essential for a student seeking employment as a licensed deck officer on a commercial vessel. Marine Transportation graduates also have a broad employment field open to them: a wide variety of shore-side management positions are available in numerous maritime sectors, including vessel operations, ship's agency, marine insurance, stevedoring, charter brokering, and federal employment.

This is the most populated major on campus, with approximately 300 enrolled students. It is also a very high-unit major, requiring 159 units to complete while the U.S. standard for a B.S. degree is 120 units (See Appendix A). One reason for the high number of units is not necessarily because of STCW requirements, but because Cal Maritime is a campus of the California State University system (CSU), a series of campuses under a Chancellor's Office that serves close to 500,000 students and is the largest comprehensive university in the country. As such, the CSU has several General Education requirements designed to complement the major program completed by each baccalaureate candidate. These requirements are designed to "provide the knowledge and perspectives that will enable CSU students to confront personal, cultural, moral and social issues that are an inevitable part of human life, and cultivate enthusiasm for lifelong learning" [9].

Additionally, the Marine Transportation program has a series of program learning outcomes, which are aligned with the institution's general education outcomes, which are then aligned with Cal Maritime's Institution Learning Outcomes. Ultimately, these correspond to the university's mission, in a triangulated hierarchical construction from the more specific to the more general. It is up to various assessment bodies on campus to ensure that students are meeting their learning outcomes on the multiple levels. (See Appendix B for MT Program SLOs and MT Gen Ed SLOs).

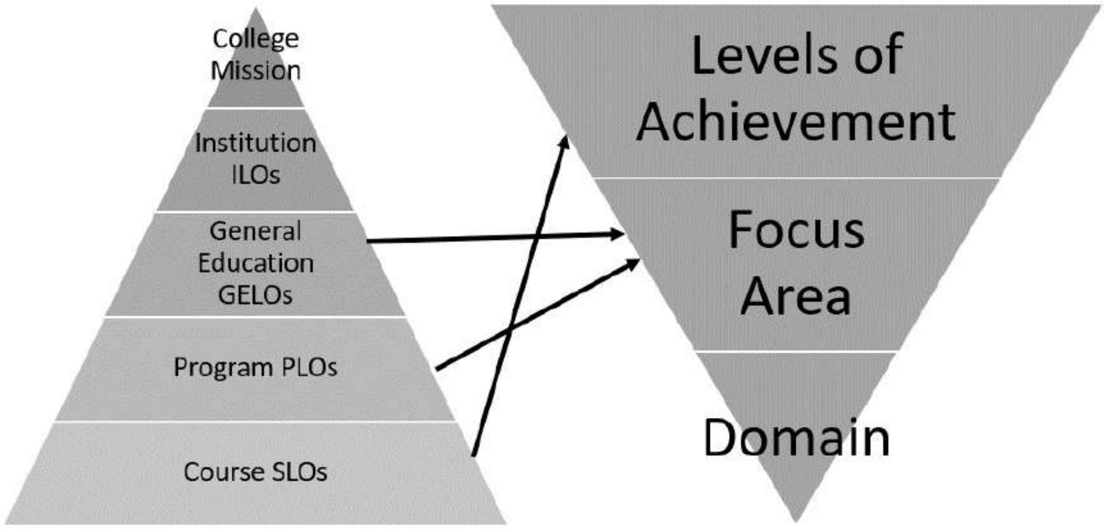

Figure 1. Learning Objectives mapped to BoK

This introductory material is presented in order to understand how the hierarchical model of learning outcomes fed into our mapping project with the BoK. At Cal Maritime, GE learning outcomes and program learning outcomes derive from a set of cohesive courses that fold up into the more generalized institution learning outcomes and ultimately, the institutional mission as displayed in the left pyramid in Figure 1. The BoK's designated levels of achievement (on the inverted pyramid on the right side of Figure 1) can only be ascertained by drilling down to the specific course outcomes that are determined by program coordinators and are assessed on the course level. The following sections will identify and analyze specific challenges we faced in navigating the BoK tables, mapping the curriculum, and ascertaining appropriate levels of achievement.

3. Navigability of the Charts

An initial problem arose when first attempting to use the proposed method of employing the tables in accordance with the implementation framework. As suggested, after selecting the appropriate GMP tier, the program administrator would move to "Related Focus Areas," select the corresponding level of achievement, and finally locate the associated "Intended Learning Outcomes." However, this led to an important question of how exactly the institution intends to use to the framework. This approach works if the intent is to see what the institution needs to do to bring its program up to the pre-determined thresholds of the specific tier. A different orientation to the assessment – which we found to be more useful – was to *begin* with the Intended Learning Outcomes, compare them to our own program learning outcomes, and then work backward through the LoAs and the Related Focus Areas. This allowed us to better see where our program met, exceeded, or failed to meet the level of achievement as determined by the framework.

While the specific tier tables in Appendix 1 of the BoK helped to alleviate this problem of navigating across domains and levels and areas, an assessor would still have to toggle between, say, Table 7 (Tier A Levels of Achievement) and Table 10 (Tier B Levels of Achievement) if the intent was to measure compliance to that higher domain level.

This issue was unfortunately reinforced by the BoK tool that was built using Microsoft Access, a database management system that combines the relational MS Jet Database Engine with a graphical user interface and software- development tools. Despite the ubiquity and global reach of Microsoft products, this is not a DBMS that is used widely at Cal Maritime: it had a somewhat clunky interface, and was not very user-friendly in extracting specific foundational or academic elements. Additionally, there was limited ability to format the data into reports to disseminate to affiliated groups on campus for curricular review and revision. Of course, this is by no means a fault of the BoK framework itself: the conclusion of this essay makes a recommendation for adopting a different technology for this particular function.

4. Curriculum Mapping of the Cognitive Domain

Perhaps a less significant observation, but in introducing the GMP framework to program coordinators and assessment committees, there was some initial confusion as to how the levels of achievement were meant to be associated with the program under observation because the language used to describe each level mirrored the language in rubrics used to assess programmatic outcomes, even though the purpose of these rubrics are quite different. For example, when looking at the mathematic focus area of the cognitive domain, to meet the level of Tier B, the program should rise to "Level 4: Analyzing" (See Figure 2)."

Table 4: Intended learning outcomes in the cognitive domain

Focus Area	*The Cognitive Domain level of achievement*					
	1 Remembering	2 Understanding	3 Applying	4 Analyzing	5 Evaluating	6 Creating
	Foundational elements					
1. Mathematics	**Identify** key mathematics information and **recall** equations related to academic and professional skills.	**Explain** relevant mathematical principles.	**Demonstrate** the application of mathematical principles to the solution of relevant problems	***Analyze*** *complex problems to determine relevant mathematical principles and* ***examine*** *solutions in light of this analysis.*	***Evaluate*** *the merits of using different mathematical approaches to solve problems.*	***Create*** *new knowledge/approaches in mathematics.*

Figure 2. Bok LoA for Mathematics Focus Area. [10]

In contrast, at Cal Maritime when assessing mathematics (or what we term "quantitative reasoning") a conventional rubric is used to score specific artifacts. In Figure 3 (an excerpted appendix from a Cal Maritime annual assessment report), a scale of 1-6 is used to determine students' mathematical proficiency, with a predetermined benchmark of 4 declared as meeting that particular outcome. Thus, if a subset of students based on any number of factors (major, gender, ethnicity, economic status, etc.) fails to meet the benchmark, targeted actions can be recommended for improvement. Therefore, while the language in the rubrics in Figures 3 and 4 may be similar, they are used for different purposes – one to provide data on specific groups of students in order to promote continuous improvement, and the other (in the case of the BoK tables) a more static exercise to identify a program's position in a specific hierarchy. Perhaps this was self-evident to other institutions using the BoK, but it required some reflexive work on our part.

ILO-C: "Use numerical information to identify, analyze and solve problems."

A person who is competent in quantitative reasoning possesses the skills and knowledge necessary to apply the use of logic, numbers, and mathematics to deal effectively with common problems and issues. A person who is quantitatively literate can use numerical, geometric, and measurement data and concepts, mathematical skills, and principles of mathematical reasoning to draw logical conclusions and to make well-reasoned decisions.

The benchmark for meeting this Student Learning Outcome will be a 4 or greater on this 6-point rubric.

	Initial (1-2)	Emerging (3)	Satisfactory (4)	Good (5)	Exemplary (6)
Demonstrate the ability to use numerical and/or symbolic information to identify, analyze and solve quantitative problems.	Demonstrates little or no understanding of what information and assumptions are needed to perform the analysis. Did not organize or calculate a mathematical strategy for a given situation, or did so in a completely invalid manner.	Demonstrates basic understanding of what information and assumptions are relevant to the analysis. Translation into mathematical symbols, graphs, and/or tables is flawed or incomplete. Approach and information gathering appears essentially effective, but includes major mistakes in organization or calculation	Demonstrates satisfactory understanding of what information and assumptions are relevant to the analysis, and translates into mathematical symbols, graphs, and/or tables with minor errors. Approach and information gathering appears essentially effective, but includes minor mistakes in organization or calculation	Demonstrates high level of understanding of what information and assumptions are relevant to the analysis, and correctly translate into mathematical symbols, graphs, and/or tables. Correctly organizes information in an appropriate form and calculates desired result with one minor error.	Demonstrates high level of understanding of what information and assumptions are relevant to the analysis, and correctly translate into mathematical symbols, graphs, and/or tables. Correctly organizes information in an appropriate form and calculates desired result with no errors.

Figure 3. Cal Maritime Institution-Wide Assessment Report 2019, Appendix A [11].

One additional challenge in the curricular mapping (which will be re-addressed in the "Results/Discovery" section) concerns *who* does the mapping. The BoK suggests that this should be done by "program administrators," but that term itself might not translate globally into environments that have assessment coordinators, department chairs, academic deans, etc. Different personnel with different levels of knowledge and experience with the curriculum may come to very different conclusions when determining specific levels of achievement.

5. Affective and Psychomotor Domains

While the cognitive domain is comprehensible to assessment committees and coordinators, there is much less emphasis on the Affective and Psychomotor domains for assessment and accreditation purposes. Certainly, they have relevance as derived from Bloom's taxonomy and in MET research devoted to these specific domains. However, while the cognitive domain can be mapped by a program coordinator or committee by attending to the previously existing program learning outcomes, determining the appropriate LoA in the Affective Domain in particular proves more difficult to assess, as reliable data must be primarily drawn via student self-reflexive feedback. This is an exercise that is not widely practices at Cal Maritime, and would take additional resources in time and effort to gather and analyze results. It is beyond the purview of this paper, but the issue begs the question: how are affective learning outcomes *taught* in MET programs? How are they measured? How is the body of knowledge on this topic specific to maritime education informing assessment practices of these domains?

6. Results and Discovery

As hypothesized, Cal Maritime's Marine Transportation program met most of the thresholds for a Tier B program. A few observations about the process: first, as indicated before, there may be an issue of bias with those assessing the program. The BoK suggests this to be a program coordinator who would certainly have the knowledge to make such distinctions, but a committee might be more prudent. It would be expected that if this outcomes mapping exercise was conducted blindly and independently by different faculty or administrators familiar with the program, there may be multiple and/or contradictory results. While this internal dissonance may be corrected by collaboration through committee rather than individual work, the issue is potentially exacerbated when deployed across dozens of institutions from several different nations. Concomitantly, despite the extensive descriptors, a "norming session" could help calibrate the process and provide cleaner data.

Relatedly, there is an internal bias of self-evaluation: if a program is predetermined to be a "Tier B" program, and is "supposed" to reach specific thresholds in accordance to that level, then more often than not, it "must" be at that level. Also, in our assessments there were discussions around some of the descriptors which narrowed the scope in ways which led us to question if we had achieved that level. For example, under "Contemporary Global Issues" the language in the higher plane LoAs conclude with the prepositional phrase "*in the maritime industry and practice.*" [12]. Some required classes, however, explore social, political, and cultural manifestations of globalization that have less relevance to the maritime realm, and therefore disqualify them from counting toward that threshold. Additionally, there is the issue of electives: in the Cal Maritime MT curriculum – especially in the general education segments – students are offered choices of courses in the humanities, sciences, and social sciences. Some of these would satisfy or exceed the LoA for certain elements, but others would not. For example, a marine transportation student *could* take a higher level course in logistics but doesn't necessarily have to – which leads to the idea that one could build an internal GMP roadmap to satisfy different levels. A different, tangential concern regards those classes with outcomes that don't relate to the GMP schema. Because of its status as a public, state-supported institution, Cal Maritime students are required to take courses in American history and government. Is it necessary for the BoK to acknowledge other national or regional requirements? Of should the framework be indifferent to these courses? Finally, there is a problem with verbs and taxonomy as a whole. As noted by Newton, Da Silva, and Peters, "The taxonomy is widely implemented as a hierarchy of verbs, designed to be used when writing learning outcomes, but a 2020 analysis showed that these verb lists showed no consistency between educational institutions, and thus learning outcomes that were mapped to one level of the hierarchy at one educational institution could be mapped to different levels at another institution" [13].

Cal Maritime's program fell below the expected Levels of Achievement in our first assessment of the program in the following focus areas:

- Contemporary Global Issues
- Situational Awareness, Preparedness and Response.
- Sustainable Development
- Human Resource Management
- Mentorship
- Computing and Informatics

Generally, in these categories the program fell between a level 3 and a level 4 – between "applying" and "analyzing" for focus areas that were less defined in the MT curriculum, given the reasons elucidated above.

Focus Area	*The Cognitive Domain level of achievement*					
	1 Remembering	2 Understanding	3 Applying	4 Analyzing	5 Evaluating	6 Creating
Human resource management	**Define** "human resource management" and **describe** the development of the concept from the earlier concept of "personnel management"	**Explain** the principles underpinning human resource management and **distinguish** between different techniques, activities and approaches and their relevance to a multicultural environment	**Apply** relevant human resource management theories and techniques to **achieve** goals related to own maritime professional practice	**Diagnose** the causes of ineffective human resource management and **prioritize** the actions to be taken to address problems that may arise due to poor human resource management practices	**Judge** the effectiveness of different human resource management approaches and techniques in different contexts of maritime professional practice and highlight areas that need further attention	**Develop** new human resource management techniques when conventional techniques are not suitable or not applicable.

Figure 4: CSUMA articulation to the LoA of Focus Area Human Resource Management.

Cal Maritime's program *exceeded* the expected level of Tier B in

- General humanities and social sciences
- Problem Recognition and Solving
- Environmental Awareness, Sustainability and Stewardship

These findings have to yet to be confirmed and corroborated by other stakeholders on campus, but the results show some variance in the expected levels of achievement. Further steps, in accordance with standard assessment practices, require deeper study of the underlying reasons for the variances and where they can be addressed, but also – and this is a crucial issue – *if* they should be addressed as legitimate deficiencies in a particular program.

7. Recommendations and Conclusion

The authors of the BoK clearly acknowledge the need to revise and adapt this document contingent on educational and societal changes as well as revisions necessary for it to remain relevant and applicable to MET institutions: "This Body of Knowledge is not intended to be a singular, static document, but rather a living resource that adapts and evolves so as to be a key resource for all stakeholders involved in training, developing, education, employing, and overseeing Global Maritime Professionals" [17]. In accordance with this intent, the following recommendations are suggested in the spirit of collegial collaboration.

1. Consider using a different technology for the BoK tool While other DBMSs' may be more expensive, the use of an algorithmic database that walks a reviewer through a series of questions based on the LoAs may be more effective in capturing the truer essence of a particular program.

2. A bold proposal: consider the elimination of the Affective and Psychomotor Domains, or better explain their usefulness. There is scant information in the BoK – as to why these domains are relevant and what they bring to the overall assessment of an MET program – and they may serve to muddy what is an already complicated framework. Perhaps more research on the significant of these domains is underway; if so, this should be tied back into future editions of the Bok to better explain their purpose.
3. Somewhat related to #2, if the BoK is to evolve and grow with more frameworks for non-shipboard programs– perhaps envisioning, say, even five new framework in logistics, policy, law, maritime energy and environment – this would lead to an exponential number of LoAs and even different elements under the cognitive domain alone. At what point might the tables become difficult to manage?
4. In mapping Cal Maritime's program through this framework, it became clear that such an exercise would benefit from external validation. Such a process may take the form of an IAMU Special Interest Group, or other such organization that would allow interested parties to share their experiences in modeling their programs, identify shared points of confusion or frustration, and offer insights from their own experiences that would expedite the process.
5. Finally, to put this most bluntly, at the conclusion of the exercise, what are the next steps? The initial immediate action would appear to be internal reform to redesign the program in order to comply to the appropriate tier. But after that? Should there be an external notification (akin to what this paper is trying to accomplish)? Should there be a portal by which institutions can view each others' self-identified measurements? This may be accomplished via surveys, as suggested in the BoK, but perhaps there may be a stronger and more unified repository of the collective results.

Ultimately, the Global Maritime Professional Book of Knowledge represents a quantum leap forward for MET, and the IAMU, in terms of reaching the objective of a standardized global curriculum that will enhance cooperation and collaboration amongst all member institutions. Coupled with the new scholarship program offered in partnership with the Nippon foundation, the GMP framework may prove to be a breakthrough phase in advancing the mission of the organization.

Appendix A: Marine Transportation Curriculum

STUDENTS ENTERING IN 2020 — **REVISED 1/21/21**

APPENDIX A Marine Transportation Curriculum

FALL 2020

COM	100	Introduction to Computers	2.0
DL	105	Marine Survival▶✱	1.0
DL	105L	Marine Survival Lab▶✱	1.0
DL	105X	USCG Lifeboatman's Exam▶✱	0.0
DL	109	Industrial Equipment and Safety✱	1.0
DL	115	Marlinspike▶✱	1.0
FF	200	Basic/Advanced Marine Firefighting▶[1&2]	0.0
MTH	100	College Algebra and Trigonometry (Area B4)	4.0
NAU	103	Introduction to Marine Transportation✱	3.0
NAU	104	Shipboard Security and Responsibility▶✱	1.0
NAU	105	Ship Structure▶✱	2.0
PE	101	Swim Competency Exam	0.0
PE	102	Beginning/Intermediate Swimming	(0.5)
		Total	**16.0**

SPRING 2021

CHE	105	Introductory Chemistry (Area B1)	3.0
CHE	105L	Introductory Chemistry Lab (Area B3)	1.0
DL	100	Small Craft Operations✱	1.0
DL	110	Ship Operations I▶✱	1.0
DL	120	Cargo Operations▶✱	1.0
ECO	100	Macroeconomics (Area D-Lower Div)	3.0
EGL	100	English Composition (Area A2) **"G4"**	3.0
EGL	110	Speech Communication (Area A1) **"G4"**	3.0
FF	200	Basic/Advanced Marine Firefighting▶[3&4]	0.0
NAU	110	Seamanship▶✱	3.0
		Total	**19.0**

SUMMER CRUISE 2021

CRU	100	Sea Training (Deck)▶	8.0
		Total	**8.0**

FALL 2021

American Institutions I Elective (Area D-Lower Div)[3&4]			3.0
DL	111	Ship Operations II▶✱	1.0
DL	225	Radar/ARPA▶✱[1&2]	2.0
DL	225L	Radar/ARPA Lab▶✱[1&2]	2.0
EGL	220	Critical Thinking	3.0
[Critical Thinking Elective] (Area A3) **"G4"**			
NAU	102	Navigation I▶✱	4.0
NAU	102L	Navigation I Lab✱	0.0
NAU	230	Rules of the Road▶✱	2.0
PHY	100	Physics I (Area B1)	3.0
PHY	100L	Physics I Lab (Area B3)	1.0
		Total	**18.0 OR 17.0**

SPRING 2022

American Institutions I Elective (Area D-Lower Div)[1&2]			3.0
Life Science Elective (Area B2)			3.0
DL	240	GMDSS▶✱	2.0
DL	240L	GMDSS Lab▶✱	1.0
DL	225	Radar/ARPA▶✱[3&4]	2.0
DL	225L	Radar/ARPA Lab▶✱[3&4]	2.0
NAU	205	Ship Stability▶✱ (Area B4) **"G4"**	3.0
NAU	240	Electricity/Electronics✱	3.0
NAU	240L	Electricity/Electronics Lab✱	1.0
		Total	**16.0 OR 17.0**

SUMMER CRUISE 2022

CRU	200	Sea Training II (Deck)	5.0
CRU	200L	Sea Training II Lab (Deck)	3.0
		Total	**8.0**

FALL 2022

Arts Elective (Area C1-Lower Div)			3.0
Humanities Elective (Area C2-Lower Div)[1&2]			3.0
DL	301	Navigation Piloting Lab✱[1&2]	1.0
DL	310	Marine Supervisory Lab✱	1.0
EGL	300	Advanced Writing	(3.0)
NAU	302	Advanced Navigation▶✱	3.0
NAU	302L	Advanced Navigation Lab✱	0.0
NAU	320	Tank Vessel Operations▶✱	3.0
NAU	330	Meteorology▶✱ (Area B-Upper Div)	3.0
NAU	335	ECDIS▶✱[3&4]	2.0
NAU	335L	ECDIS Lab▶✱[3&4]	1.0
		Total	**17.0 OR 16.0**

SPRING 2023

Humanities Elective (Area C2-Lower Div)[3&4]			3.0
DL	301	Navigation Piloting Lab✱[3&4]	1.0
DL	311	Marine Management Lab✱	1.0
DL	320	Introduction to Bridge Simulation▶✱	2.0
NAU	120	Marine Engineering✱	3.0
NAU	300	Celestial Navigation✱	4.0
NAU	300L	Celestial Navigation Lab✱	0.0
NAU	325	Cargo Vessel Operations▶✱	3.0
NAU	335	ECDIS▶✱[1&2]	2.0
NAU	335L	ECDIS Lab▶✱[1&2]	1.0
		Total	**16.0 OR 17.0**

SUMMER CRUISE 2023

CRU	300	Sea Training III (Deck)▶	8.0
		Total	**8.0**

FALL 2023

Humanities Elective (Area C-Upper Div)			3.0
DL	305	Tug and Barge✱[3&4]	1.0
DL	405	Shipboard Medical▶✱[1&2]	1.0
DL	405L	Shipboard Medical Lab▶✱[1&2]	1.0
DL	410	Ship Handling▶✱[1&2]	1.0
DL	420	Watchstanding Simulation▶✱	2.0
GOV	200	American Government	3.0
[American Institutions II Elective] (Area D-Lower Div)			
HUM	400	Ethics (Area C-Upper Div)	3.0
NAU	410	License Seminar✱	2.0
NAU	410L	License Seminar Lab✱	0.0
NAU	415	Transportation Security▶✱	2.0
		Total	**18.0 OR 16.0**

SPRING 2024

Social Science Elective (Area D-Upper Div)			3.0
DL	305	Tug and Barge✱[1&2]	1.0
DL	405	Shipboard Medical▶✱[3&4]	1.0
DL	405L	Shipboard Medical Lab▶✱[3&4]	1.0
DL	410	Ship Handling▶✱[3&4]	1.0
LAW	315	Admiralty Law	2.0
MGT	310	Port and Terminal Management	3.0
NAU	400	Advanced Maritime Topics✱ **CHOOSE THIS**	3.0
NAU	420	Maritime Casualty Seminar✱ **OR THIS**	3.0
NAU	430	Liquefied Gas Cargos✱ **OR BOTH OF**	2.0
NAU	430L	Liquefied Gas Cargos Lab✱ **THESE**	1.0
NAU	435	Marine Transportation: People, Planet and the Profession - MT Capstone✱	3.0
		Total	**15.0 OR 17.0**

THIRD MATE'S/OICNW LICENSE REQUIRED FOR GRADUATION

CSU Writing Proficiency Requirements may be met by passing the Graduate Writing Exam, or passing EGL 300 Advanced Writing.

[1&2] Divisions 1&2 take course
[3&4] Divisions 3&4 take course

"G4" "Golden 4" Courses (Must receive a "C-" or higher)
▶ STCW Courses (Must receive a "C-" or higher, or "CR")
✱ Required Courses in Major (CGPA = 2.0 is required)

NOTE: Course content/curriculum may be modified to meet STCW or other regulatory requirements.

Appendix 2: Program and General Education Learning Outcomes

Marine Transportation Program Student Learning Outcomes	
MT PLO 1: Discipline-Specific Knowledge	Graduates will demonstrate competence in the concepts and technologies of international marine transportation
MT PLO 2: Leadership and Teamwork:	Graduates will demonstrate the ability to work effectively as a leader and member in professional teams
MT PLO 3: Communication	Graduates will demonstrate effective communication skills
MT PLO 4: Ethical Awareness	Graduates will use ethical reasoning to make decisions related to the maritime industry
MT PLO 5: Quantitative Reasoning:	Graduates will demonstrate the ability to analyze numerical data.
MT PLO 6: Information Fluency	Graduates will define a specific need for information; then locate, evaluate, and apply the needed information
MT PLO 7: Critical and Creative Thinking	Graduates will analyze problems in new and different ways
General Education Learning Outcomes	
English Language Communication and Critical Thinking Outcomes	GELO 1: Demonstrate proficiency in oral communication in English, examining communication from the rhetorical perspective and practicing reasoning and advocacy, organization, and accuracy.
	GELO 2: Demonstrate proficiency in written communication in English, examining communication from the rhetorical perspective and practicing reasoning and advocacy, organization, and accuracy.
	GELO 3: Demonstrate ability to analyze, criticize, and advocate ideas; to reason inductively and deductively; and to reach well-supported conclusions.
Scientific Inquiry and Quantitative Reasoning Outcomes	GELO 4: Apply scientific principles and the scientific method to data about both living and non-living systems.
	GELO 5: Demonstrate ability to reason quantitatively.
	GELO 6: Explain and apply mathematical or quantitative reasoning concepts to solve problems.
Arts and Humanities Outcomes	GELO 7: Evaluate aesthetic experiences subjectively as well as objectively.
	GELO 8: Demonstrate awareness of the relation between the arts [C1] and their cultural contexts.
	GELO 9: Demonstrate awareness of the relation between literary and philosophical texts [C2] and their cultural contexts.
Social Sciences Outcomes	GELO 10: Identify and explain the links between human social, political and economic institutions and behavior.
	GELO 11: Analyze social problems and issues in their contemporary as well as historical settings and in a variety of cultural contexts.
	GELO 12: Explore the principles, methodologies, value systems and ethics employed in social scientific inquiry.
Lifelong Learning and Self-Development	GELO 13: Demonstrates ability to pursue knowledge and solve problems independently.
	GELO 14: Applies knowledge and skills from one context to another.
	GELO 15: Identify, access, and evaluate appropriate sources of information.

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Proceedings

Smart Maritime Supply Chain and Logistics

Is outsourcing the Panacea? A discourse on the sustainability of Indian Ports A case of Jawaharlal Nehru Port Trust

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Abstract: The discourse on sustainable transportation illuminates the fact that port competitiveness and efficiency gains are two major pillars of blue economy in a world which is much integrated than in the past. However, most literature on port efficiency measurement undermine the very eco system of a port. Port eco system is complex interconnected web of network which requires collaborative involvement of spate of stakeholders such as CFS, Agents, ICDs, Transportation companies, to mention a few. Understanding such network and their holistic potential impact on the efficiency of port performance is scarcely addressed in the context of larger dialogue on port efficiency. Such an analysis is paramount when deeper levels of economic integration and spatially competitive ports are considered to be co joint twins. Further, efficiency gains of ports have received much academic attention in view of total quality management which focuses on customer delight and thus customer retention. It is this regard; the present paper tries to make an infant endeavour in terms of measuring terminal efficiency with respect to the turnaround time which would include export cycle time and import cycle time of CFS (a potential outsourcing activity of a port). Such a step in efficiency measurement of ports is scanty in Indian scenario. A case of Jawaharlal Nehru Port Trust is referred as a case in point.

Setting the Stage

With the dawn of globalisation, market around the world is getting integrated. Such integration results in global transaction, a development that demands operational efficiency in supply chain. In this regard, ports are key gateways in the global supply chain to the extent that efficiency of global supply chain depends to a significant degree on port efficiency (Kennedy *et al*, 2011; Sen *et al*, 2020) and thus affects international trade. This is because efficient ports can potentially reduce operational bottlenecks in the supply chain, thus reduce cost and time of maritime transportation (Clark *et al*, 2002; Lei and Bachmann, 2020) and thereby increase the strategic competitive advantage of a country in terms of international trade. In this context, there exists an undisputed consensus in the larger discourse on the positive linkage between port performance and economic development due to multiplier effect (Dwarakish and Salim, 2015). Ports create employment, purchasing power, linking a country with other parts of the world, helps a country earn foreign exchange and thus significantly contribute to economic development of any country. Due to such importance, sustainable port efficiency is seen as a survival strategy for ports as it affects ports competitiveness, cost advantage and customer retention (Kim, 2012). In this context, Nyema (2014) and, Sinha and Bagodi (2019) illuminate that inefficiency in port operation may lead to longer stay of a ship in the port and in return escalate transport cost and cost of operation to shipping companies. Thus, lead to diversion of cargo from such port to other ports. Such linkage between operational efficiency and port performance stipulate for outsourcing as a source of efficiency gain. In port sector such outsourcing could be seen in the form of public private partnership model of ownership model (world Bank,2020).

The question of efficiency gains necessities focus of organisations mostly on their core competencies and thus improve competitive advantage, and outsource non-core activities to other firms which pursue such activities efficiently. In this regard, outsourcing could be defined in the words of Ishizaka *et al* (2019) as "*Outsourcing is a business agreement, either domestic and/or international (known as offshoring), and strategic management initiative for gaining a competitive advantage of a firm by contracting out their existing internal and/or external non-value added functions, and/or value-added functions, and/or core competencies to competent supplier(s) to produce products and/or services efficiently and effectively for the outsourcing firm*". Thus, semantically such intervention leads to value creation and improvement in the competitive stance of an organisation. At the same time, mixed views exist on the cost of outsourcing and the efficiency outcome of outsourcing as being unsynced. If outsourcing firms and activities are not selected in a proper way by an organisation, the results of outsourcing may prompt questions on optimality of such exercise (Kalinzi, 2016).
Transportation sector is no exception. However, as pointed out by Parola *et al* (2016) port competitiveness is affected by a complex web of activities by various stakeholders presented in the maritime ecosystem. Such elements in the maritime ecosystem affecting port efficiency would include Exporters, importers, Container Freight Station (CFS), Shipping companies, to mention a few. Such multidimensional interactions potentially affect efficiency of a port. Any inefficiency in the ecosystem would lead to leakages in efficiency gains. It is in this context that, outsourcing is rewriting traditional functions of a port wherein the public sector involves

itself as planning, developing, and regulating activities whereas private sector involvement is seen as service provider and operator (World Bank, 2020). Outsourcing and its positive impact on port efficiency has been acknowledged (Nyathi, 2014) but scarely in the literature. Spate of the studies like Monteiro (2018), Merk & Dang (2012), Rajasekar *et al* (2014), Swaminathan (2019) focus on measurement of port efficiency using Data Envelopment Analysis (DEA) to establish efficiency scores. Such studies essentially focus on efficiency from the perspective of port operations. Also, there are attempts like Kennedy *et al* (2011) which use Stochastic Frontier Production Function to measure efficiency of ports. However, there have been scanty attempts made to study the impact of an element of maritime ecosystem on the efficiency of a port. For instance, in a partial equilibrium analysis, efficiency of a CFS reflected in terms of dwell time of handling a container could potentially affect efficiency of port. Such scenario exists as CFS facilitates decongesting ports (Klomperee, 2000). Since there are private players in CFS domain, their activities could be defined as outsourced activities for port which they serve in line with Ishizaka *et al* (2019). Further, studies focusing on the impact of agents of maritime ecosystem on port efficiency are sparse particularly in Indian context. From the above discussion, it is evident that in the literature on port efficiency measurement are mostly DEA focused, and is limited in Indian context. In this regard, the present study tries to fill this gap by taking an infant step in measuring the contribution of CFS to port efficiency. Knowledge of such linkage is important from managerial perspective because lower dwell time of handling containers leads to competitive advantage to ports through efficiency gains particularly in pandemic situation resulting in customer retention and customer delight.

Methodology

As is discussed above, the present study considers private CFS as a crude representation of outsourcing activity of a port and thus tries to estimate the linkage between the two in terms of efficiency of port being affected by efficiency of CFS attached to such port. To understand this linkage in Indian context, Jawaharlal Nehru Port Trust (JNPT) is considered as a case. JNPT is considered as it is considered as a top port in Asian continent (Swaminathan, 2019) and handles more than half of containers that are handled by all major ports of India (Rathi *et al*, 2020). It has five terminals and has both private and government CFSs. For the present study, only private CFSs are considered to represent outsourcing activity. To estimate the linkage between efficiency of CFS on efficiency of ports, variables like cargo handled at various terminals of JNPT **in tons**, import dwell time in hours, terminal wise import dwell time in hours, export dwell time in hours, terminal wise export dwell time in hours, and CFS dwell time in hours is considered. The timeline for the data is financial year 2019-20 covering 12 months. A total of 13 CFSs are considered for the study. It is assumed that each of these 13 CFSs serve all the five terminals of JNPT. To establish understand the linkage between efficiency of CFS and efficiency of JNPT, Structural equation modelling (SEM) is used. The justification of using SEM is that it is a multivariate analysis which combines multiple regression and factor analysis to estimate structural relationship between variables. SEM is used in port related studies to estimate linkage between ports and economic development (Goncalves and Assumpção, 2016). Worth mentioning is that paucity of data on several other variables which could affect port efficiency is observed. The year taken for the study April 2019-March 2020 is considered to be a not normal year for international business in view of Covid 19 pandemic. These observations may lead to unrobust results.

<u>Results and discussion</u>

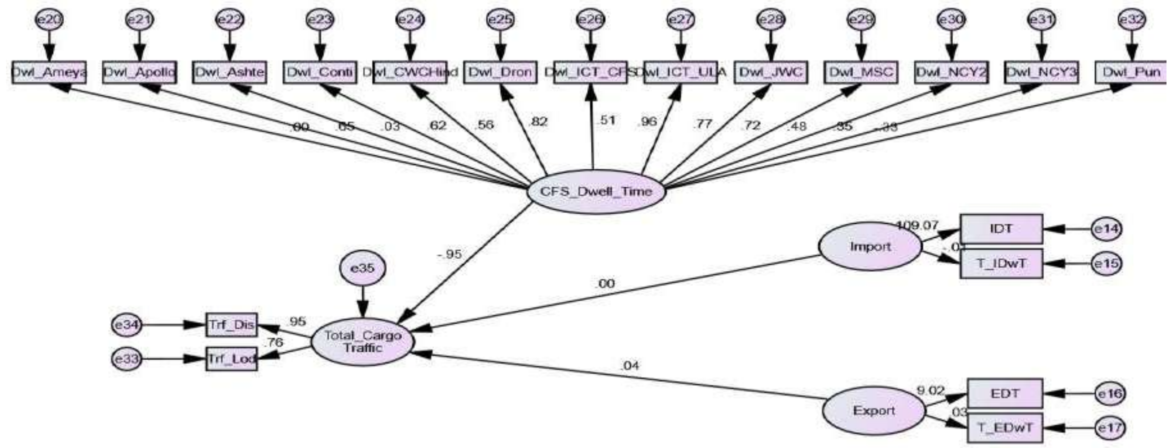
The first hypothesis presumed is that CFS dwell time (CFS_Dwell_Time is the total time (in hours) taken inside the CFS to clear a container after all prescribed formalities) has inverse effect on cargo handled at a port (Total_Cargo Traffic). This is presumed because the more time a container spends in CFS, it cannot be released to go to the port or cannot be released to the customer in the case of exports and imports respectively. The lesser the CFS dwell time the lesser is the time of container handling, thus in turn lead to efficiency gains.

The second hypothesis is that import dwell time (terminal dwell time (T_IDwT) as well as dwell taken from port out gate to CFS in gate (IDT)) has **an** effect on cargo traffic handling of JNPT.

The third hypothesis is that export dwell time (terminal dwell time (T_EDwT) as well as dwell taken from CFS out gate to Port in gate (EDT)) has **an** effect on cargo traffic handling of JNPT.

A terminal wise SEM is considered for all 13 CFSs. The above hypothesises were tested. In the case of BMTC terminal of JNPT, it is found that increase in CFS dwell time negatively impact total cargo traffic of JNPT. But, neither of import delivery time, export delivery time as well as dwell time at BMCT have an effect on total cargo traffic of JNPT (Fig.1.1.).

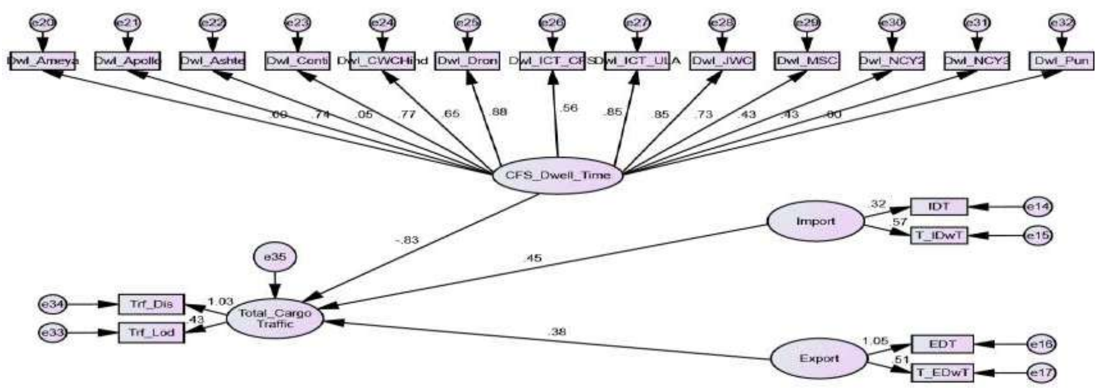
Figure 1.1: Results of SEM for BMTC terminal of JNPT



Source: Author’s own estimation

In the similar line of BMTC terminal, GTI terminal results of SEM indicate that increase in CFS dwell time negatively impact total cargo traffic of JNPT. But, neither of import delivery time, export delivery time as well as dwell time at GTI have an effect on total cargo traffic of JNPT (Fig.1.2).

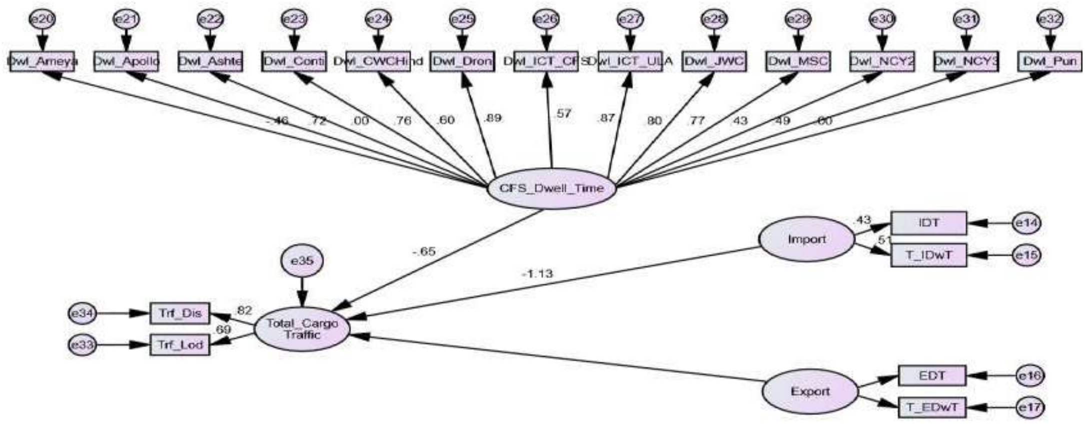
Figure 1.2: Results of SEM for GTI terminal of JNPT



Source: Author’s own estimation

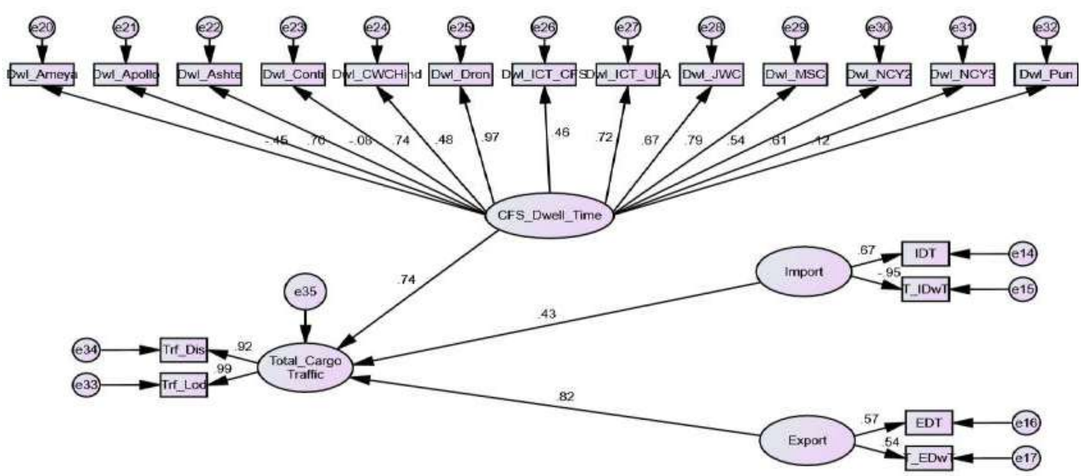
The above figure highlights that increase in CFS dwell time, import delivery time as well as import dwell time at JNCPT negatively impact total cargo traffic of JNPT. But, export delivery time as well as export dwell time at JNCPT don't have an effect on total cargo traffic of JNPT (Fig.1.3)

Figure 1.3: Results of SEM for JNPCT terminal of JNPT



Source: Author's own estimation

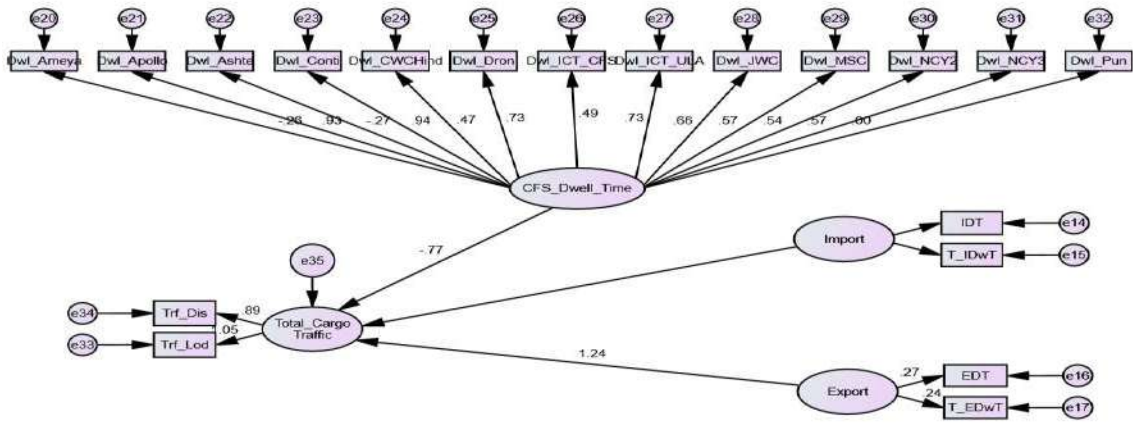
Figure 1.4: Results of SEM for NSICT terminal of JNPT



Source: Author's own estimation

It is evident from Fig.1.4 that CFS dwell time, import delivery time, export delivery time as well as dwell time at NSICT have positive effect on total cargo traffic of JNPT.

Figure 1.5: Results of SEM for NSIGT terminal of JNPT



Source: Author's own estimation

Fig.1.5 depicts that that CFS dwell time has a negative association with total cargo handled at NSIGT, and further export dwell time has a positive association with total cargo traffic.

From the above analysis, it can be concluded that except one terminal (NSICT), in all four terminals of JNPT, CFS dwell time is inversely associated with total cargo traffic handled. This is semantically possible as lower the time it takes for a CFS to clear a container, higher is the number of containers that reaches to the port in the case of export container and to the customers in the case of import containers. Such a tendency definitely improves efficiency in terms of cargo though put and customer satisfaction and delight.

<u>Concluding remarks</u>

Efficiency of port is affected by many factors and is important for sustainability of maritime transportation as higher port charges may lead to diversion of cargo to other ports or exploration of other modes of transportation. However, research in this regard has been focused on using DEA technique and not much research work exists to establish linkage of port efficiency with efficiency of stakeholders in maritime ecosystem. In this regard, the current study makes an endeavour to establish such linkage by take into account efficiency of CFS. JNPT is taken as a case. The results of the SEM shows that there is an inverse association between the dwell time of CFS and total cargo handled at JNPT. Such results reveal that lower dwell time of CFS or higher efficiency of CFS leads to more cargo handled at a port terminal or efficiency gains for a port. Since private CFSs were considered as a representation of outsourcing activity of JNPT, it is found in the study that efficiency gains through CFS activity or outsourcing does have an impact on efficiency of JNPT.

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Maritime Surveillance in the Gulf of Suez: Identifying Opportunities for Future Improvements

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Abstract

The Gulf of Suez (GOS) is one of the most important waterways in the world. Furthermore, issues like maritime safety, avoidance of accidents and effective conduct of navigation, as well as protection of the marine environment in the GOS are always among the highest priorities of Egyptian legislators. As a result, maritime surveillance in the area under discussion is facilitated by a technologically advanced Vessel Traffic Management System (VTMS) that has been established by the competent authority as a cost-effective measure to reduce and mitigate risks in accordance with international standards and guidelines. The main aim of this paper is to discuss the status of the GOS VTMS and identify relevant opportunities for improvement.

This effort utilizes qualitative primary and secondary data. Primary data was collected by employing in-depth, semi-structured interviews; secondary data was sourced from relevant national legislations, IMO, IALA and UK hydrographic office publications. Thus, the distinctive features of the GOS VTMS along with its degree of compliance with international standards and guidelines have been closely examined for a comprehensive assessment. A conclusion standing out is that GOS' VTMS is a very powerful tool for a more efficient conduct of navigation, with a positive contribution on maritime safety and the protection of the marine environment; however, certain gaps that must be addressed in the near future were identified. A portfolio of the necessary recommendations on how to improve the system's overall performance are also provided.

KEYWORDS: Safety of navigation, Marine environment, Data integration, Vessel Traffic Services, IMO, IALA.

1- Introduction

According to the Merriam-Webster Dictionary, the term ocean describes the body of salt water which covers approximately 71% of the surface of the Earth (Ocean, n.d.). Considering the truly vast areas involved in this discussion, maritime surveillance should be viewed as a very important step towards creating maritime awareness, or simply put "knowing what is happening at sea". Any Maritime Surveillance System

(MSS) must first and foremost comply with the primary function of covering and providing a comprehensive maritime situation picture to control the main areas where maritime activities are being carried out. Coastal states are using Maritime Surveillance (MS) to increase the safety of navigation, protect the marine environment and the State's own interests. MS has been defined by many scholars, International Organizations and Agencies, by using various different perspectives. For example, the Maritime Affairs Directorate of the European Commission is using the following definition: "Maritime Surveillance is the effective understanding of all activities carried out at sea that could impact the security, safety, economy, or environment of the European Union and its' Member States" (European Commission, 2010, p.1). This definition is very similar to the International Maritime Organization's (IMO) definition for Maritime Domain Awareness (MDA), which is defined as "The effective understanding of anything associated with the maritime domain that could impact up on the security, safety, economy, or environment" (IMO, 2010a, p.1).

Egypt, as a member state of IMO, has exercised its sovereignty in the Gulf of Suez (GOS) by establishing measures to ensure the safety of navigation, protect the marine environment and its various economic interests. This paper will discuss the current state of MS and explain the role of VTMS within the GOS. This research effort will explore the cooperation between different entities in order to establish a successful and cost-effective MSS under the scope of national legislations. It will clearly highlight the role of GOS VTMS in increasing the level of situational awareness, which in turn contributes towards the protection of the marine environment and safety of navigation. Finally, it will propose how to improve MS in the GOS specifically and in Egypt in generally, by establishing a national cross-sectoral information-sharing environment.

2- Governmental and non-governmental agencies involved in the Gulf of Suez Maritime Domain surveillance

MS includes the interaction between many maritime agencies that face the challenge of ensuring security, safety, environmentally friendly and clean seas (Chintoan-Uta & Silva, 2017). Commercial vessels are monitored by Maritime Administrations, Fisheries Administrations/Agencies track fishing vessels and the Coast Guard or other law enforcement agencies often undertake monitoring of activities at sea. Each one of these entities/administrations has developed and operate a MSS that compiles and processes the information in relation to their needs (Tikanmäki, 2017). Data collection for the GOS' VTMS is performed by various different organizations. Governmental and nongovernmental entities are involved in MS in Egypt in general and in the GOS in particular -under the scope of national legislation- in order to enforce the rule of law and fulfill their assigned responsibilities.

2.1 Marine Survey Department (Navy)

The Ministry of Defense, represented by the Navy-Marine Survey Department has the legal basis for application and enforcement under the Law 232/1989 on the safety of ships to provide hydrographic services in Egyptian territorial waters. Its responsibilities are the collection, classification, circulation, and update of all hydrographic data necessary for safe navigation. Also preparation and issuance of both paper and electronic charts; other similar issues include sailing routes, lists of lights, tide schedule and other publications, the production of Marine booklets (publications) and Notices to Mariners to meet the needs of safe navigation.

2.2 Egyptian Authority for Maritime Safety (EAMS)

The legal basis of application and enforcement is Presidential Decree 399\2004 on the establishment of the Egyptian Authority for Maritime Safety and law 232 of 1989 on the safety of ships. EAMS is the maritime administration acting as competent authority of Coastal State/Flag State and also executes Port State Control. EAMS provides navigational aids in Egyptian coastal and territorial waters, promulgate publications and navigational alerts, investigation of marine accidents and monitoring of VTS (Maritime Transport Sector, n.d.).

2.3 National Telecom Regulatory Authority (NTRA)

The legal basis for application and enforcement is Telecommunications Law 10\2003 Directive that regulates the procedures of maritime communications services. Responsibilities of NTRA include its role as the National Data Provider by registering the data of distress devices of Egyptian ships using COSPAS SARSAT System, issuing radio licenses for Egyptian vessels, registration of Egyptian ships data at ITU (List of Ship Stations), issuing General Operators Certificate (GOC) to radio operators in accordance with STCW 78.

2.4 Telecom Egypt (TE)

The legal basis for application and enforcement was provided under the scope of the Telecommunications Law 10\2003, in addition to license No. 1\2006 issued by the NTRA to TE and the cooperation protocol signed between Telecom Egypt and the

Meteorological Authority. TE has the responsibility to operate coastal radio stations for communication and distress services, broadcast radio navigational alerts and weather forecast services to ships in Egyptian territorial water including the GOS.

3- Traffic features and cost-benefits of maritime surveillance in the Gulf of Suez

The high costs of a high-tech surveillance systems are among the main problems which the Maritime Administration may face; consequently, the lack of an economical and operational criterion is an obstacle to establish and put into operation a well-developed surveillance system. For that reason, costs must be in balance with the benefits which will be achieved by the system and those benefits may be monetary and/or other immaterial valued benefits. Improvements of MS are required because of a wide range of risks, threats and vulnerabilities. The heavy maritime traffic within the Mediterranean Sea, Red Sea as well as Suez Canal is associated with safety, security and environmental challenges for Egypt. According to the World Economic Forum "Global Competitiveness Index (2019)", the global competitiveness of Egypt's liner shipping connectivity and seaport infrastructure rank 18 and 41 respectively among 141 countries and regions (Schwab, 2019).

Ports in Egypt are mainly located around the Gulf of Aqaba, the Mediterranean and the Red Sea. Egypt's Ports have achieved 6.24 billion Egyptian pounds of surplus in 2016. While the annual holding capacity of Alexandria port is 1.613 and Port Said is 3.050 million TEUs, according to Lloyd's List, in 2018 Alexandria port has been ranked 94 and in 2019 port said has been ranked 57 among the top 100 international ports (Lloyd's List, 2018 and 2019). The Suez Canal (SC), is very important link of global maritime transport system by linking the Mediterranean Sea with the Indian Ocean. It connects Europe, Africa and Asia and holds 8% of international trade shipment and 14% of the international seaborne trade in volume (Egypt Economic Development Conference, 2015). SC is one of the pillars of Egypt's economy, its annual revenue being around six billion USD. In 2019 the SC revenue accounted for 2.4% of the Egyptian GDP and the foreign direct investments it attracts account for up to 8% of the total volume (Egyptian Center for Economic Studies, 2020).

3.1 Gulf of Suez Waterway features and status of safety incidents

Gulf of Suez is a waterway that lies at the north of the Red Sea (Fig. 1). The area of interest (AOI) which encompasses the entire Gulf is approximately 175nm. The GOS is a narrow waterway in most areas being only 10-15nm wide and at the widest being about 25nm (Jica, 2008). In general, one of the main features of the GOS is the intensity of traffic, oil wells, prohibited areas and a large number of non-SOLAS vessels. Any accident in this confined waterway will lead to economic losses expressed in delays of ships, loss in property, life and environmental damage.

Oil rigs and fishing vessels operations are frequent. Numerous oil rigs and platforms are the main hazards to navigation in the GOS on both shores of the Gulf; some marked by lights (and in some cases by racons as well). Also mariners are warned that some of these structures are temporary and that they should not rely on the charted positions; due caution is required when navigating in their vicinity and entry into certain areas containing oil fields is prohibited (UK Hydrographic Office, 2019).

Professors Dalaklis, Siousiouras and Nikitakos (2009) also stated that although maritime accidents occurred in the past and could continue in the future, utmost effort must be made to ensure safe and efficient shipping operations. In order to evaluate these statements and identify the risk in the GOS area, further investigation in trends of maritime incidents has been carried out.

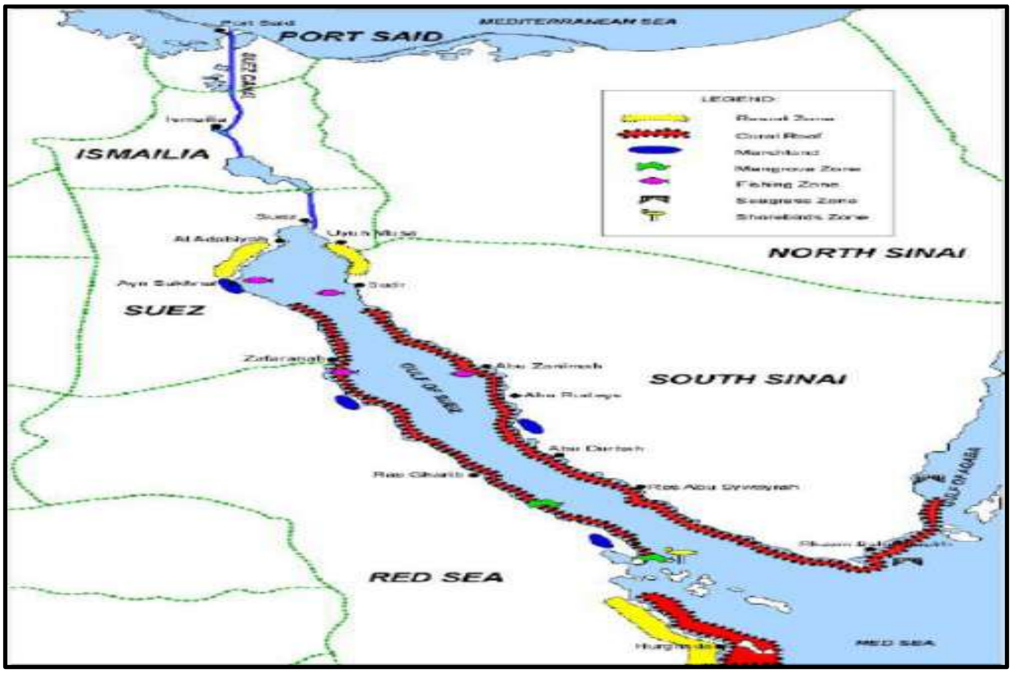

Figure 1: GOS geographical and environmental features (source: Jica, 2008)

In 1990, the total number of incidents/casualties in the GOS accounted for 7, while in 1997 this number increased to 16 accidents. Between 1990 and 1997 the total number of incidents reached 88 with different types of indicative types being oil pollution, collision and grounding (Abelhafez, 1998). In 2014, a collision between a fishing boat and a Kuwaiti flagged container ship resulted into 25 fatalities in the GOS (Ahram

Online, 2014). Moreover, GOS is the region associated with most risk of pollution in the Red Sea, particularly oil pollution (Ghalwash & Elkawam, 2004). Consequently, Traffic Separation Scheme (TSS), Aids to Navigation (AtoN) and Vessel Traffic Service (VTS) are risk control options that have been established by competent authorities. The requirements and standards of these risk control options have been mandated in the international regulations such as UNCLOS, SOLAS in addition to recommended guidelines issued by IMO and IALA.

3.2 Rules for ships navigating in the Gulf of Suez

For safe navigation within the GOS, special rules were issued by EAMS; these measures have been endorsed by IMO and included in part F of "SHIP'S ROUTEING MANUAL". All ships should take into account throughout their passage in the GOS the following: All ships must have their radar in operational mode day and night across the passage between Shaker Island and Suez Port as assistance to achieve maximum compatibility with the lane and avoid collision risks. Ships transiting the GOS are required to watch-keeping broadcasts of traffic information in the GOS and inform "SUZ" if any aids to navigation are out of position or malfunctioning (IMO, 2019).

3.3 Traffic separation scheme (TSS)

Maritime traffic rules are typically limited to national legislations and confined by the IMO-approved routing scheme which is implemented as a TSS. At the northern end of the GOS vessels enter and leave the Suez Canal. In the central area of the GOS, there is intense marine oil field related activity and in the south of the GOS there is an increase in the recreational traffic due to expanding tourism related to the coral reefs. Five areas have been identified as critical traffic management areas in the GOS (UK Hydrographic Office, 2019).

3.4 Aids to Navigation in the Gulf of Suez

Egypt as a coastal state has the obligations/ rights as stipulated in SOLAS V/13 and III code paragraph 48.8 to implement AtoN with regard to the traffic density and risk degree in accordance with IALA guidelines and maritime buoyage system. According to national legislations, EAMS has the legal basis of application and enforcement to the establishment and maintenance responsibilities of AtoN in Egyptian waters. GOS AtoN are including lights, racons, light beacons and light floats that are established throughout the GOS to aid safe navigation of the TSS and safe entrance and approach to ports and major oil terminals (IALA, 2013a).

Lighthouses, buoys, shapes and marks are the main components of AtoN. The operational status of these components are monitored by EAMS engineers via a designated GSM and satellite monitoring system in order to maintain their proper function. Type, number and range of AtoN operating in the GOS are (Table 3):

Table 1: Aids to Navigation in the GOS

Navigation Aids	**Number**	**Range in NM**
Light Houses	7	Between 15-22 NM
Beacons	11	Between 7-18 NM
Safe water buoy	5	Between 9-12 NM
Isolated danger buoy	2	9 NM

To understand the current situation of AtoN in the GOS, an overview has been carried out via the secondary source of data in "Admiralty LIST OF LIGHTS AND FOG SIGNALS NP77 volume D". This publication is weekly updated from the notice to mariners. Any information regarding faults or changes to the aids to navigation is broadcast by Serapeum Radio. But on the other hand, seafarers are warned that AtoN in the GOS are unreliable and may be unlit, or off-position; navigation must be conducted with great caution (IMO, 2019)

3.5 VTMS as total maritime surveillance and its role as a cost-effective safety tool

IMO member states are required to take all essential measures to reduce the probabilities of risks in addition to reducing consequences in critical waterways such as collisions and groundings. VTMS is a tool for risk reduction established by EAMS as a competent authority in accordance with SOLAS V/12, III code para 48.7 (IMO, 2013) and IMO Resolution A.857(20) (IMO, 1997). The objective of the GOS VTMS is to provide safe and efficient operation of the GOS ports and waterways through real-time monitoring and analysis of vessel movements, types of cargo with an accent on hazardous cargo, environmental conditions and other vital information needed (EAMS, 2020). Although the GOS VTMS is a high-tech with a high-cost surveillance system, it improves the performance of ports and GOS waterway and thus facilitates commerce and significantly contributes into the development of Egypt's economy. Zhang, Pedersen, & Villavicencio (2019) study, stated that reducing the frequency of ship grounding and collision is the ultimate cost-effective control option. Thus, it is obvious that GOS VTMS is playing a crucial role as a cost-effective safety tool. If an accident has already taken place and immediate action is needed, consequences reduction measures are established in the GOS represented by Maritime Rescue Sub Centers (MRCSC) in Hurghada and Ismailia (ICAO, 2018).

3.6 Compliance with international regulations

The VTS is a shore-based maritime traffic management system established by the competent authority to assist the bridge team (IALA, 2016). In other words, VTS is classified as a socio-technical system established to manage and control maritime traffic in port approach as well as coastal areas and congested waterways that represent navigation difficulties for the bridge team (Praetorius, 2014). Cutting a long way short, the GOS VTMS provides comprehensive information on maritime traffic for ships. According to IALA, the VTS consists of three main services including TOS, INS, and NAS, which are all explained next (IALA, 2016).

Information services (INS) is a service where a Vessel Traffic Service Operator (VTSO) provides when necessary all vessels in the region with necessary safety-related information (Dalaklis et al., 2009). The information varies from hydro-meteorological to the location information, intent and identity of other ships in the area (Costa et al., 2018). Very briefly, INS seek to ensure that all parties are familiar with the current situation of the area to help them in building situational awareness. Basically, this service is standard and provided by VTS centers.

Traffic Organization Service (TOS) is a traffic management service inside the VTS coverage area (Siousiouras & Dalaklis, 2009). It regulates traffic to prevent hazardous situations such as problems related to conflicting travel routes and space allocation that may lead to crowding or grounding or in the worst case collisions (Blokus-Roszkowska & Smolarek, 2014). It works by allowing maneuvers, preventing entrance into specific areas, set the speed limits and grant permits. It ensures the safety and efficiency of traffic flow within the coverage area of VTS.

Navigational Assistance Service (NAS) is explained by Professors Dalaklis, Siousiouras and Nikitakos (2009) as the provision of maritime assistance services provided to ships have problems and/or difficulties in navigating safely on its own and seeks the benefits of VTS assistance. The lack of onboard navigation equipment or other internal/external problems may lead the decision-maker onboard ships to request the service (Van Westrenen & Praetorius, 2014). By actively providing the ship's crew with information about other ships' positions, currents, obstacles, and factors to consider when navigating in a limited area, the goal of the VTSO providing NAS is to assist in making navigational tactical decisions onboard ships. (Siousiouras & Dalaklis, 2009; IMO, 1997). After providing the advice, the VTSO monitors the outcomes through the decision support system. The service is almost rendered exclusively at the request of the ship and the instructions provided must be results-oriented, which means that execution details are left to the shipmaster.

The GOS VTMS meets the functional objectives outlined in the guidelines for VTS, which include collecting and recording pre-arrival and pre-departure information about all vessels in the surveillance area as well as target acquisition and continuous tracking of ships in the AOI to enable; detection, supervision and control of inbound and outbound traffic, monitoring vessel traffic within the surveillance area and coordinate traffic, search and rescue activities and all subsidiary services, provide information to ongoing ships to enable safe and expeditious navigation, provision of pollution control tools, store ship information for statistical analysis and provide evidence in case of an accident or incident. Thus, in accordance with IALA and IMO Resolution A.857(20), established GOS VTMS services comply with all requirements.

4- GOS VTMS contribution to increased situational awareness on board ships and onshore

Although there are several debates relating to the definition of SA, this research effort is utilizing the definition provided by Brödje et al. (2010), which stated that SA is the concept used to describe how people are formulating their mental picture in a dynamic environment. Also, it considered the SA definition in the VTS domain provided by Endsley (1995; as cited in Wiersma & Mastenbroek, 1998, p. 36) which stipulates that "Situation awareness is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future". As per this definition, when discussing SA as a perception of elements in the VTS domain, there are two approaches to be explained. The first is the SA of VTS operators which is strongly related to their personnel abilities such as competency and professionalism and equipment such as sensors, work stations and data processing available in the VTS center. The second is the SA of the shipboard crew, which mainly depend on instruments available onboard such as radars, AIS and VHF information provided by the shore side from the operators of VTS.

4.1 Multi-sensors data fusion and its role in situation awareness and decision making

A study carried by Dalaklis et al., (2009), along with the work of de Vries, (2015) showed that decision making is based on the collected information and communication initiated between the bridge team and shore operators. Brödje et al., (2010) research findings showed that VTSOs are using VHF, radar and AIS as a primary source for information; VTSOs are making decisions based on data fusion from different sensors therefore, information is crucial in the VTS operation. The type of information used by VTSOs as well as how, when and why it is used is crucial to understand the cognitive status of the operators. From the ships' crew perspective, a better understanding can be achieved by looking at the range of services, including TOS, INS, and NAS provided by the VTMS (IALA, 2016; Dalaklis et al., 2009). It is obvious that increasing SA of the ship's crew is created by providing comprehensive information on maritime traffic. This result can be supported by the findings of Blokus-Roszkowska & Smolarek (2014); Van Westrenen & Praetorius (2014); Costa et al., (2018) and Wiersma (2010). Information communication between the ship's bridge and VTS Center, in addition to data fusion of multiple sensors from different remote sites enables the VTSO to configure and construct a holistic traffic image in the waterway and supporting the decision-making process. However, there are several limitation and shortcomings of AIS; VTSOs are mainly depending on radar sensors for detection and tracking and the data are overlaid on AIS data then displayed on the main electronic geographical map to allow the operator to confirm the vessel's position and identifying the vessel by receiving ship's particular such as MMSI, ETA, destination, type of cargo and other static and dynamic data. GOS VTMS operators are mainly depending on radar sensors network located along the coast of the GOS as well as VHF communication, while AIS is considered to be a secondary source of information. This finding is in line with the study carried by Brödje et al., (2010), which stated that radar readings are the most important visual data and AIS is not usually used for navigation and detection.

5- Results and Recommendation

Primary data was collected through in-depth interviews with targeted sampling techniques for VTS competent authority officials as well as highly experienced users of the GOS such as masters and chief officers in addition to service providers. The data was obtained from the interview transcript and then analyzed by Coding (or sometimes an activity that is referred as indexing). The coded data describes data that has been repeated several times by the interviewee or who himself explicitly stated that it is important. The researchers conceptualized the data by describing the connection between the labeled categorized data, presenting the results and then proposed a solution under the scope of international best practices.

5.1 Towards integrated Maritime Surveillance

Maritime surveillance and monitoring data within and around Egyptian waters is gathered by a number of agencies for a range of different purposes including promoting safe navigation, environment protection, managing fisheries, and monitoring borders and migration control. Each of these maritime stakeholders are working independently and each entity follows a sectoral approach to MS and the absence of a multidisciplinary approach. Each agency has its own organizational culture, bureaucracy and legal basis for the application and enforcement under national legislation. Since different authorities have a variety of competencies, and thus, different information is needed to be collected which is very specific to those competencies where only some of this information within these systems will be useful to other users. That is why separate or single-sector systems were needed. Changes in the scope and focus of MS over recent years have been accompanied by technological developments that allow large amounts of data to be obtained, processed and exchanged in real-time. Therefore, it is necessary to establish a national cross-sectoral information sharing environment. Although there are several separate systems are running, the existing surveillance systems have to be consolidated and move to a higher degree of integration of MS information.

In fact, to make data integration and aggregation is a difficult process due to differences in data formats and technical systems specifications as well. This technical obstacle can be removed by following the best practices already implemented by European member states. Since 2010 integrating the MS approach has been adopted by European Member states expressed in Common Information Sharing Environment (CISE) (European Commission, 2010).

This paper examined the GOS VTMS as a case study in order to verify its compliance with international instruments regarding the role of VTMS as a Maritime Surveillance System. Although international guidelines are not obligatory, IMO urged member states to follow them in order to apply these guidelines as a global standard.

Hence, with the above-identified benchmark, it is possible to discuss how to fill the gaps to ultimately improve the current state of affairs. The VTMS is made of different authorities that are carrying out various MS tasks. Sharing (on a need to know basis) information between VTMS and coastal stations will create a better understanding of maritime traffic/activities within Egyptian waters. Also it can increase the coverage area of the GOS VTMS, which in turn will enable the operator to early detect critical situations providing adequate time to initiate proper actions, well before a potential threat is manifested.

5.1.1 Policy harmonization

Integrated policies and establishing a cost-effective national cross-sectoral information sharing environment will improve the efficiency of Maritime Surveillance System by covering existing information gaps, while avoiding duplication of data. This can be achieved through integrated policies that are based on harmonization of laws, regulations and standard operating procedures (SOPs) with the aim to avoid contradictions and gaps. A cost-effective decentralized interconnection of several information layers, could also improve the efficiency of Maritime Surveillance System under examination by effectively dealing with information gaps that exist throughout Egypt waters, while avoiding duplication of data. MS integration aims to create an added value through additional relevant surveillance cross-sectoral data which will enhance the existing sectoral maritime awareness image among users of the Egyptian maritime domain (Fig. 5).

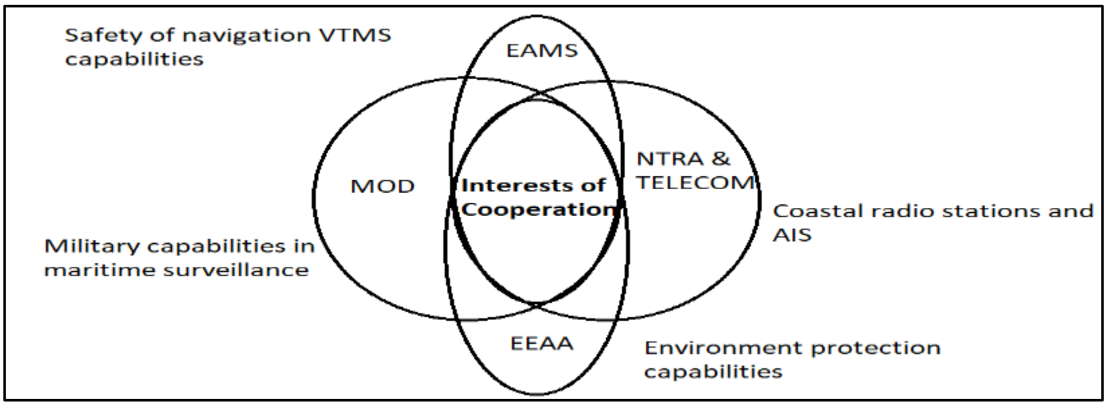

Figure 2: A need to know information sharing among MD stakeholders.

As a consequence, better situational awareness will be achieved which in turn can positively impact on issues like maritime safety and security, prevention of marine pollution, as well as more effective fisheries management and borders control. In other words, an improved sharing of information could also bring costs down, since the cost-effectiveness of Maritime Surveillance System will be optimized.

6- Conclusion

This research effort heavily focused on emphasizing the importance and role of maritime surveillance in the GOS to enhance the safety of navigation and protect the marine environment. Data collected/analyzed indicated that several governmental and non-governmental agencies are involved in the surveillance of Egypt's maritime domain. Also, it was explained that Egypt has exercised its sovereignty and deployed certain tools available such as the GOS Traffic Separation Scheme (TSS), Aids to navigation and Vessel Traffic Management System that were all established by the competent authorities under the scope of national legislations and in compliance with the relevant international instruments.

Due to the extensive existence of oil wells, offshore Rigs and heavy traffic of non-SOLAS and SOLAS ships transiting the waterway, GOS is one of the hot spots of oil pollution in the Middle East region. Consequently, GOS VTMS is a cost-effective risk reduction and mitigation safety tool, established in a very important and quite narrow waterway. This research effort discussed how exchanging and updating information between VTS Centers and vessels is playing a dominant role in improving SA for the shipboard crew as well as the onshore VTSOs in a complex dynamic traffic image. Consequently, the improved SA is leading to construct a holistic traffic image which in turn will facilitate the safety of navigation and protect the environment. The research results also indicated that there are a number of gaps, in comparison with international regulations and guidelines. The lack of a multidisciplinary approach for maritime surveillance is one of the main gaps. This is mainly happening when governmental and non-governmental agencies are working independently and each entity follows a sectoral approach to maritime surveillance. It is recommended to establish a cross-sectoral information-sharing environment, at the national level. This can be achieved through integrated policies that will the competent authorities to avoid contradictions and gaps, mainly in relation to their standard operating procedures and the way the sharing of information is taking place.

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THE IMPACT OF THE CONTAINER THROUGHPUT OF THE ADRIATIC GATE CONTAINER TERMINAL AT THE PORT OF RIJEKA ON AIR QUALITY ENVIRONMENTAL PARAMETERS[1]

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Abstract

In this paper, the authors emphasize the increase in air pollution in the eastern part of the city of Rijeka caused by the increase of the container throughput of the container terminal at the Port of Rijeka (Adriatic Gate Container Terminal), i.e., the increase in the number of vessel arrivals, the increase in the number of trucks in arrivals/departures related to road deliver/dispatch of containers.

Since the Adriatic Sea is the deepest part recessed in the European mainland, it is logical that the northern Adriatic Sea provides the Central European countries the closest access to world seas through the Gulf of Trieste and the Gulf of Rijeka. The natural advantage of the Port of Rijeka is the fact that the Dinaric Mountain barrier is the lowest and narrowest on the transport route through the northern Adriatic Sea. The North Adriatic traffic flow is the shortest natural thus the most economical way Europe relates to the Mediterranean and, by sailing through the Suez Canal, with most of the countries in Asia, Africa and Australia.

Important transportation links from landlocked Central European countries to seaports on the Adriatic coast, i.e., the Port of Rijeka, intersect on the territory of Croatia, Slovenia and Italy with other important traffic flows which move from Western and Central Europe to South-eastern Europe and the Middle East. Considering Northern and Western European ports, sea distance from Far East ports and Northern Adriatic ports, i.e., the Port of Rijeka, is approximately 2 000 nautical miles shorter, resulting in a shorter voyage time up to ten days. As for land cargo traffic directions, main Central European industrial and commercial centres are closer to the North Adriatic region by 400-600 km.

[1] The paper is the result of research activities of the scientific project Connected Traffic implemented within CECOM for smart cities (CECOM – Center of Competence for smart cities, the city of Rijeka), funded by the EU ESIF fund, started in March 2020. and ends in March 2023.

This paper presents the geographical and traffic characteristics of the Port of Rijeka, analyzes the total container throughput and land transport to/from the Adriatic Gate Container Terminal at the Port of Rijeka. The air quality at the measuring station Rijeka 2 was also analyzed, where the parameters in five years were analyzed; nitrogen dioxide, sulfur dioxide, particulate matter (<10µm), carbon monoxide, particulate matter (<2.5µm) and ozone.

This paper aims to interpret the possible dependence between the increase in container throughput of the Port of Rijeka and air quality concerning the increased traffic of trucks, but also the port activities themselves. The expected results of this paper are manifested through an increase in container throughput in the past five years, increased flow of ships in the Port of Rijeka, a high share of shipping/delivery of containers by road transport and an increase in certain environmental parameters.

Keywords: air quality parameters, container terminal, environmental parameters, port of Rijeka.

1. INTRODUCTION

The port of Rijeka has an extremely favourable geographical and transport position, gravitating towards the lands of Central Europe. As marked on Kvarner Bay, it is the backbone of the sea and land transport route as part of the Mediterranean transport corridor. This corridor connects the Danube region and the Adriatic Sea, and is also the link between Central European countries, the Adriatic Sea and the Mediterranean Sea (Vilke, Šantić and Glad, 2011).

The container terminal Adriatic Gate Container Terminal, where container handling takes place between the sea and land sides of the Port of Rijeka, has a great impact on the increase of rail and road traffic in the city of Rijeka. In 2020, a record number of 344 091 TEU were loaded on the Adriatic Gate Container Terminal (Port of Rijeka Authority, 2021). The increased amount of shipping traffic not only brings profits to the port and the city, but also negatively affects the air quality of the area by releasing an increased number of pollutants into the atmosphere. A similar issue was highlighted in (Anastasopolos et al., 2021) where Canadian port cities further emphasize the impact of ships and fuel quality on air pollution. Given the problems in some Asian and European ports, new tools are being developed that are used to encourage the development of "green" ports in the functional activities of port operations (Lam and Notteboom, 2014).

Air quality monitoring in the territory of the City of Rijeka and Primorsko-goranska County is measured at 16 monitoring stations. The largest number of stations is located in the industrial part of the city, while the remaining number of stations is located in congested places or in areas where waste is disposed of and recycling is carried out. The results of air pollution measurements in 2018 include most of Primorsko-goranska County in the 1st category of air quality, which means clean air or negligible pollution (Project study – Connected Traffic, 2020).

2. GEOGRAPHICAL AND TRANSPORT ASPECTS OF THE PORT OF RIJEKA

Since Adriatic Sea is the lowest point on the European continent, it follows that for Central European countries North Adriatic provides the shortest access to the world's sea through the Gulf of Trieste and Rijeka. North Adriatic ports are the main link of the southern European traffic flow, the shortest natural direction connecting Europe with Asia, Africa and Australia (Vilke, Brčić and Kos, 2017) . The northern Adriatic traffic flow connects two economically complementary worlds, the industrially developed countries of Western Europe and the Asian and African developing countries. In the narrower area of Central European there is a significant existing and possible potential economic and demographic market that could use the North Adriatic traffic flow as an optimal route for the flow of goods from the Mediterranean and the rest of the world.

Table 1. Sea distances (in nautical miles) between ports of Rijeka, and Hamburg, and significant global ports

Port	*Rijeka*	*Hamburg*
Port Said	1 254	3 551
Bombay	4 315	6 620
Shanghai	8 555	10 855
New York	4 785	3 535
Singapore	6 275	8 585
Hong Kong	7 734	10 029

Table 2. Railway distance (in kilometers) of the Northern Adriatic and North European ports to certain Central European economic destinations

Railway	*Rijeka*	*Hamburg*	*Rostock*
Budapest	592	1406	1166
Bratislava	602	1022	980
Prague	806	686	644
Vienna	580	990	984
Linz	557	911	923
Munich	563	777	876

Source: (Vilke, Brčic and Kos, 2017)

The sea distance from the ports of the Far East and Northern Adriatic is about 2,000 nautical miles shorter than from the ports of the North and Western European, resulting in a shorter voyage time of up to ten days. As far as land transport directions are concerned, the main Central European trade centres are closer to the North Adriatic region by 400-600 km (Vilke, Brčic and Kos, 2017).

3. RAILWAY AND ROAD TRAFFIC CONNECTING THE AGCT WITH THE HINTERLAND

The Adriatic Gate Container Terminal is located in the eastern part of the city of Rijeka and, together with other terminals in the vicinity, forms the backbone of the port handling of the Port of Rijeka. At the terminal with a depth of 14.88 meters, it is possible to accept Post-Panamax vessels in the size of two berths, which together exceed a length of 600 meters. On a total area of 17 hectares with 2 Panamax container cranes, 2 Post-Panamax cranes, 6 RTG storage handling gantry cranes and 2 RMG rail handling gantry cranes, total annual handling of 600 000 TEU can be achieved. Since 2011, International Container Terminal Services Inc. has taken over the concession over the terminal for the next thirty years to secure an advantage in world trade over other North Adriatic ports (Adriatic Gate Container Terminal, 2021).

Figure 1. Adriatic Gate Container Terminal Rijeka (2021)
Source: (Adriatic Gate Container Terminal, 2021)

In the last eight years, the share of rail freight at the container terminal has doubled, which is a shining indicator of the application of Directive 2009/33/ EC of the European Parliament and the Council of 23 April 2009 on the promotion of clean and energy-efficient vehicles in road transport (European Parliament and Council of the European Union, 2009). The Adriatic Gate Container Terminal could see a further increase in rail capacity in 2020 thanks to the development of a new terminal intermodal facility, the operation of two additional long-range gantry laptops and the commissioning of Ranch Tunnel Pećine.

The data from Table 3 clearly show the share of land transport for the last six years in the container transport of the Port of Rijeka. According to the data below, in the period from 2015 to 2020, a period of a positive trend in the growth of port transhipment and road and rail transport was observed.

Table 3. The share of land transport in container transhipment of the Port of Rijeka

Year	***Port Transhipment*** *(TEU)*	***Road transport*** *(TEU)*	***Railway transport*** *(TEU)*	***Lorries*** *%*	***Wagons*** *%*
2015	161.883	124.725	37.158	77.05	23
2016	177.401	132.984	44.417	74.96	25
2017	210.377	147.173	63.204	69.96	30
2018	227.375	162.422	64.953	71.43	28.6
2019	271.817	168.643	103.174	62.04	38
2020	344.091	176.746	126.880	58.3	41.7

Source: Created by authors by statistical data (Adriatic Gate Container Terminal, 2021)

In the period from 2015 to 2020, road transport has increased by nearly 42%, while railway transport has increased more than three times. It should be noted that the container terminal has significantly increased its rail capacity and more than 40% of all freight is transported by rail. It appears Table 3 and Graph 1 are used for dependent variables, but there are also other variables that must be considered.

4. THE IMPACT OF CONTAINER THROUGHPUT OF THE AGCT AND RELATED LAND TRAFFIC ON AIR POLLUTION

Motor vehicles are the primary air pollutants, with road vehicles responsible for 80% of pollution. The classical air pollutants can be divided into five groups of pollutants: Sulfur compounds (produced by the combustion of fossil fuels), carbon (II) oxide (CO), nitrogen oxides (hydrocarbons), soot, particulate matter, aerosol.

Following the pollutants occurring as combustion products of motor vehicles, which are divided into pollutants whose effects have a negative impact on human health and those whose emissions have a harmful effect on the atmosphere (so-called greenhouse gasses), ecological parameters are proposed that sensors could measure (Project study – Connected Traffic, 2020).

4.1. MEASUREMENT OF ECOLOGICAL PARAMETERS AND FUNCTIONAL REQUIREMENTS FOR ECOLOGICAL SENSORS

Following the research (the CECOM project Connected traffic) carried out in the project, ecological parameters are defined, which the sensors should measure in the area of the city of Rijeka and in zones near the terminal. Furthermore, when adopting the proposal of locations for the measurement of air pollution parameters, the current state of measurement of ecological parameters in the wider area of the city of Rijeka was considered, assuming the application of the method of direct measurement by sensors installed at fixed locations.

The main pollutants released by motor vehicles, the measurement of which would be necessary, include (Project study – Connected Traffic, 2020):

- Particulate Matter (PM 1.0, PM 2.5, PM 10) - can be primary and secondary pollutants formed from hydrocarbons, nitrogen oxides and sulfur dioxide. The exhaust system of diesel engines is a major contributor to this form of pollution.
- Volatile Organic Compounds (VOCs) - react with nitrogen oxides in the presence of sunlight to form ozone near the ground level and are the main component of smog. Exhaust gasses from vehicles most often appear in the form of toxic pollutants, namely benzene, acetaldehyde and 1.3 butadiene.
- Nitrogen Oxides (NOx) - a harmful primary pollutant that can form ozone at the ground surface or appear as particulate matter PM (secondary).
- Carbon Monoxide (CO) - a colorless, toxic gas produced by the combustion of fossil fuels such as gasoline.
- Sulfur Dioxide (SO_2) - produced when fuels containing sulfur are burned, particularly diesel. It can also react in the atmosphere to form particulate matter (PM).
  Other greenhouse gasses - the largest contributor in this group is carbon dioxide (CO_2), followed by methane (CH_4), nitrogen oxide (N_2O) and hydrofluorocarbons (HFCs).

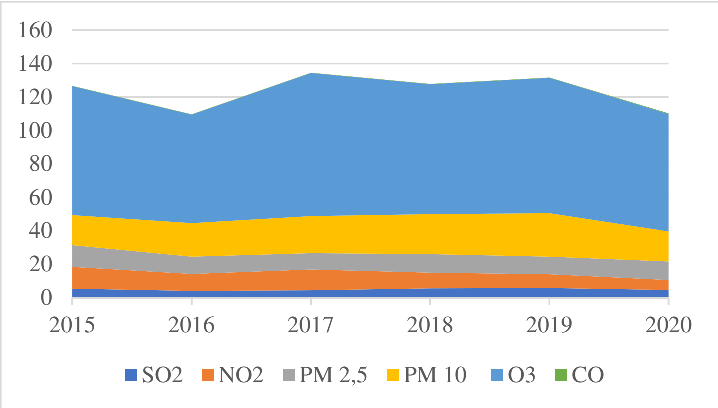
4.2. OVERVIEW OF AIR QUALITY ENVIRONMENTAL PARAMETERS AT RIJEKA 2 MONITORING STATION

The source and amount of air pollution are major factors through which it is possible to influence its reduction. Particulate Matter 2.5 (PM 2.5) and Particulate Matter 10 (PM 10) are measured as indicators of air quality, and according to European Commission, it is reported that in the EU transport is responsible for 25% of particles causing that cause air pollution in cities while industrial activities contribute 15% to pollution. Thus, although, there are significant differences between individual regions within the European Union (European Commission, 2015).

Since the port of Rijeka, i.e., Adriatic Gate Container Terminal has seen a steady increase in port transshipment (Table 3) for the past six years, analyze of parameter measurement results (SO_2,

NO_2, $PM_{2.5}$ and PM_{10}), whose excessive concentration negatively affects the quality of life of the population, has been produced in the period from 2015 and 2020.

When measuring the ecological parameters near the container terminal, the data from the station located in the immediate vicinity of the terminal, i.e. on the access road to the port of Rijeka, were considered.



Graph 1: Mean of collected parameters 2015-2020

Source: Created by authors by data (Croatian Agency for Environment and Nature, 2021)

* Note: PM10 for 2019 is the estimated value.

The data in Graph 1 show a decrease in the values of all parameters except PM10 between 2015 and 2017. The increase continued until 2020, triggered by the COVID-19 pandemic, which caused significant traffic restrictions resulting in a decrease in the value of all parameters. The estimated value (based on the increase in previous years and the available data for the months of 2019) was considered for the measurement of PM10 parameters as the instrument was in the calibration process for a certain period. However, there are other variables that must be considered (urban transport, industry, etc.) as they also affect environmental parameters.

In addition, the analysis showed that the increase in port throughput had no impact on the decrease in the quality of life of residents (in terms of air quality) in the vicinity of the terminal. Furthermore, the slight increase in container transhipment via road transport had no impact on air pollution as a significantly higher proportion of containers were allocated to rail transport.

4.3. POSSIBILITIES FOR OBTAINING MORE RELEVANT VALUES OF ENVIRONMENTAL PARAMETERS

Determining the environmental impact of port activities and the air quality of port cities is a rather complicated task, as pollution caused by port activities is mixed with land-based sources of pollution such as industrial areas, traffic, etc. (Merico *et al.*, 2021).

According to the activities carried out in the project Connected Traffic, it was found that the system for measuring ecological parameters in an urban area can have several functional levels, given the complexity of obtaining information based on the collected data. The system of measuring ecological parameters in an urban area may have several levels of function, depending on the complexity of obtaining information based on the collected data, while the method of measuring ecological parameters with appropriate equipment may be direct and indirect.

In direct measurement, sensors measure pollutant levels at predefined stations outside the pollution center and it is questionable to what extent the values obtained reflect the impact of traffic on air pollution. While such a method provides information on the measured level of pollutants at the measurement location, it does not capture the exact proportion of pollutants from motor vehicles, as the dispersion of air gasses is already present at the measurement location. A more successful method of direct measurement can be achieved by installing mobile sensors on public transportation or municipal utility vehicles. By using such method, information can be obtained on the pollution footprint and on changes or dynamics in the movement of the footprint within the target area

The indirect measurement method represents the highest level of functionality, as the subsequent analysis of the movement dynamics can provide information on the impact of traffic and its flow in terms of environmental parameters and pollution. The most relevant values of ecological parameters can be obtained by sensors placed at the source of pollution and computer models based on movement dynamics obtained by video analysis and virtual sensors, which will also be applied in the continuation of the research. Instead of applying sensors placed at the source of pollution, the devices will be installed at the container terminal itself or at the operating shore where loading and unloading of ships for pollution by ships and handling mechanization is carried out. Also, sensors will be installed at the ramp of entry and exit points for trucks at the terminal. The application of computer models will provide information on the impact of traffic and its flow in terms of ecological parameters and pollution (Project study – Connected Traffic, 2020).

In line with EU greenhouse gas emission reduction targets and increasing air pollution, it is necessary to highlight the importance of organic transport or energy efficiency in transport and to encourage projects to increase the energy efficiency of transport systems and to use vehicles with less environmental impact that make greater use of renewable energy sources and have reduced CO_2 emissions.

CONCLUSION

Road and railway infrastructure on the territory of the Republic of Croatia is very uneven, although in recent years a lot has been invested in the construction of new roads. Additional investments are needed in both existing and new infrastructure to connect the coast with the hinterland, i.e. to strengthen intermodal transport on the Rijeka transport route.

Among the many advantages for the country's economy, ports also bring certain disadvantages in terms of air quality reduction. This problem is most acute due to ships, which are the main source of pollution, along with vehicle emissions, dust and noise. Although AGCT is located near a densely populated area, according to the analysis carried out, no excessive pollution was detected that would endanger the population. However, the Port of Rijeka has the potential to attract larger amounts of cargo, so in the future it will be necessary to carry out further measurements of ecological parameters and research that will result in the sustainable development of the Port of Rijeka. The recently expanded intermodal rail terminal also has a positive effect on reducing pollution.

The Adriatic Gate Container Terminal represents an important part of the economic activities of the city of Rijeka, as the ports are considered the "gateway" to global trade. The potential for further growth of traffic in the port of Rijeka is reflected in its geographical location in the northern Adriatic with road connections with the center and Southeastern Europe. Considering the great potential of the Port of Rijeka, a further increase in container throughput followed by a higher share of shipping/delivery of containers by road transport is expected, which so far have not significantly affected the quality of life of residents living near the terminal.

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Proceedings

Innovative MET Environment

ACTIVE LEARNING STRATEGIES IN MARITIME ENGLISH TRAINING

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Abstract

The aim of higher education has always been to equip graduates with a set of professional skills for a particular professional area. This is provided by a number of technical subjects which guide students in acquiring necessary knowledge and practicing essential skills. From such perspective, Maritime English occupies a special place in MET, as it combines knowledge of language itself, professional terminology and communication skills with knowledge of the profession itself. The process of Maritime English training is complex enough as it requires answers to the questions what should be trained, how to organize the process and evaluate the progress. It is a real challenge to integrate language learning activities with a profession-focused content into meaningful tasks, find and implement interdisciplinary content to trigger genuine communication. Students should be engaged into a real-life maritime scenario simulation, provided with an opportunity to apply a broader set of professional knowledge, understand, adapt, and create a new scenario in response to the investigated complex problem. The students are trained to think critically and transfer knowledge to the other situation, as well as develop career skills, such as ability to plan, prioritize and communicate in a decision-making process, demonstrate their leadership and teamwork.

To provide sustainable development and face challenges of the current pandemic situation, the educational system shall apply innovative approaches and technologies into the learning process. As the language teachers, our task is to organize a collaborative classroom environment and establish a process for asking questions and developing knowledge through students' cooperation and effective communication. Active learning as a key approach to teaching Maritime English aimed at customizing the educational process to the individuals' needs, encouraging students to reflect on and share responsibility for their progress and train

life-long learning strategies. It is implemented into everyday practice through embedding inquiry into the learning process, when students collaborate to create hypotheses, select information and investigate a driving question. The learning process has moved beyond the class and transformed into flipped classroom environment, where students drive their own learning, and teachers coach them to facilitate and personalize learning through developing individual playlists. It requires from teachers to adjust learning materials and training tasks to respond to students' needs and develop new generation course books as well as digital courses (e-learning) to provide a wide access to applicable resources and make learning feasible.

The article describes the ways how to apply active learning strategies in Maritime English training. The authors of the article share their experience of implementing active learning strategies to provide students with "good command of English in written and oral form" necessary to perform profession-oriented tasks and meet occupational requirements listed in the STCW Convention.

Keywords: communicative competence, active learning strategy, Maritime English course.

Introduction

Nowadays one of the most advanced strategies in higher education institutions is active learning. Researchers in the field of pedagogy attract attention to the fact that still a lot of teachers in higher education verbally transmit information to the students, and students passively receive it. Traditional "passive" method of learning may not be considered to be effective way for students to learn (Michel N., Cater III J.J. & Varela O., 2009; Ghilay Y., Ghilay R., 2015). Moreover, many studies highly recommend to apply teaching techniques that encourage students to be actively engaged in the training material because this type of engagement promotes deeper levels of thinking and better facilitate encoding, storage, and retrieval than traditional "passive" techniques (Peck A.C., Ali R.S., Matchock R.L. & Levine M.E., 2006).

An important part of seafarers' professional training is Maritime English, in particular, development of communicative skills required for professional communication within the maritime field. Teaching and learning Maritime English is inseparably connected with active communication between the training process participants, be that student-student or students-teacher interchange, the more so if it is based on the principles of communicative approach. IMO Model Course 3.17 "Maritime English" (2015), approved by International Maritime Organization, stipulates the necessity of active learning by stimulating frequent learner participation in order “to assess how much students already know, stimulate interest in a topic, and increase opportunities to interact in English”, which is mostly done by teachers. Researchers have provided wide coverage of active learning definitions, elements and strategies mostly concerning ways of conducting lectures with scarce references to teaching Maritime English. We would like to mention some general concepts that were particularly important for our research.

Active learning is defined as any instructional method that engages students in the learning process, where students do meaningful activities and think about what they are doing (Prince M., 2004). The strategies promoting active learning in the classroom are vital because of their powerful impact upon students' learning (Bonwell Charles C., Eison James A., 1991). Students learn more when they are asked to apply what they are learning in different settings (Weston C., Finkelstein A., Ferris J. & Abrami J., 2010).

Thus, in current theories and researches concerning active learning strategies, two important components are specified: activities involving higher order thinking skills (HOTS) (based on Bloom’s taxonomy) and student reflection on their learning, with the latter to be done by students themselves.

The purpose of the paper is to describe the practice of implementing active learning into Maritime English training.

Main text. Methodology

On the basis of our successful project concerning implementation of communicative approach in teaching Maritime English, there came a decision of continuing it with a complementing project of incorporating active learning strategies into the training process. As a group of sixteen teachers of Maritime English, we were aware of the existing similarities between communicative and active learning. They both view speaking, reading and writing as well as various forms of student interaction to be the major learning components.

After a series of workshops on active learning (*Active Learning in Higher Education* in November 2020; *Active Learning Strategies* in April 2021) to help ourselves understand the similarities and differences between communicative and active learning, we chose to develop a set of course books in which both ways of learning can be intertwined.

The course books have a unified structure: five modules grouped around essential competencies, three parts in each module with each part containing reading, speaking and writing sections. The activities elaborated for each module present possibilities for developing all levels of cognitive thinking going from lower levels (understanding, remembering, applying) up to higher ones (analyzing, assessing, and creating), the latter presenting active learning strategies.

As the students' interaction – individual, pair and group work – is characteristic of both learning strategies, the active learning indication depends on two elements of meaningful activities: those promoting students' HOTS and those reflecting on the content measured by the required learning outcomes. To describe how things should be done correctly (e.g. identify and describe ship's type, structure and equipment; explain symbols and abbreviations on a chart; role play the words and phrases for emergency situations etc.) using English in written and oral form is the goal of learning the discipline of Maritime English (STCW, 2011).

The most rewarding foundation for promoting HOTS are undoubtedly cases, sea stories, extracts from maritime accident reports, extracts from books written by seafarers. Provided the tasks are thoughtfully elaborated, they serve as promising catalysts for arousing students' interest and motivation to plunge into exhilarating discussions based on the acquired knowledge and skills.

Short cases and extracts from books by mariners are placed within certain topics in the module parts. Their length fluctuates between 100 and 200 words. A typical set of questions might be: What did the crew member do wrong (analysis)? Could the accident have finished in a more serious injury (assessment)? How could the accident have been avoided (creation)? They are commonly discussed in small groups structured as buzz groups, round table discussions, or jigsaw and expert groups. The emphasis is put on developing critical thinking (analysing and assessing) and decision-making skills (creating) based on communication skills. As a follow-up, students either produce oral reports to the class by a nominated speaker dwelling on the most challenging question/issue or have whole class comments on the question of their choice.

Sea stories and extracts from maritime accident reports designed as texts for extensive reading form a separate section in the course books. Topically, they are connected with the module content and its essential communication competency, but what is truly beneficial, those stories and reports content coverage is much wider making students revise their knowledge of the Maritime English syllabus and refer to their life experience. With this format of extensive reading, a flipped classroom method is effectively used: students are notified about the extensive reading lesson well ahead to have time for individual reading, clarifying the meaning of certain phrases, think the proposed questions over and express their personal attitude to the events in the story.

The younger students' knowledge of General and Maritime English is rather low, so the activities for reading and discussing sea stories by them are limited: general discussion, comprehension check, your ideas (mostly presented as questions), and creative task. Except for the comprehension check, all the other tasks are focused on application of HOTS. To provide an example, the sea story "Drama in Real Life" to the module "Life-Saving Appliances" (Welcome Aboard, 2021) is preceded by a discussion "What hazards can happen to a seafarer lost far at sea?" and followed by such questions as "Why could the crew panic instead of preparing to abandon the ship (analyzing)?" "How efficient were the life-saving appliances used by the crew (assessing)?" etc.

Extracts from maritime accident reports are meant for increasing students' ability to apply their knowledge and skills to tackling critical situations at sea. The list of tasks is longer, and those requiring HOTS are as follows: critical understanding of facts, making assumptions, stating the problem, analyzing facts concerning the problem, generating and assessing alternatives, and developing an action plan. Besides the activities used for the above mentioned purposes, teachers have an ample choice of strategies to engage their students into; the most appreciated, though, are group strategies (think-pair-share, quescussion), reasoning strategies (debate, four corners), and instructional strategies (Socratic questioning).

Another element featuring in active learning is student reflection. In common teaching practice, students are suggested to revise some previous aspects of learning or work at review lessons on the least mastered knowledge and skills. Reflection is a different approach. It means students analyse and assess their learning including their achievements and failures, the effectiveness of some activities for their learning. The success of reflection activities is directly related to the students' mentality peculiarities, their personal preferences and their attitude to sharing personal opinions. The same is true about the teachers: whether they are open to knowing the students' thoughts, especially about the impact of certain activities on their learning (Kudryavtseva V., Barsuk S., 2021). We consider that reflection strategies can be divided into three types:

1) whole group reflection in oral form organized on the teacher's initiative at the end of the lesson, module, or semester when students are asked questions like "What did you understand best/worst of all? What was the most interesting task?" or comment on how they worked through a certain activity while collaborating within a group or come up with their suggestions on ways of improving their skills;

2) individual reflection in written form taking up the format of one-minute papers, exit slips the teacher / students write a comment on the same issue/activity;

3) individual reflection in written form following students' topical essays.

In our effort to implement reflection strategies, we have come upon initial students' unwillingness and inability either to participate in them or respond specifically. Also, this depends on whether their reflection is oral or written. Most students do well with anonymous exit slips, more likely if they become aware of the teacher's positive reaction to their comments.

Special attention has been paid to the essays by first-year students. On an electronic forum, students wrote their two-hundred-word essays built on a video, suggested title, or individually chosen topic. For the second time, they had to correct their mistakes or the essay structure by themselves or with the peers' assistance. And their final reflection was done after the teacher's comments written below the essay. The lessons learnt are: 85% of students appreciated this type of individual work with them; they became visually aware of their typical mistakes and tried to eliminate them in speaking; about 30% of students disliked the process after the second step; about 40% were eager to continue composing essays connected with the module they were learning; reflecting on essays is time-consuming, especially for the teacher.

Active learning strategies may be applied at online lessons of Maritime English with some limitations for intense regret which are as follows:

- impossibility of organizing the activities that get students moving and make their learning more enjoyable and personalized, e.g. post-it parade, four corners;

- pair and group work can be done only on few learning platforms, e.g. Zoom, Microsoft Teams where students have the possibility to work in separate rooms;

- the most applicable forms of interaction in learning Maritime English (pair and small group work) give way to individual performance; due to it, student speaking time at the lessons decreases considerably while individual offline tasks in written form can become more dominant.

HOTS can be improved by regular progressive practice. Much depends on teachers' enthusiasm due to the unfortunate situation that the main concerns of official assessment for learning are knowledge, proficiency and competence with no reference to higher order thinking which is, therefore, logically implied and may be taken into consideration.

Data analysis

The learning process has been constantly monitored, two methodologies were executed to determine student attitudes and perceptions to active learning as pedagogical instructional strategy. The first method involved the usage of standardized tests (Stop and Check) to measure academic achievement. Thus, learning progress was explored in terms of traditional criteria, such as grammar accuracy, vocabulary appropriateness, and professional competency. Whereas the second method involved students' and teachers' interviewing as the participants of learning process. To increase the findings validity, the results were compared with the Moodle database analysis set on the complex assessment of students' engagement in the course.

The survey group comprises 60 participants, who are the first-year students studying at Navigation Department of Kherson State Maritime Academy and attending Maritime English course as part of their professional training. The majority of them are native citizens (40 persons) as well as foreigners (20 persons), who are mostly representatives of Egypt, Nigeria and Lebanon. Also, 15 teachers of the English Language Department for Deck Officers were interviewed on some key aspects of active learning strategies to get their feedback on pros and cons of this approach applied in their daily practice and to make teaching/learning a more productive and enjoyable experience.

The main data collection tool is a questionnaire, that consists of two parts. The first one comprises 25 statements and examines the reliability of the four teaching/learning domains: focus on HOTS as learning objectives, personalized learning strategies application, students' attitude to collaboration types and to mistakes, sharing responsibility for learning achievements. Students indicate their responses on a four-point scale ranging from strongly disagree to strongly agree (closed questionnaire multiple choice).

The first set of statements is designed to investigate the students value of HOTS training as learning objectives in the course. All the students recognize the positive impact of HOTS development on knowledge perception and their ability to apply it to a different context.

The second group has 8 clauses relating to active learning strategies and students' preferences. Students responses indicate that collaborative work and inquiry-based learning as well as self-reflection papers enhance their learning and train self-studying skills.

To reflect on language performance and attitude to mistakes correction the students respond to the third set of questions. The answers analysis shows that all the students perceive their learning experience as positive and enjoyable, recognizing mistakes as an essential part of the process and peer-correction as the most appropriate way.

The first part of the questionnaire finishes with the statements to reflect on the teacher's role and the extent to which students take responsibility for their learning. The analysis indicates that most students perceive the teacher as "a sage on the stage" being the main source of knowledge presented in class (85%). They also appreciate feedback on their performance as a valuable tool for improvement (97%); about half of the responders believe their progress depends on the teacher's regular checks (45%). However, 85% of students demonstrate their readiness to share responsibility for learning results and importance of out-of-class learning.

The second part of the student questionnaire consists of two ranking tasks and four open questions designed to examine portions of data from the questionnaire. Ranking tasks overlap previous questions and provide more precise information on learning objectives and outcomes as well as the skills trained. Thus, all the students have chosen knowledge understanding as primary learning objective as well as applying knowledge to different situations (40%), and information analysis and facts investigation (40%). Active learning strategies contribute to development of communication skills (100% of responders), critical thinking skills (60%), teamwork skills (60%), leadership (40%), and decision making skills (25%).

The open questionnaire is designed to collect data on students' preferences referring to learning activities, self-study strategies, and their motives for learning. The results analysis shows that such activities as case-study, role-play, working tasks simulation, project work, directed to engage students in group work interaction and focus on creating the best solution / searching for information and its analysis / performing job-oriented duties / developing a group project are among their favourite ones (75%).

The question to investigate the students' motives to study suggested some options to choose and an open answer. All the students have chosen intrinsic motivation, such as personal development as a main motive to study language, as for external motivation the responses vary from employer's requirement (60%) to academic success (20%).

To sum up the findings from the students' questionnaire, we can characterize their responses as generally positive, often relating to success of embedding active learning in Maritime English course.

To develop insights into the students learning and reflect on active learning strategies implementation, a questionnaire was designed for teachers, who teach Maritime English for students of different years of study. The questionnaire contains five multiple choice questions with open answers to evaluate the results, identify potential problems, and discuss possible solutions to modify teaching practices.

Thus, to determine the problems the teachers encountered, 53% of them notify that students of lower language level are not ready to work independently; some students are reluctant to participate evenly in group work (40%); it is difficult to create criteria to assess HOTS levels of development (40%). Among the assessment techniques the teachers use most often are teacher's developed tests (66%), self-assessment and peer-assessment based on the criteria familiar for students (50%), and group work performance (40%). To examine learning strategies of frequent use, the teachers focus on simplified-inquiry tasks (projects) and role play / simulation (73%), and a minute paper as a reflection on learning (67%) as the most efficient ones. These strategies require tasks accomplishing, active engagement and sharing personalized information, they provide valuable input for further discussion to evolve knowledge and skills training. Reviewing their practices, the teachers name such benefits of active learning approach as training of effective collaboration and team work skills (86%), development of creativity (66%), speaking skills improvement (60%), and critical thinking skills development (53%). To evolve their practice and overcome the problems they experienced the teachers believe that students learn better when they are actively engaged in the learning processes. To increase students' involvement and make their learning more personalized, students might be involved in course materials development by choosing the topics for discussion and the ways to demonstrate their achievements (73%). It is also a good idea to encourage students to reflect on the course material, the implemented learning strategies and the lessons outcomes (60%).

Conclusion and recommendations

This paper is designed to highlight advantages and problematic areas of active learning strategies implementation into Maritime English course and may lead to general recommendations on the course development. Based on deeper learning approaches (inquiry-based learning, personalized instruction, flipped classes) active learning strategies focus on training HOTS and develop decision-making and critical thinking skills, which contribute greatly in communication skills improving and, as a result, general learning enhancing.

In this respect, some recommendations are suggested:

1) students' reflection on their performance, course material, learning strategies is welcomed in order to make study personalized;

2) self-correction and self-assessment are encouraged to increase self-awareness and learning efficiency;

3) effective collaboration in groups should be the main type of students' interaction that leads to development of HOTS and communication skills.

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Application of Augmented Reality (AR) / Virtual Reality (VR) Technology for Remote Maintenance of Autonomous Ships

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Abstract

Autonomous ships are going to be the ships of the future. The operation and maintenance of Autonomous ships will be vastly different, requiring proper knowledge and understanding of many interrelated human and machine components. Today's skills would become obsolete for running Autonomous and remotely operated ships. Modern technology tools will need to be incorporated, so that the seafarers could be trained to use such tools and enhance their knowledge to help them operate ships from remote locations, and also improve the safety of the vessel as also the safety of lives of those few human beings who would be required to work onboard such vessels. Thus, the entire training will need to be revamped and various skills including Augmented Reality (AR) / Virtual Reality (VR) technology will need to be included in the curriculum and syllabus of Maritime Education and Training programs. Since there will be limited crew on board, it will be necessary to carry out trouble shooting and diagnosis of failure of machinery from remote locations and also plan the survey and repair of the machinery using AR technology. The future education experience can also be enhanced by using Augmented Reality (AR) / Virtual reality (VR) and such technologies like the HoloLens technology, which will make learning more effective through annotations and interaction by simulating various conditions that could be experienced on board a vessel. It would also help to simulate conditions which might not be safe and practically possible to be carried out on board a vessel. Such training could be carried out in shore- based establishments where various types of vessels operating under different environmental conditions could be replicated through simulation, thus, making training as effective, if not more effective, in comparison with the current training methods. In this paper an attempt is made to outline appropriate trouble-shooting procedures, machinery survey procedure from remote locations as also suitable training methods for training crew for autonomous ships of the future.

Key Words

Augmented Technology, Virtual Reality Technology, HoloLens Technology, Training, Curriculum.

1. Introduction

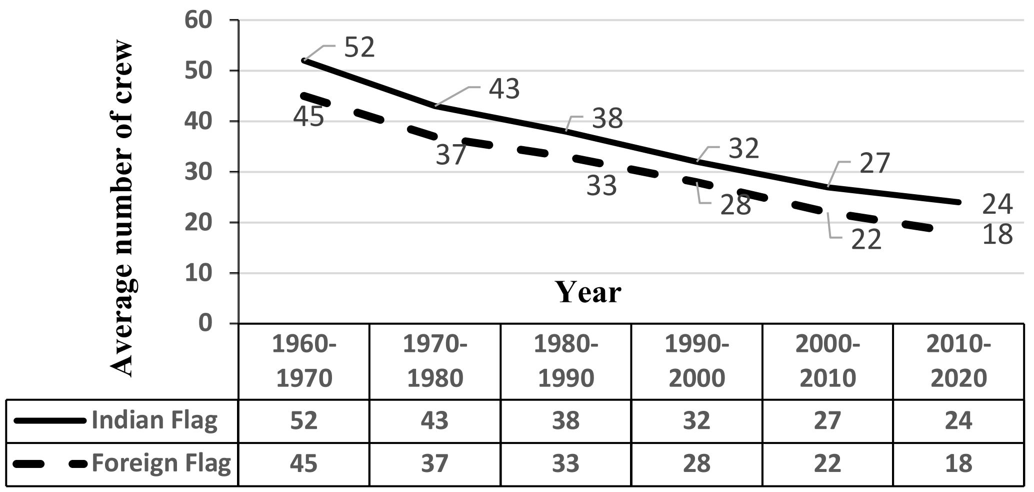
Technology is advancing at a tremendous pace and to keep in step with it the way of operating and maintaining ships is also changing rapidly. In the past, during the era of ships with sails, the number of sailors required for working onboard to rig the sails and operate and maintain the ships was large. The dawn of the industrial revolution and the consequent induction of the steam engines onboard for propelling the ships resulted not only in the reduction of crew onboard, but also in the changes in the method of training and certification of mariners to safely operate and maintain the ships.

The introduction of diesel engines and other auxiliary machinery to replace the steam engines for propulsion of ships as also for power generation brought in further changes in the form of reduction in the number of mariners onboard, the methods of training and certification of mariners and their deployment onboard to safely operate and maintain the ships.

With the rapid development of electronics and automation and their successful deployment in various shore- based industries prompted the introduction of instrumentation and automation onboard ships as well. This move further brought down the crew requirement onboard ships.
We are today on the threshold of another major change in the shipping industry in the form of autonomous ships which could drastically alter the size of the crew onboard, possibly reducing it either to zero in the case of fully autonomous ships or to a very small number in the case of remotely controlled autonomous ships. The arrival of autonomous ships is also expected to bring about major changes in the method of training and certification of mariners.

2. Changing Work Culture Onboard

The reduction of crew onboard ships over a period of time as depicted in Figure 1, due to induction of newer and more advanced technology onboard, in order to bring down the operating costs of ships, has had an impact on the work culture onboard. Right up to the late 1970s / early 1980s the crew complement onboard average sized ships ranged between 40 and 60 members. During this period, due to the presence of sizeable number of hands available onboard, all the activities pertaining to the maintenance of the vessel were carried out by the ship’s crew. Also, at that time due to relatively long port stay for cargo loading and discharging work, the ship’s crew could undertake time consuming tasks such as opening up of main engine units for overall and maintenance work. But due to the progressive reduction in the strength of ship’s crew, ranging from 28 members to 10 members, as a result of increasing automation onboard coupled with the reduction in the port stay from a number of days to a few hours due to shorter turn-around time, maintenance work requiring many days to complete were not undertaken by the ship’s crew. Such time- consuming tasks depending upon their nature were either outsourced to shore based marine workshops or to the experts from Original Equipment Manufacturers(OEM) as the per the requirement or were taken up at the next dry-docking opportunity. All these developments over a period of time have contributed to the present day changed work culture onboard ships. It is evident from these historic changes that maritime operations would further be simplified by integrating VR/ AR technologies for maintenance.



	1960-1970	1970-1980	1980-1990	1990-2000	2000-2010	2010-2020
Indian Flag	52	43	38	32	27	24
Foreign Flag	45	37	33	28	22	18

Courtesy: *Archives of Shipping companies(South India Shipping, India Cements Ltd, Good Earth Maritime)*

Figure 1: Average number of crew from 1960 to 2020

3. Autonomous Ships

The past three years have seen a flurry of activities on the autonomous ships front by the shipping industry, as described below:

-The era of autonomous shipping dawned on the 3rd of December 2018 with the world’s first autonomous car ferry FALCO making its maiden voyage from Parainen to Nauvo in Finland. The return voyage of this ship was remote controlled from a control centre located 30 kms away in Turku.

-The first autonomous cargo vessel made an international maiden voyage crossing the high seas from Mersea island in the UK to Ostend in Belgium on 6th May 2019.

-IRIS LEADER a 70,826 DWT autonomous car carrier made its maiden voyage on 14th September 2019 from Xinsha in China to Nagoya in Japan and later from Nagoya to Yokoyama on the 19th of September 2019. However, the vessel had onboard the full crew complement for carrying out other normal tasks.
In addition to the above, the world's first transatlantic voyage by a fully autonomous research ship MAYFLOWER 400 fitted with special equipment for carrying out scientific survey is expected to sail out in early June 2021, from Plymouth in the UK to Plymouth in Massachusetts in the USA.

The above -mentioned events seem to prove to the world that autonomous ships are a reality and that this type of vessels are the ships of the future (Chary,2018). There is, however an urgent need for a regulatory framework to be put in place for governing the safe operations of autonomous ships on high seas. It is reliably understood that the following organizations, among others, are working overtime to achieve this objective:

1. The International Maritime Organization (IMO).
2. The Maritime Autonomous Systems Regulatory Working Group, UK.
3. Safety and Regulations for European Unmanned Maritime Systems (SARUMS).
4. Advanced Autonomous Waterborne Applications (AAWA), Finland.

The successful completion of voyages by the autonomous ships enumerated above indicate that not only the business of shipping itself is set for a major change but also the way of operating and maintaining the autonomous ships. Advanced technologies like Augmented Reality / Virtual Reality, HoloLens technology and the like are expected to play major part in the efficient management of autonomous ships.

4.Advanced Technologies and Their Application in Shipping

Virtual Reality (VR), is a simulation of the real world around us. It is not physical but a clone of the reality that can be seen, felt and heard thus giving one an impression that it actually exists. In other words it is a digitally created environment that makes one believe that he or she is physically present in this environment. A person can interact within this artificially created environment using certain special electronic devices.

Augmented Reality (AR), on the other hand is a blend of real life and Virtual Reality (VR). AR lets the user to interact with virtual entities in the real world through the use of certain devices called Optical Head Mounted Displays (OHMD) which enable AR and VR live audio and visual functionalities.

Both Augmented Reality and Virtual Reality have the same goal of making the user delve deep into a virtual world. With AR, users continue to be in contact with the real world while interacting with the virtual objects around them, whereas with VR the user is far away from the real world while being completely immersed into the virtual world.

HoloLens (see Figure 2**)**, a short name for holographic lens is an example of OHMD. It is a creation of Microsoft for the realization of Augmented Reality. It uses multiple electronic sensors, advanced optics and holographic processing software that enables a seamless merger with its environment which could, for example, be the engine room or the wheel house of a ship.

The components of the HoloLens are:

1)The Visor which contains number of HoloLens sensors, displays, brightness control buttons, volume control buttons, power on/off switch and USB port.

2)The head band to wear the HoloLens.

There are a variety of HoloLens sensors such as:

a)The head tracking sensor consisting of four visible light cameras.

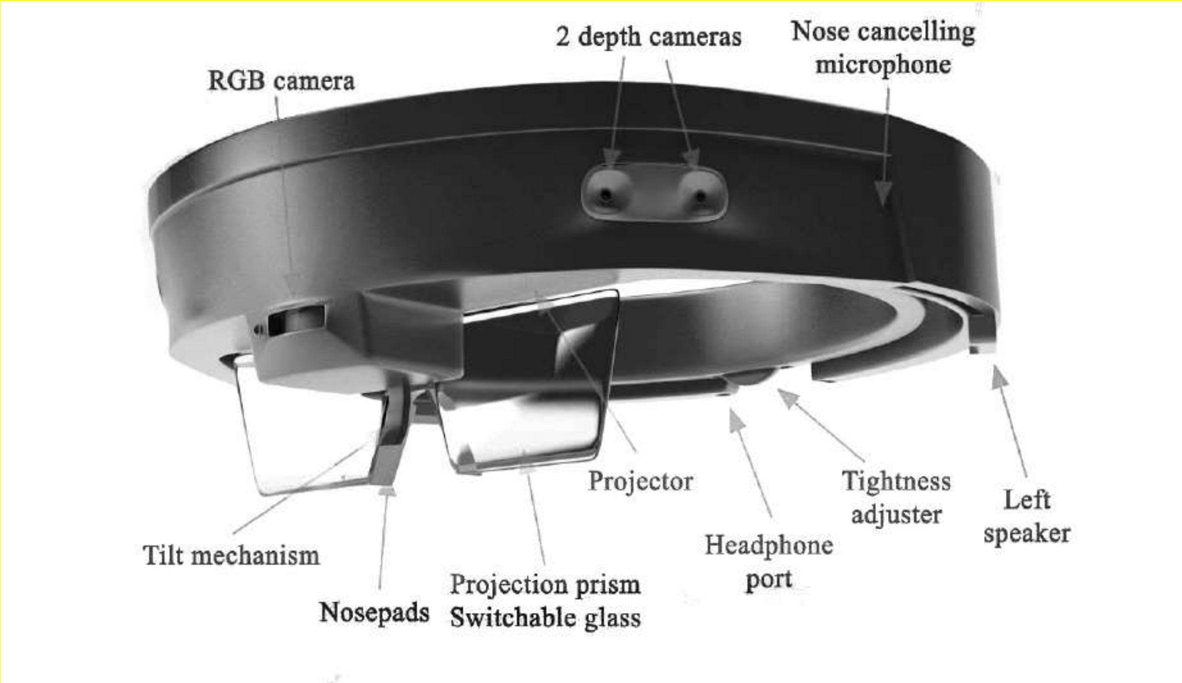
b) The Eye tracking sensor consisting of two infrared cameras.

c) The depth sensor

d) The Inertial Measurement Unit consisting of accelerometer, gyroscope and magnetometer

e) An array of Microphones

f) A set of multiple speakers



Source: *https://mspoweruser.com/instead-of-5-cameras-hololens-2-0-may-just-have-one/*

Figure 2: HoloLens (OHMD)

Augmented Reality and Virtual Reality allow experiences that are evolving more rapidly than anticipated and are finding scope for application in various fields such as entertainment, education, science, medicine, simulation, robotics, military applications, etc. Augmented Reality is ahead of Virtual Reality, as there are several products already in the market. Virtual Reality has its limitations. In spite of providing whole immersive experience VR blocks the user's interaction with the surroundings. Augmented Reality devices, on the other hand are more commercially successful as they do not completely disconnect people from the real world. AR headsets do not require users to stand at one place; they can move around and remain productive while attending to other tasks as well. This is also an important reason why AR despite being behind VR on application development, is expected to have a bigger impact on the enterprise market.

Virtual Reality has already manifested itself in the shipping industry more than a decade ago in the form of bridge simulator, engine room simulator, full mission simulator and cargo handling simulator that are used for the purpose of training shipboard personnel. Augmented Reality though apparently lagging behind Virtual Reality in the race, has the potential to play a very important role of a different kind , particularly onboard remotely controlled autonomous ships, using for the purpose OHMD device like the HoloLens.

5.1. Remote Trouble Shooting Technique

5.1.1 Consider the case of three remote controlled autonomous ships sailing with highly reduced shipboard staff, in different geographical locations and needing the guidance of a shore based expert for trouble shooting purposes onboard. It is quite obvious that a shore based expert can not be present in different locations at the same time. AR combined with HoloLens can enable the shore based expert to interact with the ship staff onboard all the three ships on a real time basis, view the problems along with them and guide them in resolving the issue.

5.1.2 Marine engineers maintain the operational status of all the systems in the engine room so as to diagnose and rectify problems that arise, and to understand what kind of maintenance will be required in order to maintain the vessel in an operational and safe condition. Through training and experience, the engineering crew can read and interpret the various parameters displayed by the engine room instrumentation and employ their intuitive feel for normal operation in-situ. In order to examine the possibilities of maintenance of crewless autonomous vessels from remote locations, developments have taken place for the creation of virtual reality simulated engine room based on a real vessel. Even though the end product is effectively a virtual simulation, the original audio from the engine room is recorded and used, thus providing a more accurate and immersive experience to the users. Research is already on for the application of a remote server to feed audio and other data into the simulated virtual engine and to create hypothetical scenarios of failures for the purposes of testing and training. The results suggest that the upcoming paradigm of the Internet of Audio Things can become a vital element in the operation of Autonomous Ships in the future.

5.2.Remote Inspection/Survey Technique

In the shipping industry a trend is developing to enable Classification Society surveyors to carry out remote inspection of ship's tanks using for the purpose custom built drones fitted with suitable sensors like Normal Visual Light Range camera, Infra-red/Thermal camera, Stereoscopic (3D) camera, LIDAR, etc. (Doshi et al., 2021). On similar lines, Augmented Reality using OHMD devices like HoloLens can be used for the live presentation of engine room as well as deck machinery and equipment for inspection and certification by the surveyors who are based at remote locations.

6. Maritime Education And Training

It is a well known fact that the evolution of maritime education and training closely followed like a shadow the induction of technology onboard ships. For example, soon after the industrial revolution when the steam engines were introduced to replace the sails for the propulsion of ships, the concerned maritime authorities introduced the concept of training and certification for the seafarers. Those seafarers who chose to operate and maintain the steam engines were given appropriate training and were awarded a certificate which was later called MOT 1st Class (Steam) certificate of competency(CoC). Subsequently, when diesel engines were introduced to replace steam engines for propulsion and also for electricity generation onboard ships the seafarers who successfully completed their training on the operation and maintenance of diesel engines were awarded the certificate of competency of MOT 1st Class(Diesel). At about this time those seafarers who could prove their competence in operation and maintenance of both steam and diesel engines were awarded the MOT 1st Class(Combined) certificate of competency.

A similar trend can be noticed on the nautical department side of the ship as well . Until the late 1980's the use of the sextant together with the ability to read and interpret the outputs presented by the devices like Decca, Omega and Loran C hyperbolic radio navigation systems were considered a treasured skill for position fixing onboard. With the advent of Global Navigation Satellite Systems, the GPS / GLONASS have been introduced onboard ships as the preferred primary electronic position fixing system along with the Electronic Charts and Display Information System (ECDIS). It can thus be observed that the Navigation Bridge or the Wheelhouse of a modern seagoing vessel is equipped with microprocessor based electronic systems and devices that are crucial for monitoring the vessel's position as also for safe navigation of the vessel. These developments necessitated a sea change in the curriculum and the content of the syllabus for the nautical officers and cadets across the world.

As and when newer technologies such as instrumentation and alarm systems, automation systems, navigation and communication systems, etc., were introduced onboard, the Standards of Training , Certification and Watchkeeping (STCW)convention requirements for the ship's crew got updated and revised. As a result, the revised STCW convention made it mandatory for the seafarers to update their knowledge through appropriate training and revalidate their CoCs in order to become eligible to work onboard ships. These developments support the conjecture that the training requirements of seafarers closely followed the induction of new technologies onboard.

Now with the high possibility of ships becoming autonomous in not too distant a future along with the possibility of new technologies like Artificial Intelligence(AI) (Stuart J. Russell & Peter Norvig, 2016) , AR,VR and the related technologies getting introduced in the field of shipping, it is reasonable to expect changes in the STCW requirements in due course of time and the consequent changes in MET both in its content and methods. Hence it is felt that there is an urgent need to introduce Augmented Reality (AR) and Virtual Reality (VR) in the curriculum of Maritime Education and Training.

7. Conclusion

- The era of autonomous shipping has arrived thus necessitating a different approach for the operation and maintenance of ships as also for training the seafarers who will be running them.
- Extensive use of latest concepts and technologies like, Augmented Reality, Virtual Reality and HoloLens technology will be made for the purposes of remote operation, trouble-shooting and maintenance of autonomous ships in a cost-effective manner.
- The methods of training and certification of shipboard as well as shore-based personnel who will be required to run the autonomous ships will need to change.
- New and relevant courses as mentioned above will need to be introduced in the curriculum for Maritime Education & Training programs in order to enhance the competencies of shipboard as well as shore-based personnel who will be involved in the running of autonomous ships.

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Behind the scenes – Educating to work as done or work as imagined.

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Keywords: ISM-Code, Goffman's front stage/back stage behaviour, regulation, human factor, Work as Imagined vs Work as Done.

Abstract

The ISM-Code became mandatory in 1998 and with the adoption of the Code, meta-regulation was introduced into maritime regulation. The Code added a "triple loop" regulatory system, which means that shipping companies became forced to evaluate and report on their self-regulation strategies and document the effectiveness of these. The effectiveness of the ISM Code has been studied by several researchers. The point of departure for this paper is a research project that studies how the ISM Code influences practice on board and whether it is in accordance with the regulator's initial intentions. This study was conducted in the period from 2017 to 2020 and is based on case studies conducted in two Danish shipping companies. It showed that, despite intensified evaluation, reporting and auditing, there was a divergence between what was done in practice and what was documented. Observations disclosed *front stage/back stage* behaviour among the seafarers. This behaviour is regarded as a consequence of the discrepancy between requirements and resources. A newly published report from the World Maritime University describes this discrepancy as "*a culture of adjustment*". Their study emphasises that it is common among seafarers to adjust records of work/rest hours to ensure compliance with regulations. This behaviour is also acknowledged by the companies involved in the current study. Comparing the seafarers' workload based on a planned maintenance system (PMS) and their watch schedules with the resources available, a gap was identified. Even though this problem is well-known, the companies often leave it to the master to bridge the gap between procedure (work as imagined) and reality (work as done). This research project concludes that this system, to a large extent, is supported by the existing system of governance and by the industry, which ignores reality and depends on paper trails. The question is whether we, as teachers in an educational institution, support this gap by our way of teaching. The students are taught to act the "right" way and follow the rules and procedures. The issue of the matter is that, on board a vessel, they will not always be able to follow the rules and procedures;

hence, they will be forced to adapt to each situation, a conflict that may result in *front stage/back stage* behaviour.

This paper will focus on whether *front stage/back stage* behaviour is supported by the training the master mariners are given based on narratives from a case study onboard a medium-sized tanker.

Introduction

The perspective of human factors as having a decisive influence on maritime accidents, and the ambiguity of balancing financial goals and safety, has, since the late 20th century, influenced the regulatory work in the maritime industry. When Amoco Cadiz ran aground of the coast of France in 1978, the government of France in a note to the Maritime Safety Committee [1] stated that if the master of a ship is not protected by legislation, he would mainly be accountable to the shipowner. Consequently, the risk of decisions being primarily financially motivated would be increased. As a result, the International Maritime Organization (IMO) adopted resolution A.443(XI) [2], which urges the flag States to take the necessary measures to protect the master's discretionary power. Also, emphasizing the master's right to take decisions with regard to safety or environmental protection, without undue interference from shipowners, charterers or others. Noteworthy is that the master on one hand is responsible for safety and on the other hand has to ensure efficient operation, which can be inherently contradictory in some situations. In those situations, the master is required to bridge the gap between demands and reality. Concern with a lack of support from owners and the flag State in these situations has been raised and linked to substandard shipping by Australia, among others [3]. One of the initiatives to rectify this negative development in the maritime industry has been to adopt the International Management Code for Safe Operation of Ships and for Pollution Prevention, denoted the ISM Code [4]. The purpose of the Code is to provide an international standard for safe management and operation of ships, and for pollution prevention.

The ISM Code introduced a new regulatory mechanism in shipping, known as meta-regulation, thus introducing what Parker [5] calls the regulatory triple loop. The triple loop perspective is presented in figure 1 and it means that the ISM Code as a part of the flag State law forces the company to develop a Safety Management System (SMS) (the first loop). The SMS is regarded as an enforced self-regulation that the company develops to ensure compliance with regulations and the applicable industry guidelines. The SMS is applicable to all vessels operated by the company (second loop). Onboard, the master is responsible for the implementation and for the crew's compliance with the procedures (third loop). Onboard, the master shall review the SMS and report any deficiencies to shore-based management (third loop evaluation). The company shall, through internal and external audits, assess the effectiveness of the system (second loop evaluation); audit reports form the basis for corrective actions and, as part of the documentation, when the flag State is to verify compliance with the ISM Code (first level evaluation). A Document of Compliance is issued to the company as evidence of being capable of complying with the ISM Code, whereas a Safety Management Certificate is issued to a vessel upon verification of the company and its shipboard management acting in accordance with the SMS.

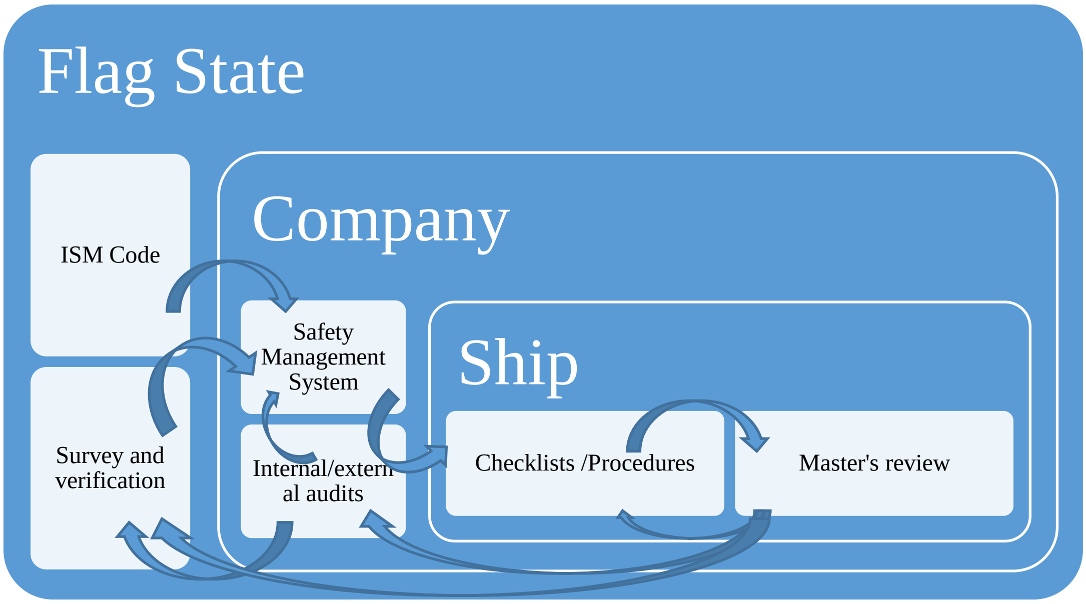

Figure 1 The ISM Code triple loop system

The current study has found that the triple loop system makes it possible for a company to appear as if it is providing a high safety standard, when in fact it is only safe on paper. Checklists, reviews and audits document one behaviour, while in fact practice onboard is another. These findings are supported by studies conducted by Størkersen [6], Bhattacharya [7] and a newly published study from WMU [8]. The current study concludes that, to a large extent, the system of governance and the industry ignores reality and depends on paper trails. The question this article asks is whether maritime education and training (MET) may even contribute to compounding the gap between practice and theory.

The structure of the article is as follows: in the next chapter the theory will be presented, followed by methods and analysis and, finally, the discussion and conclusion.

Theory

This paper focuses on two theoretical approaches: “Work as imagined” (WAI) vs “work as done” (WAD) and Goffman’s front stage/back stage theory [9]. The concept of “work as imagined” vs “work as done” originates from safety research within resilience.

According to Hollnagel [10] WAI '*refers to the various assumptions, explicit or implicit, that people have about how work should be done. WAD refers to (descriptions of) how something is actually done, either in a specific case or routinely'*. The concept of WAI emphasises how rules and regulations written by people who are not involved in the actual performance of the job are sometimes described in a way that makes it difficult for the people at 'the sharp end' to meet demands and deliver on target, as the objectives may be ambiguous or in conflict with operational practice. Legislation and procedures are considered results of WAI, while employees attempting to comply with regulations in their everyday work are seen as WAD. According to Hollnagel, there is a discrepancy between WAI and WAD. Employees attempt to adjust procedures to reality, learn to recognize the actual demand, and interpret and apply procedures to match the conditions. These attempts usually result in success, but sometimes in failure. The employees try to adjust to the situations with the help of ETTO principles [11] (efficiency thoroughness trade-off). Depending on the situation the employees try to be efficient or thorough, but in real life it will never be possible to maximise efficiency and thoroughness at the same time. In the classroom, future navigators learn WAI (thoroughness), as they are taught through legislation and procedures how an operation should be conducted, but when onboard, they experience WAD (efficiency), which can be different from MET.

Another theoretical approach used in this paper is Goffman's understanding of front stage and back stage. These concepts originate from the theory of a total institution. Goffman defines a total institution *as "a place of residence and work where a large number of like-situated individuals, cut off from the wider society for an appreciable period of time, together lead an enclosed, formally administrated round life"*[9]. In light of this definition, a ship can be regarded as a total institution because the crew are not equal but are subject to a hierarchy and a bureaucratic structure. According to Goffman, the individuals within total institutions tend to be split between back stage actions and front stage actions. The individuals have front stage behaviour when they know that others are watching. This kind of behaviour reflects internalized norms and expectations of behaviour. Back stage behaviour occurs when no one is watching, and the individuals feel free from the expectations and norms that dictate front stage behaviour. The seafarers in their everyday work use both front stage and back stage behaviour. The use of certain types of behaviour depends on the context. Documentation offers a possibility to document front stage behaviour, while in fact the seafarers use back stage behaviour while performing their duties.

These two theoretical approaches supplement each other to some degree. When the seafarers attempt to convince others that they are following the rules (WAI), they demonstrate front stage behaviour, while in everyday work (WAD) they exercise back stage behaviour. However, MET builds on WAI and the expected front stage behaviour.

Methods

This study is based on two types of data. Data for WAI consist of regulations, company SMS and a best practice guide. Data for WAD are observation notes collected during a two-week voyage on a Danish operated tanker. Kusenbach's [12] go-along method has been applied, and observations have been supported by follow-up interviews, which have been transcribed. For this article, the case of a mooring operation has been chosen. A mooring operation is considered an everyday operation; still, it is a high-risk operation and one of the important elements of the teaching syllabus regarding safety training. The operation is quite complex and affected by several regulations, yet no regulation specific regards the conduct of operation. WAI data has been analysed to determine what from the regulators' point of view are considered key elements of a safe mooring operation, and what is considered important in MET. WAD is based on a narrative from a mooring operation, the citing is from the observation notes, also the follow-up interview is part of the analysis of the practice onboard.

Analyse

Table 1 illustrates the mooring operation as seen from the differing WAI and WAD perspectives.

Table 1 WAI and WAD perspectives on mooring operation

Regulation (WAI)	Best practice (MET) (WAI)	Practice onboard (WAD)
MLC 2006: minimum requirement for rest hours. ISM Code: Mooring Procedure	Risk assessment; 5-step (mapping, assessment, action plan, risk assessment document, and follow-up) Pre-mooring meeting; equipment, procedure, risk assessment, communication. Safety culture: tools to improve.	Lack of resources Lack of communication Documented compliance with relevant regulations such as rest hour.

Regulation (WAI)

From the regulation perspective on mooring, there are two primary regulations: The Maritime Labour Convention MLC 2006 [13] on rest hours and the ISM Code.

Rest hour regulation lays down the minimum required hours of rest. Rest hours shall be documented, so that it is possible to control compliance with regulations. It shall be noted that if a ship is found not to comply with rest hour regulations, it shall be detained by the port state authorities until the matter is rectified. Also, and this is particularly applicable to tankers, lack of compliance would have the implication that the ship loses its vetting. Many of the oil companies only allow vessels with a positive vetting to transport its cargo, which is why the consequence of not complying with rest hour regulations would be loss of contracts.

The ISM Code does not specifically address the mooring operation, however, in accordance with the Code the company shall develop plans and procedures to ensure that shipboard operations are conducted in a safe manner. In accordance with the company's SMS, in order to ensure safe operation, the mooring operation should be supervised by an officer not involved in the operation of winch or handling rope, her or his main task is to communicate with mooring team onboard and ashore. It is noted in the company's SMS that the number of persons needed for the mooring operation is to be decided by the master. Thus, how the operation is conduced is at the master's discretion.

Best Practice, Training and Education (WAI)

The mooring operation is one of the most common and important ship operations, which is taught in every maritime school in Denmark. The teaching material used is a best practice guide on mooring, published in 2013 by the Danish organisation Seahealth [14]. According to this guide, the preparation phase is the basis for a safe and efficient mooring operation, which is why it is recommended to conduct a pre-arrival meeting that include the following:

- Control of mooring equipment and gear.
- The mooring team must read and understand the SMS procedure and potential variations must be identified.
- Everybody is to be instructed about the risk assessment and latest near miss reports.
- Instruction in communication, and check of radios.

Furthermore, the importance of risk assessments; repairs and maintenance; near miss reviews, instruction and training; and safety culture sessions are emphasised. The process of how to conduct a risk assessment is a key subject within the safety training in the Danish MET. It was also noted while attending the company's training sessions on the SMS that risk assessment was a key subject here as well. All crew members, regardless of rank, were to participate in a company safety culture course. Here, the key focus was risk assessments, pre-work meetings and the creation of a participating culture. The MET reflects the society and the company's required behaviour, and therefore forms the norm for front stage behaviour.

The MET assumes that during a pre-work meeting the equipment is checked and the crew who are to be involved in the work discuss the work process, using the procedure from the SMS as a starting point. Regarding the risk assessment, it is in the material used in MET in Denmark described as a 5-step process. The first step is mapping that includes identifying the hazards; then comes the assessment, where each hazard is assessed according to danger and probability; thirdly, the action plan, possible solutions to reduce risk are discussed in a meeting; next, the risk assessment document, which is a documentation of what is decided in order to reduce risks, this is the document that is part of the pre-mooring meeting. It is emphasised that periodical evaluation must be conducted by an officer.

Practice onboard (WAD)

The following narratives are based on observations made onboard a vessel during an observation voyage in the first quarter of 2020. It shall be noted that this was not an exceptional mooring operation, but it was similar to what had been experienced in other ports.

"Arrival [Port D]. Observations made from a position on the forecastle. The mooring deck forward is manned by two ABs and the motorman. Instructions on which pier number and to what side to have alongside are passed to the crew by radio from the bridge, following the arrival of the pilot. The crew start preparing the lines. Instruction was 2 – 2 – 2, however they ended up with 3 – 0 – 2 and no breast line ashore. The three people work alongside each other, none of them taking leadership. The motorman operates the winch, while the others are handling the lines, communication with shore is sporadic and they don't manage to get the linemen to put the mooring lines in the preferred positions. The aft station is manned by an officer and one ordinary seaman, a tugboat has to be made fast, hence he [crew member] leaves his station to help them with the line, but otherwise he is at the manifold, passing on distances to the bridge via radio, the helmsman (AB on duty) came down to help as soon as he was finished by the wheel." (observation book).

To be able to comply with rest hour regulations the master had decided that upon arrival the deck officer not on duty was left to sleep, thus, the mooring deck forward would be manned by rating only. A decision that also caused a lack of resources at the aft station. The master explained his considerations concerning his decision during interview. Here he stated *"... normally the deviance* [related to rest hours] *is for the bridge officers – because in port they are doing a 6 on 6 off watch, so the loading and then the mooring, so they will of course have to breach [the rules], that is why in my system, only the officer on duty is the one awake, the officer off duty is asleep" (respondent G).*

Prior to the operations which are described in the narrative no pre-mooring meeting was held. A standard risk assessment for the mooring operation was part of the SMS. When asked, the officers referred to this document and they did state that pre-mooring meetings were conducted, however during my time onboard I did not experience this. Considering the master's statement, that the reason for only one officer being called on deck because otherwise rest hour regulations would be violated, it is difficult to see what resources would be devoted to conducting a pre-mooring meeting.

Onboard the ship there are three ABs, one motorman and one ordinary seaman. There are 3 navigating officers and the master, and then there are 3 officers in the engine room who are not part of the mooring operation. On bridge, during arrival, there is the master, a navigation officer and a helmsman. The officer on watch (OOW) is relieved by the chief officer shortly before the pilot arrive. Then the OOW goes to the pilot ladder, (s)he is the one on deck who meets the pilot and follows her or him to the bridge, then (s)he returns to the aft mooring deck. When the helmsman is no longer needed on bridge, (s)he hurries to the aft station to assist with the mooring.

Discussion

The three perspectives presented above illustrate how the mooring operation is perceived by different actors. The first perspective is based on regulation. It is very general as it should "fit" different types of ships and companies. The second perspective shows in more detail what should be included in safe mooring operation. However, as the narrative illustrates, reality is very different from what is written in regulations and training materials. Both regulations and the training materials show how things should work in an "ideal world". When conducting a mooring operation, the master has to take into account several regulations and requirements from the company, customers and authorities. The master and the crew are aware of what is expected of them and try to adapt their behaviour to those expectations. In the documentation, the master and the crew will follow procedure and document "front stage" behaviour, while on deck they adapt their behaviour to be able to fulfil the task. They apply the ETTO principle, maximizing efficiency, while the documentation allows them to appear as if they are being thorough. It shall be noted that how the mooring operation is conducted is not documented. Only if an accident occurs would it become visible to others apart from the person operating on deck.

The mooring deck is the back stage, whereas as soon as the pilot arrives the bridge is the front stage, reporting is considered a part of this front stage behaviour. Here, compliance is documented. The SMS procedure describes the operation and the measures that are to be taken, and even though this is not followed on deck, because of the procedure and the fact that no one observes WAD, to the outsider the operation is perceived as being conducted in a safe manner. This is what Størkersen and Bhattacharya have termed paper safety.

In the narrative on the forecastle, a few corrective actions would have changed the operation from being unsafe to become safe. If one of the ABs had been appointed to be in charge of the operation, (s)he would assume responsibility for directing the operation, (s)he would not be handling the ropes but retaining an overview of the deck and communicating with shore, as described in the SMS procedure.

In MET and the best practice guide it is assumed that the mooring team consists of one officer and two ABs, however this is far from possible under all conditions due to a lack of human resources onboard. Both MET and SMS procedures have been conducted based on WAI and, as DMAIB [15] criticized in their report, it is the seafarer who has to bridge the gap between WAI and WAD. The MET do very little to close the gap or even discuss it. Underlying factors such as fatigue or being too busy are mentioned but the recommended course of action is risk assessments and pre-mooring meetings, which absorb even more resources.

The skills that are taught belong to the front stage behaviour. This enables the seafarer to reply correctly during a PSC, assessment, or vetting, but in daily operation the seafarers are bound to make it work with the resources with which they are provided. Thus, even in those situations it is possible to enhance safety if we dare to bring reality into the classroom, make the seafarers discuss what could be done if they find themselves in a situation that is not ideal yet have to adapt to reality.

Conclusion

As illustrated above, regulations and procedures stem from WAI, whereas onboard operation is WAD. This article argues that MET, by departing from WAI, not reflecting on conditions onboard and WAD, supports front stage/back stage behaviour. Taken to extremes, one could say that MET only trains the seafarers to perform at the front stage, while they are on their own when they need to bridge the gap between WAI and WAD. The MET materials analysed in the present case are found to support the triple loop and the system of paper safety, while failing to train the seafarers for real life.

Based on the current study I call for a reflection on how MET may bridge the gap between WAI and WAD and whether it would promote safety awareness.

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COMPARATIVE ANALYSIS FOR STATE-OF-THE-ART SIMULATION TRAINING SYSTEMS THOSE INFLUENCE ONTO THE FUTURE ENGINEERS' KNOWLEDGE AND SKILLS

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Abstract

Within the rapid changes of technologies and shipping digitalization, the requirements for specialists' proficiency have been constantly increasing which, in turn, demands for changes in the maritime education and training (MET). Having been discussed in great detail, this issue was examined in the context of utilizing virtual reality, augmented reality, mixed reality and e-learning applications specifically for MET [1-3]. However, this paper answers the question of possibility of Kherson State Maritime Academy (KSMA) marine engineer cadets' knowledge and skills formation being influenced by non-immersive 3D virtual reality (VR), immersive virtual reality (IVR) using a head-mounted display (HMD) simulation training system.

The role of VR simulation technologies from the point of competency-based learning and the voluntary experiments results of different methods of using simulation technologies for marine engineers' training are defined in this paper. Based on the example of "Virtual-real vessel" simulation complex at KSMA, the profit of implementing VR technologies has been shown i.e. a connection between educational process and practice, educational process changes according to the specific professional tasks, and an establishment of more proficient degree of practical skills within no life and health threating.

The paper compares the results of several cadets' subgroups studying under the "Ship Technical Systems and Complexes Operation" bachelors' program. The machinery operation task of preparing to start and starting an emergency generator has been carried out utilizing the Wartsila Engine Room Simulator "ERS 5000 TechSim", HTC head-mounted display and a real diesel generator in the different combinations of simulation equipment and cadets'

experience. The results of the experiment are certainly to be evaluated as an empirical evidence of the simulators training system usage effectiveness and conclusively to have been validated on real diesel generator.

Keywords marine education, simulator training, virtual reality

Introduction

International convention on Standards of Training, Certification and Watchkeeping (STCW) is known to be a setter for the minimum qualification standards for seafarers [4]. While compliance with the convention is essential for working on board, the competences of seafarers and the human factor ashore must be maintained at a dignified level through effective MET. Within the last decades, various simulator training systems have claimed themselves as playing a key role in learning and training in MET [5]. Nowadays, training or assessment could not possibly be imagined without utilizing of simulators standardized by marine classification societies [6].

In this paper attention is focused on the cadet's knowledge and skills building at the beginning of their professional career by means of state-of-the-art simulation training systems. An emergency diesel generator has been chosen as an object for an experiment having been held.

According to the requirements for familiarization of relevant personnel which are set out in STCW regulation I/14 and section 6 of the ISM Code, the personnel assigned to a ship is known to be required to be familiarized with their specific duties and with all ship arrangements, installations, equipment, procedures and ship characteristics that are relevant to their routine or emergency duties [7]. Furthermore, modern companies are expected to have established all the necessary procedures for ensuring that new personnel and personnel transferred for new assignments are given proper familiarization with their duties [8]. That is why familiarization and training of operation emergency generator before signing onboard is marked to be an actual and useful task during cadet's study. Besides, utilization of modern simulators technologies allows to provide effective training to save environment ashore.

Methodology

Volunteering first year engine room cadets were taking part in an experiment. In order to choose and divide experiment participants into groups a questionnaire and a test were held.

It is easy to be noticed a vivid presence of different well-validated mechanical comprehension tests, but to fulfill the aim of ranging cadets according to their level of comprehensions the

Bennett Mechanical Comprehension Test (BMCT) was chosen [9, 10]. The BMCT indicates cadet's spatial perception skills and mechanical reasoning abilities. Hence, it is highly appropriate to be used before conducting the experiment i.e. as an entry test achieving ranging purpose. That is needed to fully understand and clarify the way studying results can be influenced with cadet's comprehension level.

The BMCT is composed of 68 easy physical and technical questions mostly represented with illustrations. There are 3 possible answers following given question (or illustration) which can be chosen and only one answer is correct. The participants are to choose the correct answer. The methodology used is known to be related to so-called "timed power tests", because BMCT questions represent a wide range of question-level difficulty and the test is to be passed in 30 minutes time limit.

It is worth mentioning that the procedure of eliminating test results is simple as one correct answer is supposed to equal one point. No further points conversion to other scales is needed, the interpretation is done according to norms received with particular sample of respondents.

In this paper`s research a standard BMCT test was involved which has been converted into e-file and has been placed at the Learning Management System (LMS) MOODLE platform of KSMA [11]. Overall, 24 cadets are noticed to have taken part in the test and questionnaire.

The proposed questionnaire consisted of the following questions: have you ever been on a ship? Do you possess any knowledge about Emergency Diesel Generator (EDG)? Have you ever start the EDG? Have you worked with EDG simulator? Have you ever used an HMD?

The questionnaire results were:

- 33% (8 cadets) have been on a shipboard and 67% (16 cadets) have never been on a shipboard
- 25% (6 cadets) possess theoretical knowledge about EDG and 75% (18 cadets) don't possess theoretical knowledge about EDG
- all 100% (24 cadets) have never started the EDG
- all 100% (24 cadets) have never worked on EDG simulator
- 25% (6 cadets) have experience with HMD and 75% (18 cadets) – don't have this experience

Thus, according to the questionnaire results the participants were divided into 3 groups marked with A, B, C letters. Group A consisted of cadets who have EDG theoretical base. Group B consisted of cadets who possess theoretical knowledge, have worked with EDG simulator, and/or have started the EDG. Group C consisted of those who have never worked with the EDG simulator, have never started the EDG, and are not theoretically prepared.

Each group in turn was separated into 3 subgroups according to the level of engineering thinking having been estimated with the BMCT test.

As a result, the following subgroups were distinguished:

- high level – A1, B1, C1
- medium level – A2, B2, C2
- lower that medium level – A3, B3, C3

After completing the questionnaire and the Bennett test [10] 4 cadets have done a set of exercises on the engine room simulator. The exercises comprise preparing for start and starting the EDG according to few procedures (Table 1 and 2) installed on different type of vessels i.e. Ro-Pax ferry and tanker LCC. Then all of them and 5 more cadets went to the Emergency generator starting procedure in IVR condition by using HMD (see procedure in Table 3). Only one cadet went directly to engine room laboratory with real diesel generator (see procedure in Table 4).

Table 1 Ro-Pax ferry emergency generator starting procedure

No.	Item
	Battery Start
1	Check battery voltage
2	On the Emergency Generator Room Louvres Control Box: - set the mode selector switch to position AUTO; the louvres then open automatically on the engine start; or - set the mode selector switch to position MAN; click the buttons OPEN for Intake Air Louvres and Exhaust Air Louvres.
3	On the Emergency Generator Auto Start/Stop Panel: - Set the Operation Switch to position MAN; - Press the START button on the controller; watch the engine state gauges at the top of the panel.
4	Push the STOP button to stop the EDG
5	Put back Operation Switch to position AUTO
	Hydraulic Start
1	Pump up hydraulic starter
2	Put hydraulic starter operating lever to the start position

3	Similar to item 2 of the battery starting procedure
4	Similar to item 3 f the battery starting procedure
5	Push the STOP button to stop the EDG
6	Put back Operation Switch to position AUTO

Table 2 Tanker LCC emergency generator starting procedure

No.	Item
	Battery Start
1	Check battery voltage
2	On the Emergency Generator Auto Start/Stop Panel: - Set the Operation Switch to position MAN; - Press the START button on the controller; watch the engine state gauges at the top of the panel.
3	Push the STOP button to stop the EDG
4	Put back Operation Switch to position AUTO

Table 3 Emergency generator starting procedure in IVR condition by using HMD

No.	Item
1	Put on PPE (Personal Protective Equipment)
2	Check the Quick Closing Valve
3	Check visually Emergency Generator for any leakages, etc
4	Check the lubricating oil level of the Emergency Generator
5	Check marine gas oil level in Fuel Tank
6	Change operation mode command switch from “Auto” to “Manual”
7	Switch off the automatic start on the Emergency Switch Board panel to disable the circuit that starts the EDG in the case of power failure
8	Push “Engine start” button to start EDG
9	Confirm engine running condition, check engine speed, check lubricate oil pressure, check frequency
10	Push “Engine stop” button to stop EDG
11	Enable the automatic start on the Emergency Switch Board
12	Put back operating mode Command Switch from “Manual” to “Auto”

Table 4 Laboratory emergency generator starting procedure

No.	Item
1	Put on PPE (Personal Protective Equipment)
2	Check the Quick Closing Valve
3	Check visually Emergency Generator for any leakages, etc
4	Check coolant level in Radiator
5	Check the lubricating oil level of the Emergency Generator
6	Check marine gas oil level in Fuel Tank
7	Check battery voltage
8	Remove protective cover if required
9	Change operation mode command switch from “Auto” to “Manual”
10	Push “Engine start” button to start EDG
11	Confirm engine running condition, check engine speed, check lubricate oil pressure, check frequency
12	Push “Engine stop” button to stop EDG
13	Put back operating mode Command Switch from “Manual” to “Auto”

Professional performance is known to be highly contributed with cognitive abilities which include thinking, computation, learning, speaking, and reasoning ability. Whereas cognitive abilities play a key role in jobs related to mind activities, psycho-motor skills are being a base for handcraft professions [12]. A qualification needed to be possessed by engineers demands for high level performance of cognitive and psycho-motor skills both.

Nowadays there are plenty of test aimed to discover and check the level of someone’s cognitive abilities which can be used at an interview-for-job stage. It’s effectiveness and validity has been scientifically proved [13-15]. Moreover, it has been proved that high-level cognitive abilities correlate highly with job performance [16].

Thus, for being able to perform professionally well engineers are required to have highly leveled cognitive skills. However, test having been present on the market are thought to be not enough to fulfill the aim of checking participants level of cognitive skills after an experiment. This issue has showed a need in creating our own cognitive test.

To assess cognitive skills, test tasks were created that included ranking of actions in the correct algorithm (15 steps of one point for each correctly specified step) in preparation for the start and starting of EDG and 15 test questions (1 point per correct answer) on knowledge of correctness of fuel oil level checking in the tank, checking lube oil level in the engine, and also questions on knowledge of requirements of SOLAS, State Port Control, and classification societies to emergency power supplies.

Experimental equipment

While the experiment was held the Engine Room Simulator Wartsila ERS 5000 TechSim with 2 ship models (Fig. 1) was utilized, in particular:

- Tanker LCC (Large Crude Oil Carrier) (Aframax) with Emergency Diesel-Generator 200 kW (250 kVA), 1800 RPM, 450 V AC, 60 Hz; and Emergency Switch Board (ESB) Bus bars 440 and 230 V;
- Ro-Pax Ferry with Emergency Generator – Caterpillar 3406C prime mover (air cooled), 330 kVA, 260 kW, 440 V, 450 A, 60 Hz, 1800 RPM, 440 V and 230 V bus bars ESB.

Figure 1. Participants in the non-immersive VR engine room simulator preparing Ro-Pax ferry emergency generator to the start (on the left); Starting process of the tanker LCC emergency generator (on the right)

In case of IVR, a HMD HTC VIVE with hand controllers and Optimum Maritime Solutions Ltd (OMS-VR) software (Fig. 2) were used, specifically Emergency Diesel Generator module which is focused on SOLAS requirements regarding emergency power supply of cargo ship and practical maintenance routine. It is worth mentioning that the Module is based on the most repeated deficiencies recorded by PSC.

Figure 2. Participants engaged in the IVR conditions using HMD simulator training facility. The screens on the background display a projection of the participants' view

As a real emergency generator was used laboratory one GenSet Д246.4 60 kW power, 1500 RPM, 450 V AC, 60 Hz (Fig. 3).

Figure 3. Participant in the real conditions preparing to start and start of emergency diesel generator in the academic engine room laboratory

However, all experiments were conducted in the different laboratories at the Kherson State Maritime Academy of Ukraine i.e. "Educational and methodological laboratory of innovative technologies", "Engine Room simulator" and "Marine power plants" ones. Data was collected for the analysis to be done by means of LMS Moodle (Questionnaire, Bennett, and final cognitive tests), assessment system of Optimum Maritime Solutions Ltd (OMS-VR), event list of Wartsila ERS 5000 TechSim and interviews.

Results and discussion

This paragraph deals with question of a comparison the cognitive research results of several first-year cadets subgroups studying under the "Ship Technical Systems and Complexes Operation" bachelor program. The machinery operation task according to the procedures in Tables 1-4 for preparing to start and starting emergency generator was carried out utilizing the Wartsila Engine Room Simulator, HTC head-mounted display and real diesel generator in the different combinations of simulator equipment and cadets experience (Fig. 4 and 5).

In the Fig. 4 a chart of cognitive test score comparison for groups with EDG theoretical knowledge and different operational skills is being depicted. From the Fig. 4 it could be understood that Group 1 has better results than Group 2. Seven members of Group 1 have demonstrated an average level of knowledge, and four members – a high level. In the Group 2 no one has demonstrated a high level of knowledge.

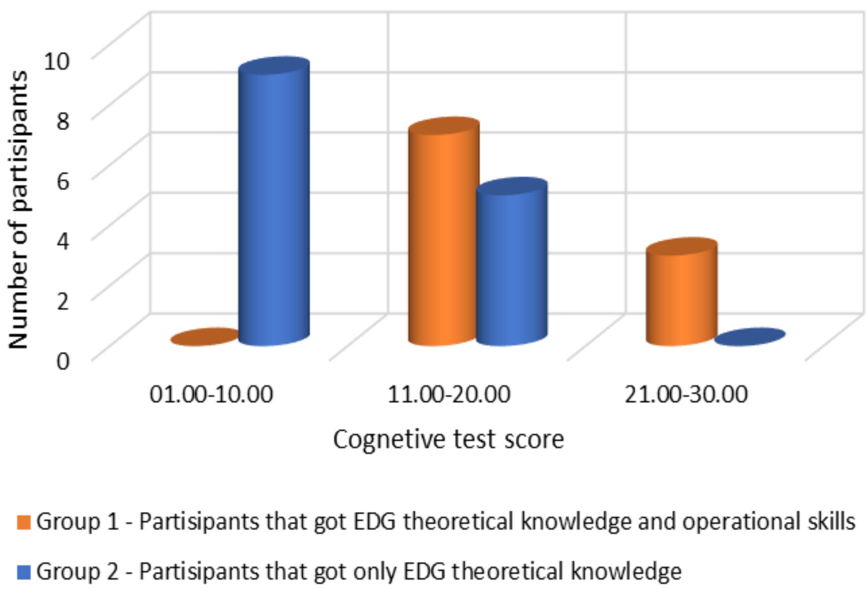

Figure 4. Chart illustration cognitive test score comparison for groups with EDG theoretical knowledge and different operational skills

A comparative analysis of cognitive test mean score of all groups was held as well.

Fig. 5 indicates that average grades of Group 1 participants that have trained with ERS and IVR are twice higher than grades of Group 2 (only partial theoretical knowledge).

A quantitative analysis of the impact of ERS and IVR technologies separately from each other on the knowledge and skills of the experiment participants was not conducted, but as a qualitative analysis we can note the following conclusions. The IVR technology by using

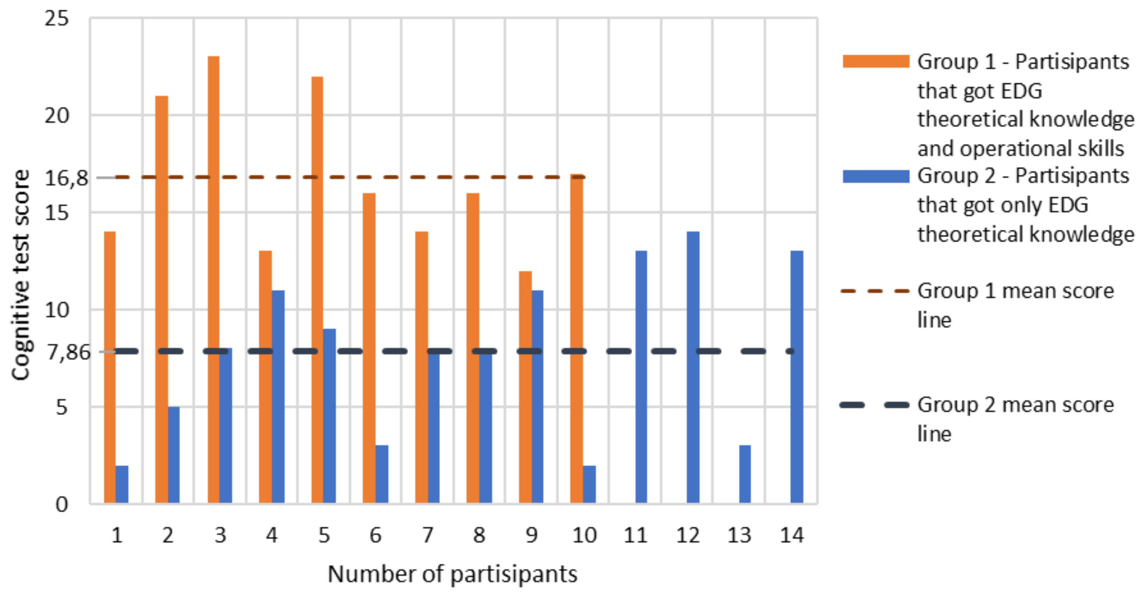

Figure 5. Chart of cognitive test mean score comparison for groups with the EDG theoretical knowledge and different operational skills

HMD seems to significantly increase the cadet's awareness of the EDG preparation and starting procedures, for instance, when they first approached a real EDG only a few cadets knew they needed to check a fuel level in the tank, oil level in the engine, and an almost no one knew how to do it. After using the IVR HMD, the procedure is clearly understood and assimilated, and working with a real EDG, the cadet checks the fuel level and looks for a dipstick to check the oil as it seems to be familial after having done it virtually. Unlike IVR technology, the ERS provides knowledge on the specifics of working with EDG on different type of vessels, performing the EDG test (blackout imitation), charging the battery, managing the operation of the EDG as part of the vessel's electric power system, knowledge of the EDG hydraulic starting procedure, troubleshooting, etc.

The above comparison applies only to the products of Wartsila ERS 5000 TechSim and OMS-VR specified in the paragraph "experimental equipment" and does not apply to other simulator manufacturers.

Conclusion

While completing this paper, new MET technologies have been tested.

The comparison of new technologies was carried out and is certainly to indicate the IVR high contribution into the knowledge and EDG operational skills increase i.e. in particular procedures for checking fuel oil and lube oil levels, preparation of the EDG before starting and start. Moreover, without the laboratory of the EDG assistance, the efficiency of state-of-the-art simulator training technologies is confirmed experimentally.

Besides, it is also a matter of focused that such a kind of education and academic training is the most relevant for cadets while preparing to the first shipboard training.

The obtained results showed that the combination of simulator training technologies ensures the maximum effect for cadets and, in comparison with subgroups that are partially acquainted with the theoretical information about requirements and technical operation of EDG, has almost twice higher score.

Thus, the greatest efficiency can be achieved making sure that all of the supported control activities are done i.e. mentoring preparation, material explanation in detail with a main things emphasis, giving the recommendation, assessment and evaluation control, correctness of the cadet's action, etc.

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DEVELOPING OUTCOMES-BASED MODEL COURSES USING IDENTIFIED EVIDENCE-BASED PRACTICES

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Abstract

The current state of the practice is for maritime education and training (MET) to use outcomes-based educational methods. Additionally, stakeholders increasingly require outcomes assessment as a means of accountability oversight. Recently, through the work of the Sub-Committee on Human Element, Training, and Watchkeeping (HTW), the International Maritime Organization has taken another step in developing its outcomes-based training policies. In this regard, a correspondence group was tasked with creating a taxonomy of action verbs to support model course development. This paper summarizes that work, provides a review of several of the many educational taxonomies across the five main domains of learning (cognitive, affective, psychomotor, interpersonal, and meta-cognitive), and examines a method for evaluating learning domain coverage for the Organization's model courses. The evaluation method presented provides a sound tool that could be used in revising existing model courses, validating current model courses, and designing future model courses. The IMO's foundational model course in firefighting is used to test/illustrate this method. While this particular model course appears to be practical and requires trainees to learn how to fight fires through practice, the mapping of domain coverage using the model indicates only 18.2% of the time allotted in the course is devoted to the acquisition of psychomotor competencies and interpersonal knowledge and skills. This study also analyzed the frequency of action verb usage in the performance criteria for the competencies in the model course and found 84.2% of the performance criteria use only four action verbs (i.e., list, state, describe, explain) which are usually devoted to knowledge (cognitive) acquisition. These findings indicate that the model course in firefighting is not-balanced in its learning domain coverage and has misplaced emphases. Using a taxonomy or taxonomies for the learning domain(s) of interest, action verbs can be chosen from the taxonomy to ensure that future revisions of this and other model courses or designs of new model courses, will have the appropriate balance between the content (and time allocated) on one hand, and the desired learning domain(s) and outcomes on the other. Additionally, this paper explores the matter of constructive alignment – how teaching methods and learning assessment can be adopted to match the outcomes they are intended to support.

Key Words

Pedagogy
MET (Maritime Education and Training)
STCW
Model Course
Outcomes Assessment

Introduction

The International Maritime Organization (IMO) has offered a program of model (training) courses since the adoption of the International Convention on Standards for Training, Certification, and Watchkeeping (STCW), 1978, as amended. Based upon contributions from IMO member states, these model courses serve as important resources for training program/curriculum development. Each model course includes an introduction, a course framework, a general outline, a detailed outline, the instructor manual, and a section dealing with assessment and evaluation.

In 2019, China, the International Association of Maritime Universities (IAMU), and the International Maritime Lecturers Association (IMLA), jointly proposed including an action verb taxonomy [1] (to assist in preparing learning outcomes for course syllabi) as a revision to the IMO guidelines for model courses [2]. In response, the IMO Sub-Committee on Human Element, Training, and Watchkeeping (HTW) chartered a correspondence group to create a taxonomy of action verbs for use in developing learning outcomes for model courses. The correspondence group consisted of representatives from the IMO member states of China, Germany, Netherlands, Sweden, and United States and representatives from the following non-governmental organizations: International Chamber of Shipping (ICS), IMLA, Global Maritime Education and Training Association, and the IAMU[1]. After four rounds of discussion and revision, the correspondence group developed a set of action verbs drawn from Bloom's taxonomy [3] for the cognitive learning domain, Dave's taxonomy [4] for the psychomotor learning domain, and Krathwohl's taxonomy [5] for the affective learning domain. The correspondence group recommended that this taxonomy of action verbs and a set of guidelines for writing learning outcomes be included as an appendix to the guidelines for model course development [6][2]. These recommendations have not yet been taken up as an agenda item by the HTW subcommittee. The seventh session of HTW was cancelled in 2020 and held virtually in 2021 as a result of the COVID-19 pandemic and the agenda has focused on other more pressing issues such as the "crew change crisis."[3] As a result, it is anticipated that HTW will consider the work of this correspondence group in 2022.

This effort by HTW marks a significant advancement of the model course policy toward enabling true outcomes-based learning for seafarers. At the same time, it also marks the beginning of the potential for much advancement in the andragogy of maritime education and training (MET) as it pertains to IMO model courses and beyond[4]. This paper will expand upon the correspondence group work by examining the action verb usage in an existing model course. A process for content-domain mapping [7] will be applied to a representative IMO model course to establish the validity or authenticity of the particular qualification such that the content of the course and its associated assessments address what was intended by the IMO and relevant stakeholders. Additionally, moving beyond the realm of action verbs and acknowledging the need for constructive alignment in courses [8], [9], the paper will also examine which learning activities and assessment methods are best suited for particular

[1] The first two authors served as IAMU representatives to this HTW correspondence group.

[2] A copy of that correspondence group report HTW 7/7 is available to the public at IMODOCS.

[3] COVID-19 caused a "crew change crisis" in that, seafarers aboard ships were unable to be repatriated after the completion of their contracts. Similarly, seafarers were unable to join their ship due to travel restrictions. During the peak of this crisis in September 2020, this impacted nearly 800,000 seafarers. By March of 2021, an estimated 400,000 seafarers were impacted.

[4] While this paper will focus on model courses, the concepts can be applied to outcomes-based policy within the STCW Convention itself and to a variety of other areas within MET more broadly.

learning outcomes within each level in a particular domain of learning. This is viewed as an essential next step in the trajectory of outcomes-based model course development.

Overview of Taxonomies

During and following a series of conferences in the late 1940s and early 1950s, a group of researchers and educators created a taxonomy of educational objectives. This seminal work was published in 1956 and entitled Workbook I: Cognitive Domain [4] and is commonly referred to as "Bloom's taxonomy" after the educational psychologist who led the group and edited the publication. While this group of researchers and educators had originally envisioned creating similar taxonomies for the psychomotor and affective domains, it was not until 1964 that Workbook II: Affective Domain [3] was published. Since then, hundreds of taxonomies have been developed and proposed as alternatives, often to address advances in our psychological understanding of learning. This section will explore some of the most prominent taxonomies that span five key learning domains: cognitive, affective, psychomotor, interpersonal, and meta-cognitive.

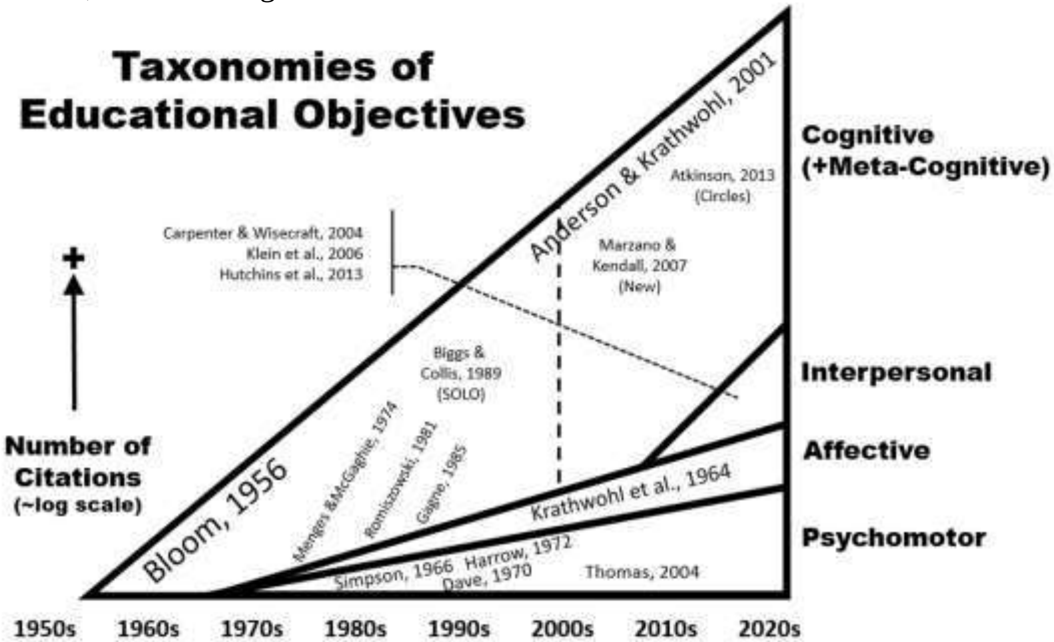

Figure 1: Developmental Progression of Taxonomies of Learning Objectives[5]

A taxonomy is an orderly classification of concepts. Figure 1 shows a classification of taxonomies of educational learning outcomes. It illustrates the chronological development of taxonomies within the five key domains of learning (listed on the right side of the figure) – cognitive first, followed by affective, and then psychomotor (often thought of as the primary trio). Later on meta-cognitive was incorporated and more recently interpersonal was developed. In addition, some taxonomies are encompassing and address several domains of learning. In Figure 1, the relative size of the triangles approximates the number of times the initial publication of the taxonomy in an article or book was cited by other works. By far, the cognitive taxonomies have dominated the educational community[6]. The most prominent are Bloom's taxonomy and the revision of Bloom's taxonomy (separated by the dashed line in figure 1).

[5] Inspired by Reebee Garafolo's classic graphic *Genealogy of Pop/Rock Music* (shown on pp. 90-91 of [29]), this figure is Paul Szwed's preliminary effort to capture a taxonomy of taxonomies.

[6] According to Google Scholar data from 1 May 2021, Bloom's original taxonomy for the cognitive domain was cited by 38,219 other works and the revised Bloom's taxonomy was cited by 23,333 works. In comparison,

While the work of the HTW correspondence group had the narrow focus of developing a taxonomy of action verbs to assist with creating learning outcomes, a much broader approach to how learners learn can be taken. For example, the UK-based Learning & Skills Research Centre (LSRC) published a comprehensive 160-page report [10] about how thinking skills are organized and evaluated 55 different frameworks to classify the skills and abilities used in thinking in order to make recommendations for teachers, learners, and even policy-makers.[7] Notably, the work's focus on older-adolescent and young-adult learners (i.e., post-16 years of age), is an appropriate target for MET because many mariners start their training during those ages.

Upon examining the 55 different thinking skills frameworks, the LSRC researchers found that the frameworks could be classified into four different categories or "family groups:"

- Models and theories of personality, thought, and learning (which they labeled as "all-embracing family"[8] and contained six frameworks),
- Models and theories of instructional design (which they labelled as the "designer family" and contained 12 frameworks),
- Models and theories of critical or productive thinking (which they labeled as the "higher-order family" and contained nine frameworks), and
- Models and theories of cognitive structure and/or cognitive development (which they labelled as the "intellect family" and contained eight frameworks).

For most of the frameworks, they provided a description, intended use, an evaluation of the scope and structure, an evaluation of the theory and analysis, and an evaluation of the communicability and practicality. Since the scope of this study is principally focused on instructional design, the focus here will be narrowed to what the LSRC group has referred to as the "designer family." This group of learning skills models and theories provide frameworks for both formulating learning objectives and also for designing instruction for developing pathways to higher-order learning.

The LSRC researchers subdivided the instructional design taxonomies (i.e., the "designer family") into two subcategories. This first subcategory provides "frameworks for formulating and classifying educational goals in terms of the thinking and learning processes which can be inferred from observed behavior and task performance." The first subcategory included the seminal work of Bloom and his colleagues [3], Ausubel and Robinson [11], Gagné [12], Hannah and Michaelis [13], Stahl and Murphy [14], and Anderson and Krathwohl [15]. This subcategory is exemplified by Bloom's revised taxonomy. The second subcategory focused on designing instruction to develop higher-order thinking. The works in this subcategory include Biggs and Collis [16], Gouge and Yates [17], Presseisen [18], and Quellmalz [19]. These authors focused on building conceptual frameworks to "understand how thinking skills are orchestrated for purposes such as decision making, problem solving, critical and creative thinking (and often extends beyond cognition to meta-cognition)." This subcategory is exemplified by Bigg's and Collis' SOLO taxonomy.

Simpson's original taxonomy for the psychomotor domain was cited by 1,327 works (between 1 and 2 orders of magnitude fewer, even when annualized).

[7] For a more compact summary of their findings and recommendations, see a published paper by some of the authors. [30]

[8] According to the authors, the so-called "all-embracing" family is not named as such because it spans all learning domains, but rather it accounts for emotions and beliefs in addition to thinking and learning. In other words, the frameworks within this family embrace many and multiple domains of learning.

The selection of particular taxonomies is complex and context dependent. For example, the HTW correspondence group focused on three specific taxonomies of learning objectives (namely Bloom [4], Dave [5], and Krathwohl et al. [3] for the cognitive, psychomotor, and affective domains respectively). Similarly, the IAMU working group that developed the Body of Knowledge for the Global Maritime Professional (GMP) [20] focused on two specific taxonomies of learning objectives (namely Bloom [4] and Simpson [21] for the cognitive and psychomotor domains respectively). In an entirely different modal context, the International Civil Aviation Organization (IACO) (which like the IMO is a specialized agency within the UN) used five taxonomies in a guide for instructional methods [22].

Learning Outcomes

Taxonomies are an important tool for course designers in developing learning outcomes.[9] Learning outcomes are an essential aspect of course design in that they inform almost every other decision made – from selection of learning activities to selection of assessment methods to determine achievement of the outcomes. A common structure used for creating learning objectives includes joining the following three components:

- A stem[10],
- The action verb phrase, and
- Identified performance (i.e., the object of the action from the verb phrase).

A typical learning outcomes statement[11] might take the following form: "Upon successful completion of this module, students (learners) will be able to diagnose a machinery casualty situation and select the appropriate corrective action." In this example, there are two action verbs following the stem: diagnose and select followed by the corresponding identified performances. Such "double-barreled" outcomes statements are not typically preferred because there are four potential results (i.e., improper diagnosis/improper selection, improper diagnosis/proper selection, proper diagnosis/improper selection, and the desired result of proper diagnosis/proper selection). Not unlike dealing with type I and type II errors in statistics, each of these results might require a different teaching/learning intervention. Therefore, this example would better be stated as two separate learning outcome statements.

While learning outcomes are an essential element of course design, this paper will now focus again on the action verbs (which could be argued to be at the heart or kernel of the learning outcomes statement) and study how a typical model course effectively employs action verbs to achieve learning across the intended domains of learning. Future work should be conducted on examining the effectiveness of the learning outcome statements (contained in the performance criteria within the knowledge, understanding and proficiency columns of the relevant tables) in IMO model courses.

Methodology

To demonstrate how educational taxonomies may be applied to IMO model courses specifically and the STCW outcomes-based policy and validation processes more generally,

[9] While the HTW correspondence group was tasked with developing a taxonomy of action verbs to be used in creating learning outcomes statements for model courses, they also included guidelines for how to write outcomes statements once an effective action verb has been selected.

[10] The stem frames the learning outcome statement. "(Upon successful completion of the course/module), students will be able to:" is an example of a common stem.

[11] Guidelines on preparing learning outcome statements abound and the above structure was based upon the work of the (US) National Institute for Learning Outcomes Assessment (NILOA) [32].

this study examined a typical model course using a method proposed by researchers at Cambridge Assessment to evaluate and validate courses and curriculum for applied qualifications [23]. This method for examining learning domain coverage uses a five-step process as described in Figure 2.

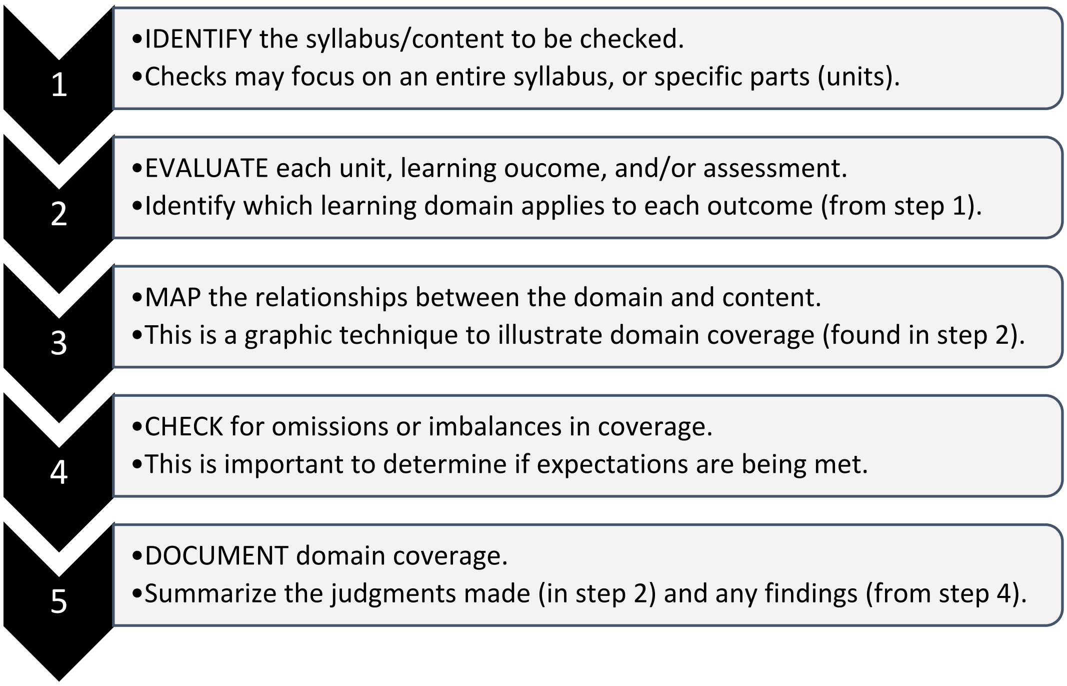

Figure 2: Method for Mapping Learning Domain Coverage

Step 1

This study examined the baseline training for fire prevention and firefighting. Specifically, the study examined the IMO Model Course 1.20 Fire Prevention and Firefighting (2000 edition – electronic)[12]. This model course was selected because it is the essential fire safety training needed by all seafarers (and prospective seafarers) prior to employment on sea-going ships. The model course is broken down into three primary competencies:

1. Minimize the risk of fire
2. Maintain a state of readiness (to respond to emergency situations involving fire)
3. Fight and extinguish fires

This study examined all of the required knowledge, understanding and proficiency performance criteria of each subpart for all three of the competencies (as specified in the detailed teaching syllabus – Part C of the model course).

Step 2

The reference study [23] evaluated nine educational taxonomies for suitability and selected two that came closest to the intended purpose of mapping domain coverage of applied qualification courses. The reason two were selected is that none of the nine evaluated were inclusive enough (i.e., they did not sufficiently span the five domains of learning). They found that Marzano and Kendall’s new taxonomy [24], [25] when supplemented by Hutchins’ taxonomy of interpersonal skills [26] spanned four domains of knowledge (as described in Table 1).

[12] The model course is designed to satisfy the minimum standard of competence in fire safety per Section A-VI/1 (paragraph 2 and table 1-2) of Chapter VI of the STCW Convention, as amended in 1995.

Table 1: Summary of the Four Learning Domains

Domain	Categories
Information: Declarative knowledge, vocabulary, factual knowledge (i.e., the *what* of human knowledge)	• *Principles* – Specific types of generalizations focusing on cause-effect or correlation relationships. • *Generalizations* – Statements for which examples can be given. • *Time sequences* – Include key events that happened between two points in time. • *Facts* – Give information about people, places, things, and events. • *Vocabulary terms* – Phrases learners understand accurately.
Mental Procedures: Procedures dealing with how to do something is situation X, follow action Y (i.e., the *how-to* of human knowledge)	• *Macro-procedure* – Highly robust mental processes that involve the execution of many interrelated sub-procedures. • *Tactics* – A set of several mental general rules with a general pattern for the order in which the rules are executed. • *Algorithm* – Mental procedures comprised of single steps which are consistently and automatically applied. • *Single rule* – Such as "if-then" (p. 13 of [25]).
Psychomotor Procedures: Physical procedures, such as being able to serve in tennis.	• *Complex combination rules* – Groups of simple combination procedures interacting and happening simultaneously. • *Simple combination rules* – Groups of foundation procedures interacting and happening simultaneously. • *Foundation procedures* – The ability to use your body.
Interpersonal Knowledge/Skills: Knowledge and skills used when people are interacting with one another.	• *Interpersonal communication skills* – Express and assimilate information in social settings (involving listening, speaking, writing, and sending/receiving non-verbal signals in an empathetic, attentive, responsive, and confident manner). • *Relationship building skills* – Develop and keep relationships with others, and build strong beneficial alliances as well as manage and resolve conflicts. • *Peer-leadership skills* – Coaching, counselling, motivating, and empowering group members. • *Social/behavioral agility skills* – Monitor and interpret own and other's behaviors (and modify self-presentation social interaction to influence and control the interaction).

In the study informing this paper, qualified evaluators examined each of the 152 knowledge, understanding, and proficiency performance criteria[13] contained in the IMO fire safety model course and judged whether it was an informational task, mental procedure, psychomotor procedure, or interpersonal knowledge or skill (i.e., in which of the four domains in Table 1 it belonged). These judgments were collected using a five-step elicitation process and after training, the evaluators were instructed to select only the primary domain for each performance criteria. For each of the four learning domains, a representative example of performance criteria was provided:

- ***Information***: Lists fire hazards in the galley (performance criteria 1.8.2).
- ***Mental Procedure***: Explain procedures for recharging empty extinguisher (performance criteria 3.3.5).
- ***Psychomotor Procedure***: Demonstrate the correct use of portable fire extinguishers (performance criteria 3.11.1).
- ***Interpersonal Knowledge/Skills***: Take part in team exercises, communicating while wearing breathing apparatus (performance criteria 3.18.4).

Inter-rater reliability was computed for the judgments of the three qualified evaluators.[14] In cases where there was agreement among most of the evaluators (i.e., all or two agreed on the

[13] In the IMO fire safety model course (MC 1.20), there are 3 introductory performance criteria, 29 performance criteria in competency 1, 52 performance criteria in competency 2, and 68 performance criteria in competency 3.
[14] The three authors served as the evaluators in this study. All three have extensive experience with MET (maritime education and training), knowledge of outcomes assessment and taxonomies, and two have had direct experience with firefighting training.

domain category for a performance criteria), that domain was listed for a particular performance criterion. In the rare cases where there was no agreement among the evaluators (due to either differences in interpretation or "domain-spanning" by performance criteria), no domain was listed for a particular performance criteria.

Step 3

Next, the domain coverage was tabulated for each of the three competencies and for the course overall. However, because the number of performance criteria for each sub-competency varied from a single criteria to as many as eight, a weighting scheme was devised. Using the approximate time (in hours) specified for the completion of the sub-competencies (as specified in the course outline and timetable – Part C of the model course), allocated times were applied to each of the performance criteria. For example, under the first competency for minimizing the risk of fire, the model course specified one half-hour (0.5 hours) to complete the sub-competency of fire hazards (1.8). Since there are five performance criteria within this sub-competency, it was assumed that the half-hour would be uniformly distributed and each performance criteria would be allocated 0.1 hours according to the model course outline and timetable.

Using this time allotment (as specified in the model course), the time and proportion of time allocated to each learning domain for the course, each competency, and also each sub-competency could be determined. A table was created to illustrate the mapping of the amount of time "allocated" to each learning domain for each competency. Steps 4 and 5 are interpretations of the results found in steps 1 through 3 and will be addressed in the discussion section.

Results

After completing the method for mapping learning domain coverage (see Figure 2), each of the three the IMO model firefighting course competencies yielded different learning domain coverage.

Table 2: Breakdown of Time (in Hours) Allocated to each Competency (IMO Model Course in Firefighting) with Mapping to Relevant Learning Domain

Competence	Information	Mental Procedure	Psychomotor Procedure	Interpersonal Procedure	Approximate Time (Hours)
0. Introduction and safety	0.50				**0.5**
1. Minimize risk of fire	2.43	0.07			**2.5**
2. Maintain state of readiness	2.91	0.09			**3.0**
3. Fight and extinguish fires	5.40	0.87	2.54	0.19	**9.0**
	11.24	**1.03**	**2.54**	**0.19**	**15.0**
	74.9%	**6.9%**	**16.9%**	**1.3%**	**100%**

Table 2 provides a mapping of competency/content to the learning domain affiliated with the performance criteria within that competency. Roughly three-quarters (74.9%) of the time spent in this IMO model course in firefighting is devoted to learning within the information domain. Learning within the psychomotor domain accounts for 16.9% of the time spent in this model course. The remainder of the time is spent on learning mental procedures (6.9%) and interpersonal knowledge and skills (1.3%).

The inter-rater reliability of these judgment may be interpreted as showing substantial agreement among the three evaluators (Fleiss' kappa = 0.702). However, when decomposed, as shown in Table 3, it was observed that the inter-rater reliability was not uniform among each competency.

Table 3: Inter-Rater Reliability when Assessing Learning Domains of Performance Criteria in the IMO Model Course for Firefighting

	Fleiss' Kappa, K	Degree of Agreement
Introduction	1.000	Perfect
Competency 1	0.138	Slight
Competency 2	-0.037	Poor
Competency 3	0.891	Almost Perfect
Overall	0.702	Substantial

In addition to the Cambridge Assessment method for evaluating knowledge domain coverage in a syllabus [23], this study also examined action verb usage in the development of the performance criteria (which serve as detailed learning outcomes). Figure 3 provides an illustration of how often verbs were used in the 152 knowledge, understanding, and proficiency performance criteria contained in the IMO fire safety model course.

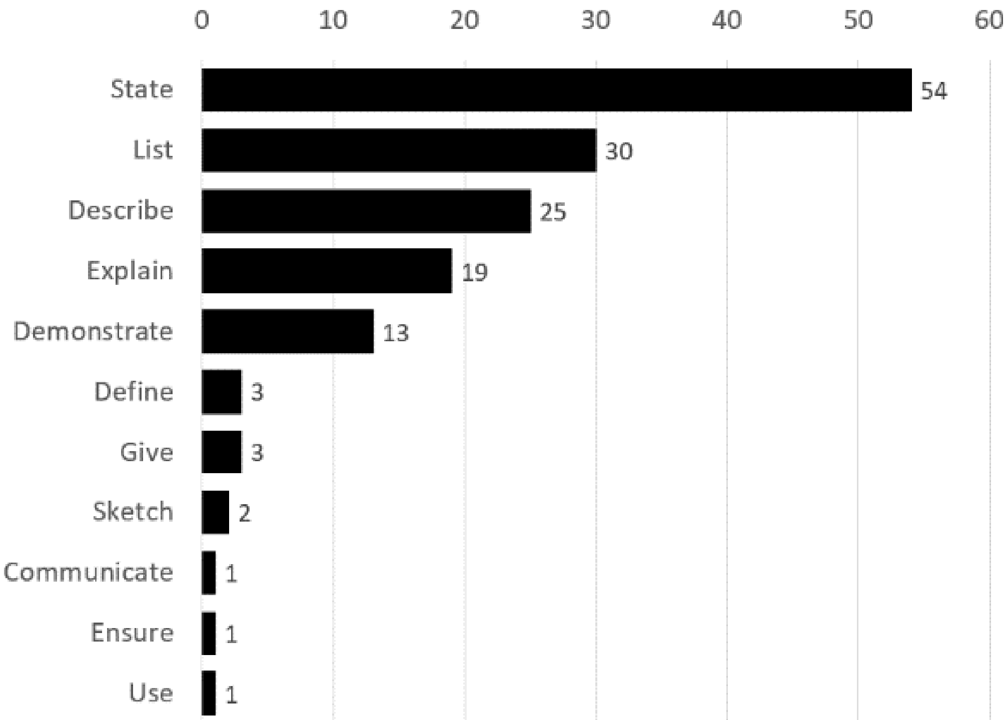

Figure 3: Frequency of Action Verb Usage in IMO Model Course in Firefighting

Additionally, the percentage agreement was calculated for each verb (such that 100% meant perfect agreement and 0% meant no agreement). Most verbs had perfect or almost perfect agreement among raters. However, three verbs accounted for the majority of disagreement among the raters (even when adjusted for usage). The performance criteria containing the verbs explain, use, and ensure had percent agreement of 53%, 0%, and 0% respectively.

Discussion

The overarching aim of the model course as stated in the course framework (Part A) is to provide the minimum standard of competence in fire prevention and firefighting. In the course objective (on p. 4 of the IMO model course 1.20 for fire prevention and firefighting, it states, *inter alia*:

> "… a trainee will be competent to take appropriate measures for the safety of personnel and of the ship and use fire appliances correctly. The trainee will also have a knowledge of fire prevention."

There are two main parts to this course objective: to act (or take appropriate measures) and to know (or have a knowledge). Based upon the order in which those two are presented (actions first and knowledge second) and the use of the word "also" (which means in addition), it can be inferred that demonstrated behavior (or actions) are the primary objective and the knowledge is a secondary objective. Therefore, the learning domain coverage of this course in firefighting would appear to be out of balance with the intent of the course as expressed in the course objective (found on p. 4 of the course framework – Part A of the model course). One would expect a majority of the performance criteria to be devoted to the learning of psychomotor procedures (and interpersonal knowledge/skills). However, only about 20% of the course time (that associated with performance criteria in the psychomotor procedures and interpersonal knowledge/skills domains) is focused on the primary action-oriented objective of the course, whereas more than 80% of the course (that associated with performance criteria in the information and mental procedure domains) is devoted to knowledge, the secondary course objective.

Additionally, within the IMO model course there are twelve overarching objectives provided along with some of the competencies (pp. 13-14 of the detailed teaching syllabus – Part C of the IMO model course). The vast majority of these overarching objectives could be classified as action-oriented. Therefore, based both on course objectives and the overarching objectives of the three competencies within the course, it seems the course is intended to be action-oriented, or applied, yet the performance criteria are predominantly knowledge-oriented based on the mapping performed. As a result, it appears the course content is out-of-balance with its intended outcomes.

This was likewise supported by the action verb analysis for the performance criteria. Here too, the first four most used verbs (i.e., state, list, describe, and explain) account for 84.2% of the course time (see Figure 3). These action verbs are typically associated with the information and mental procedures learning domains rather than psycho-motor or interpersonal knowledge/skills domains.

Further, while moderate inter-rater reliability would be expected when mapping educational outcomes [27], even though there was substantial agreement among the raters overall, there were varying levels of reliability within the competencies of the IMO model course in firefighting. Upon examining which action verbs had most disagreement, it became apparent that only a few verbs (explain, use, and ensure) accounted for the majority of the disagreement. It is unclear what the source of this disagreement was, whether it was truly low reliability among raters or perhaps low reliability in the ways in which the verbs were used. Further study would be warranted, but using such a method might be an important tool for course designers and validators to determine sources of low reliability.

This study suggests that the content-domain mapping performed would be a valuable instrument for both IMO model course designers and for those who validate model courses. In this case, to address the balance issue, it is recommended that future revisions of this particular IMO model course should incorporate more performance criteria from the mental procedure and psychomotor procedure learning domains. This can be accomplished by selecting a taxonomy that focuses on the psychomotor domain[15] and redefining the performance criteria using suitable action verbs from the appropriate level within the taxonomy.

Similarly, the course outline tables for the model courses are biased toward being knowledge-oriented rather than action-oriented, affect-oriented, interpersonal-oriented, or meta-cognitive-oriented. The column where time approximations are placed has the following header "Lectures, demonstrations, and practical work." While practical work is often viewed as action-oriented, lectures and demonstration are often a passive form of learning, and thus knowledge-oriented. It might be beneficial for the model course template to either provide a broader array of learning methods (to encompass more domains of learning) for a column header and/or to provide a resource for designers that describes which teaching methods are best suited for different domains or levels within a domain. For example, Nilson maps effective teaching methods for each level of learning outcomes in Bloom's revised taxonomy (see Table 11.1 on p. 107 of [28]).

Finally, while the work of the HTW correspondence group is a necessary advancement toward outcomes-based learning for seafarers, it is not sufficient. In addition to developing evidence-based methods for creating learning outcomes, constructive alignment suggests similar attention must be devoted to matching learning activities and assessment methods to the learning domain of the learning outcomes. For example, in this IMO model course for firefighting, particularly in the third competency which requires training, practices, and drills using firefighting equipment including in smoke filled spaces, little guidance has been provided on how to design the learning activities and assess the learning and performance of the competencies. The Instructor's Manual (Appendix D of the model course) has some general discussion of activities and suggests the development of lesson plans, but the sample lesson plan provided focuses on knowledge-oriented classroom instruction instead of the primary action-oriented objective of the course. Moving from an emphasis on knowledge acquisition only to providing examples across all domains of learning (such as more emphasis on behavioral learning in this model course) and greater description of how to teach and assess the breadth of learning would be a tremendous advancement in the outcomes-based policy within model courses and the development of STCW-related competencies in general.

[15] Examples would include the action verb taxonomy created by the HTW correspondence group, Marzano & Kendall's new taxonomy (used in this study), or any of the other taxonomies, such as those developed by Simpson, Harrow, Dave, or Thomas.

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ECDIS EHO: Handling the ECDIS failure at sea

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Abstract: The meaning of navigational safety is changing together with everlasting evolution of technology on ships at high seas. The Electronic Chart Display and Information System (ECDIS) as a most recent breakthrough in shipping, changed drastically not only layout of the navigational bridges but also navigational methods and routines. The safety reasons dictate compulsory redundancy of ECDIS system, recognising its central role in modern day navigation. If a ship's ECDIS back-up arrangement is realized by installation of second independent system, it is known as paperless ship. Duplication increases the reliability of the system, but even a duplication doesn't guarantee full reliability of the system at all times. In emergency situation as ECDIS total failure, navigator should rely on company procedures and guidelines.

The aim of research is to determine navigators' response in case of ECDIS total failure, and to identify if their reaction is supported or guided by company procedures. The research is based on international survey in form of questionnaire conducted among wide spectra of ECDIS stakeholders. This paper analyses part of the questionnaire which refers to the behaviour of navigators in ECDIS failure emergency and seek for procedure clarification by respondents. Answers are presented and discussed, revealing certain drawbacks in failure response and procedures. Along with presented results, survey of practice among shipping companies was carried out, supporting the results of questionnaire. The findings are emphasized in concluding chapter followed by proposal for further research and activities.

1. INTRODUCTION

Two and half years have passed since deadline for mandatory implementation of ECDIS onboard merchant ships. The system's introduction was preceded by preparation for it, in view of policies and procedures implementation, necessary for a smooth transition to a revolutionary navigational aid. After the actual implementation of ECDIS, new navigational routines have been developed, and the system continued to evolve. System integrated other navigational devices and had become the central navigational element of the modern navigational bridge. As electronic equipment failures are inevitable, adequate redundancy for the system is compulsory. When this redundancy is achieved by second independent ECDIS, there is no obligation for a ship to carry Paper Navigational Charts (PNC). The proposed paper focuses on navigator response to a failure of both ECDIS units: primary and back up unit. The research aims to analyse the navigator's response in case of ECDIS failure and identify the availability of adequate industry guidelines as support to the navigator in such case. In the background chapter, general arrangement of ECDIS on a paperless ship is presented, supplemented by previous research and investigations of some recent ECDIS failures.

Following background chapter is the analyse of four shipping companies' navigational procedures. Chosen shipping companies are different by the size of the fleet and type of the ships they operate. Results obtained point to insufficient penetration of failure response procedures among shipping companies observed.
The survey chapter analyses one of the questions from the international survey conducted from 2014 till 2018. The questionnaire, as a foundation of the survey, was internationally distributed mostly among navigational ranks serving on different types of vessel. Answers of target group consisting of only navigational ranks which had sailed on the paperless vessels were analysed and summarised. In order to identify potential difference between respondent's subgroup, target group was clustered based on ship's type. Difference between respondent's subgroup were identified and presented. Findings were further discussed, revealing some problems in both the implementation of emergency procedures and response to ECDIS failure. In the last chapter, results and finding are summarized, providing guidance for future research with regards to the subject.

2. BACKGROUND

The term paperless ship stands for the vessel navigating with ECDIS without paper navigational charts. The paperless ship's idea was not easily accepted by traditionalists, as paper charts were successfully serving international shipping for centuries. Several studies conducted on ECDIS acceptance among navigators revealed that there is still a significant number of supporters of PNC [1-4]. The mandatory deadline for implementing the ECDIS system as required by SOLAS ended on 1st July 2018 [5, 6]. For ECDIS to satisfy SOLAS requirements, it must be type-approved, use up-to-date Electronic Navigational Charts (ENC), be maintained according to the International Hydrographic Organization (IHO) standards and have an adequate backup arrangement. The International Maritime Organization (IMO) performance standard [9] specifies the meaning of adequate independent back up an arrangement as the one enabling safe takeover of the ECDIS function in order to ensure that ECDIS failure does not result with the critical situation and providing safe navigation for the remaining of the voyage. This phrase allows different interpretation, but according to IHO publication S-66 [10] normally accepted options are:

i. A second ECDIS powered by an independent power supply and with separate position source,
ii. Appropriate portfolio of updated paper charts,
iii. Chart radar if allowed by the flag state administration.

This paper focuses on a vessel sailing with second ECDIS as a backup option, so the other two options are not further analysed. Typical ECDIS back up arrangement is shown in Figure 1. The system consists of a minimum of two ECDIS workstations, primary and independent back up unit. Onboard the ships it is usual to have identical ECDIS units from the same maker, as companies have a single provider contract. This reduces expenses but also improves the implementation of ECDIS on board [9].

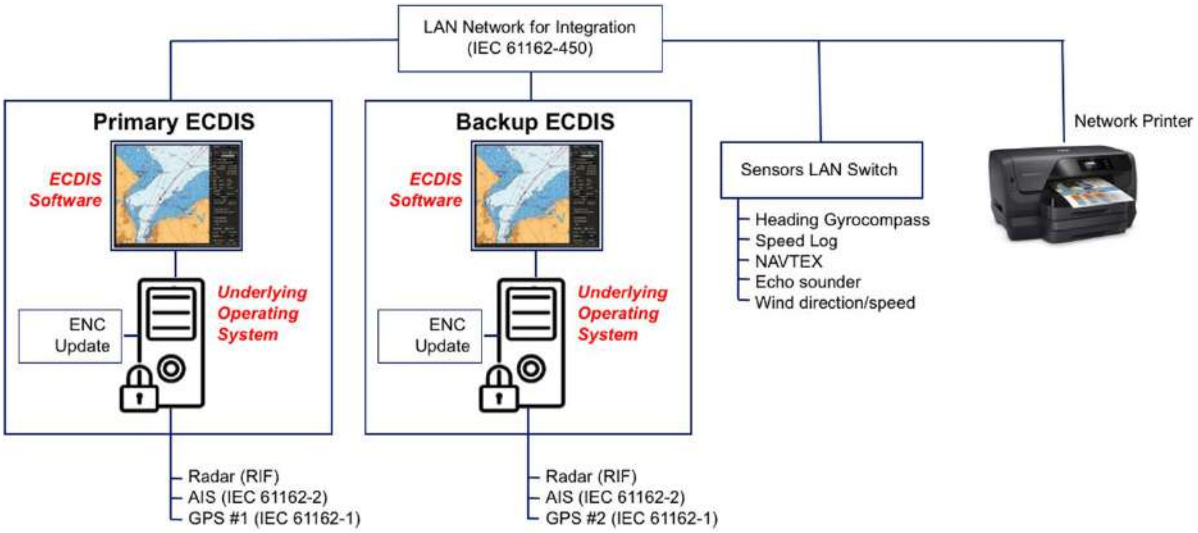

Figure 1: Primary and backup ECDIS arrangement

Such an arrangement should normally provide adequate redundancy in the case when one ECDIS workstation in any case fail. However, as almost no electronic system is failsafe, there is a possibility that both systems fail. Failure of both ECDIS unit can be a result of internal or external causes. Internal causes could be loss of sensors' feed, Hard Disk Drive (HDD) or Solid-State Disk (SSD) failure, power source failure or software failure. External causes could be caused by cyber-attack or by intentional disruption of satellite positioning signals. In his work Sumic et al. [10] proposed adding a cold stand-by ECDIS that should prevent total failure due to updating and upgrading the system device. Research on reliability of ECDIS back up configuration by Blokus et al. [11] concludes that development of systems with additional redundancy workstations is not appropriate solution, as it does not increase reliability respectively. In same research, usage of cold stand-by ECDIS as proposed by Sumic et al. is confirmed as solid option.

Upgrading and updating ECDIS software by the technical representative was a cause of the incident on board ship with integrated navigation bridge [12]. During the incident, almost all navigational systems failed, at the worst moment, in poor visibility and dense traffic. The ship navigated for two days by use of one radar only and portfolio of paper charts. The investigation found that the obsolete operating system was not able to run newly installed software and crashed. In another report, a ship arriving in Port Hedland, Australia, reported that one ECDIS's hard disk failed after the weekly update. The report indicates that such a failure is quite common on several years old ECDIS units of one global manufacturer [13]. Researches on cybersecurity onboard ECDIS equipped ships confirmed a risk to ship navigational systems [14-16]. To adequately respond to ECDIS failure emergency, shipping companies are to prepare procedures in case of emergencies, based on their navigational policy and detailed risk assessment. As each ship's navigational systems' layout is unique, generic solutions should be modified to suit particular vessel.

3. MARITIME INDUSTRY PRACTICE

The adequate handling of the ECDIS failure at sea is a matter of navigational policy and procedures implemented onboard the vessel. The shipping companies should implement policies and procedures in case of emergencies onboard according to the International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code)

[17,18]. Procedures in a case of ECDIS failure as a response to an emergency should be part of such shipping company procedures. As ECDIS is a relatively new device, mandatory for most SOLAS vessels after July 1st 2018, procedures and policies regarding ECDIS are still evolving. Bridge Procedures Guide issued by the International Chamber of Shipping (ICS) is traditionally used as a reference for safe shipping procedures by shipping companies and maritime professionals. While it recognises the requirement to understand ship procedures in a case of ECDIS failure, as part of ECDIS familiarisation procedure, there is no ECDIS failure procedure included in the last edition of this valuable publication [19].

Procedures in case of ECDIS failure usually vary depending on the shipping company profile. In this paper, four shipping companies' procedures, different by type of vessels and size, will be analysed (Table 1).

Shipping company “A” is a large shipping company managing different type of ships including Container vessels, Bulk carriers, Very Large Crude Oil Carriers (VLCC) and Liquefied Natural Gas Carriers (LNGC). ECDIS failure procedure is included in navigational procedures and contains guidance for ECDIS abnormalities, one ECDIS failure, and ECDIS failure. There is also a risk-mitigating policy suggesting creating mapping on radars and input waypoints and cross-track limits in GNSS. Setting appropriate bridge watch level in case of this emergency is not a part of the procedure.

Shipping company “B” is a large company operating cruise ships. The company implemented a procedure in case of ECDIS failure but did not consider some important actions i.e. setting the engine setting the engine to stand by, use of manual steering or transmitting safety message. Also, there is no risk-mitigating procedure as a part of the navigational policy.

Shipping company “C” is based on Cruise Ships Company operating fleet of four ocean-going vessels. Company requests from vessels to develop recovery procedures in the case the ECDIS system crash, but has no uniform company procedure in the case of ECDIS failure. ISM code clearly requires the company to implement procedures, but also work instructions, checklist and other forms [2].

Shipping company “D” is a container shipping company operating a globally significant fleet of container vessels. Company ships are equipped with two independent ECDIS workstation, and additionally with folio of port approach paper charts. However, company has no procedure in case of ECDIS failure. This was explained by low probability of failure of both ECDIS units at same time.

	Company "A"	Company "B"	Company "C"	Company "D"
Inform Master	Yes	Yes	No	No
Inform Chief Engineer	Yes	Yes	No	No
Engine standby	Yes	No	No	No
Determine ship position	Yes	Yes	No	No
Determine navigational hazards	Yes	Yes	No	No
Verify traffic condition	Yes	Yes	No	No
Manual steering	Yes	No	No	No
Reduce speed	Yes	Yes	No	No
Stop the vessel	Yes	No	No	No
Use redundancy ECDIS/ECS	Yes	Yes	No	No
Take-me-home PNC	Yes	No	No	No
Transmit Safety message	Yes	No	No	No
Set appropriate bridge level	No	Yes	No	No

Table 1: ECDIS failure procedures of analysed companies

Analysis of the above-mentioned shipping companies' procedures leads to the conclusion that ISM requirement of providing emergency policies and procedures is not yet fully implemented worldwide. Two companies analysed in this paper, have procedures in place, but two other are without procedure in case of ECDIS failure. Additionally, the ICS, as the industry recognised organisation, even recognising a necessity of ECDIS failure procedure, fail to provide a framework for such a procedure.

4. THE SURVEY RESULTS

The proposed paper is part of the larger survey started in 2014. International questionnaire as a main source of the survey was used initially as a part of ECDIS courses for merchant seamen at the Faculty of Maritime Studies in Rijeka. Survey evolved by increasing the number of questions and number of respondents. For the survey to reflect global trends, questionnaire was spread among international shipping companies. Results provide insight into opinions and practice of ECDIS stakeholder, assist to identify problems and possible solution, and finally provide some new topics for future research.

1.1. A questionnaire overview

The international questionnaire named “ECDIS Survey Analyses: Experience, Handling, Opinion” or ECDIS EHO consist of 26 questions. These 26 questions can be grouped into three categories: introductory profile defining questions, ECDIS handling questions and finally set of opinion questions. Responses regarding response to ECDIS technical failure during the navigation were collected in the period 2014 – 2018.

1.2. Respondents target group

The questionnaire contains answers from wide spectra of maritime professionals, from active seafarers sailing on different types of ships to shore staff. Responses from 350 respondents were collected and classified by rank: 99 Masters (M), 77 Chief Officers and First mates (1/O), 66 Second mates (2/O), 13 Third mates (3/O), 8 Staff captains (SC), 1 Marine safety consultant (MSC), 3 Safety officers (SO), 3 Environmental officers (EO), 4 Dynamic positioning operators (DPO), 1 pilot (P), 1 superintendent (SI), 1 supervisor (SV), 14 port State control officers (PSCO), 25 trainees (T), 1 Yacht-Master (YM) and 33 persons of unspecified position making part of the navigational watch (U) (Figure 2).

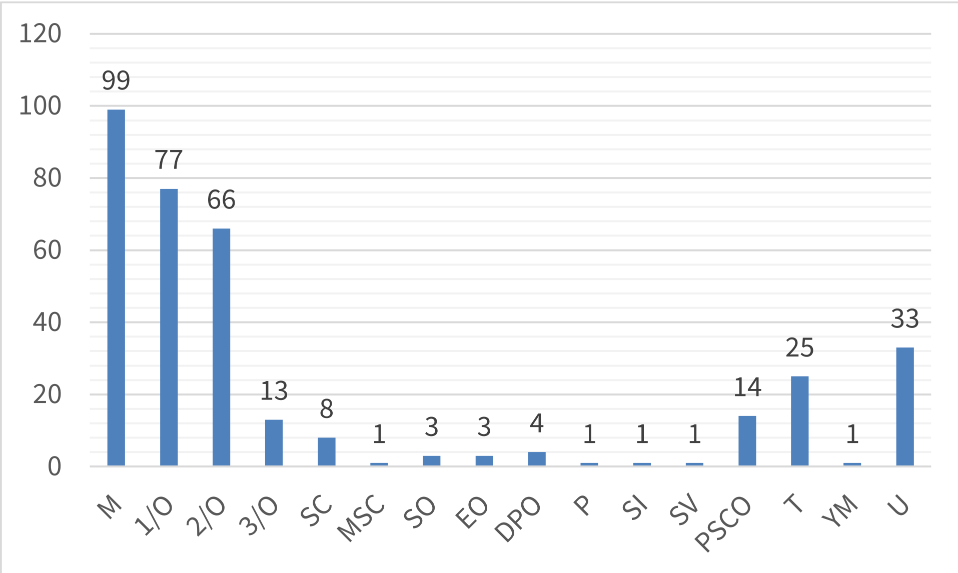

Figure 2: All ECDIS EHO survey respondents by rank

Question elaborated in this paper requires an answer of active seafarers sailing on a vessel that uses ECDIS as primary means of navigation. It is achieved by filtering the initial sample to a representative sample by using introductory questions:

1. *Is the ECDIS system used as the primary means of navigation on your ship (if ECDIS system was used as the primary means of navigation on one of your previous ships, please indicate so)?*
2. *What is your rank on board?*

Only persons that have sailed on the vessel using ECDIS as primary means of navigation and navigational ranks were considered for future analysis. The result is the target group containing 115 respondents (Table 2).

Master	Staff Captain	First officer	Second officer	Third officer	Trainee	Total
28	5	34	29	6	13	115

Table 2: Target group distribution by a rank

Target group consist of 28 Masters, 5 Staff Captains, 34 First officers, 29 Second officers, 6 Third Officers and 13 Trainee.

1.3. Results and analysis

Target group was furthermore used for evaluating the following question:

Q1: Assuming that you sail on a paperless ship, what would you do in case of an ECDIS systems technical failure during the navigation (if there are guidelines prescribed by the company in accordance with the ISM, please specify them)?

The question consists of two parts, the first part describes the respondent's action in case of ECDIS failure, and the second part defines if a company has a procedure in accordance with ISM and describes it.

The first part of the question was answered by 66 participants (57.4 %), while 49 participants (42.6 %) provided unclearly or no answer. Answers from 66 respondents that gave clear answers were further analysed. (Figure 3). Some of the respondent answers considered multiple actions, so their answers were included into more than one category.

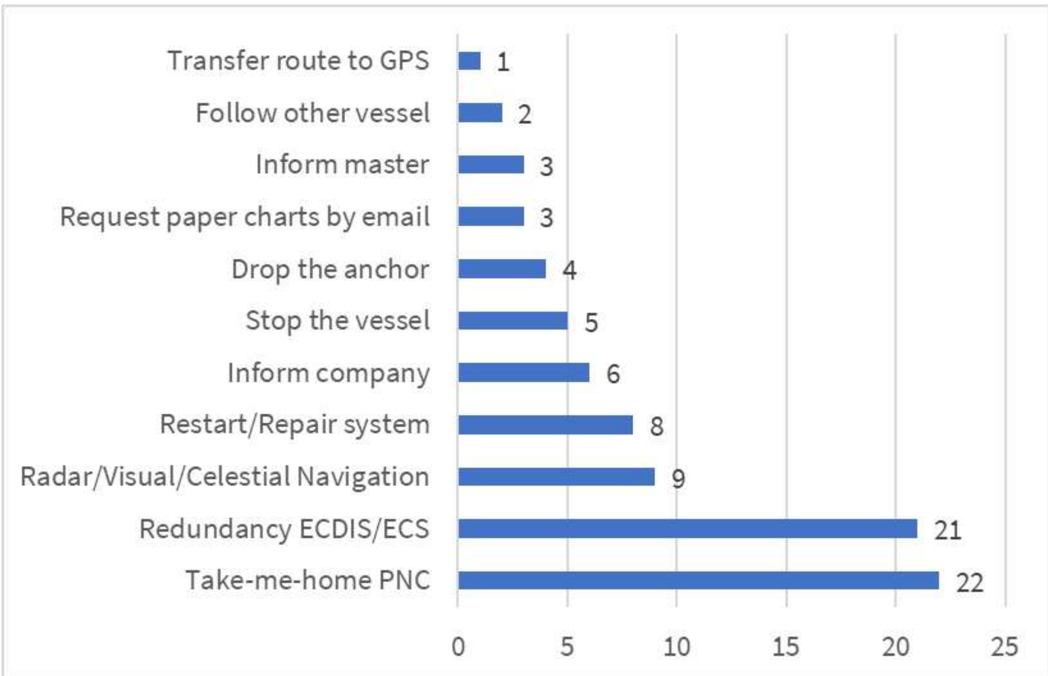

Figure 3: Distribution of answers on first part of Q1

There are two major groups of answers: usage of take-me-home paper charts answered by 22 respondents, and redundancy ECDIS/ECS by 21 respondents. Radar, visual or celestial navigation as a response is answered by 9 participants and 8 respondents would try to repair or restart of ECDIS. Other actions as informing the company, stopping the vessel, dropping the anchor are considered by minor part of respondents. Only one person would transfer route waypoints to GPS, and nobody considered slowing down the vessel to a safe speed and raising engine status to stand-by.

Additionally, as some type of ships are subject to stricter control by internal and external parties, possible difference between participant subgroups is analysed according to ships type. Target group respondents were grouped into statistically significant subgroups: Tankers (39 %), Cruise ships (29 %) and Other (32 %) (Figure 4).

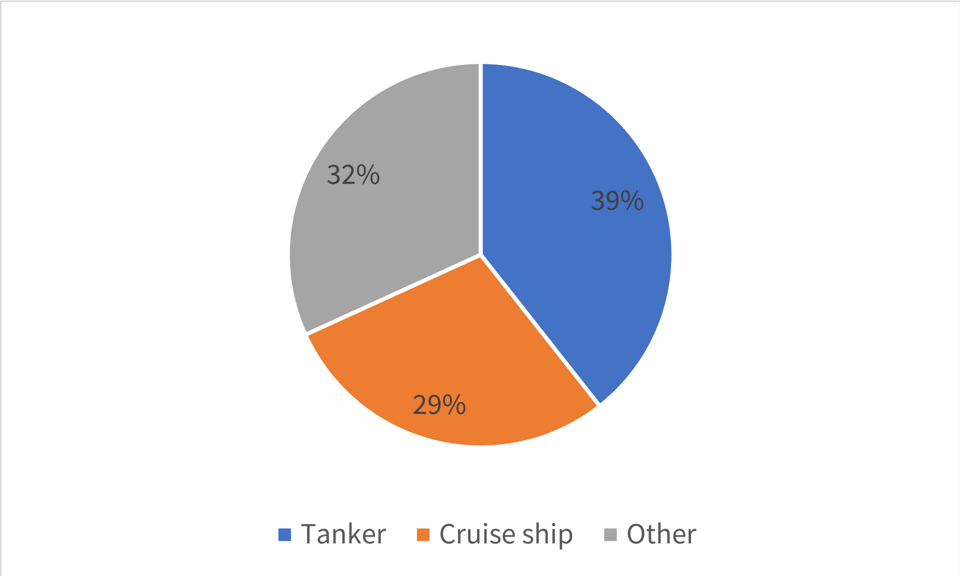

Figure 4: Target group respondents clustered by type of vessel

Only result of the four main answers, which summarizes together equal to more than 70 % of all answers, are analysed further. Distribution of answers to *Q1* among subgroups is shown on figure 5. Usage of redundancy ECDIS/ECS is the lowest in *Other* vessel group, while it is almost equal in *Tanker* and *Cruise ships* group. Usage of Gohome PNC is highest in Other vessel group.

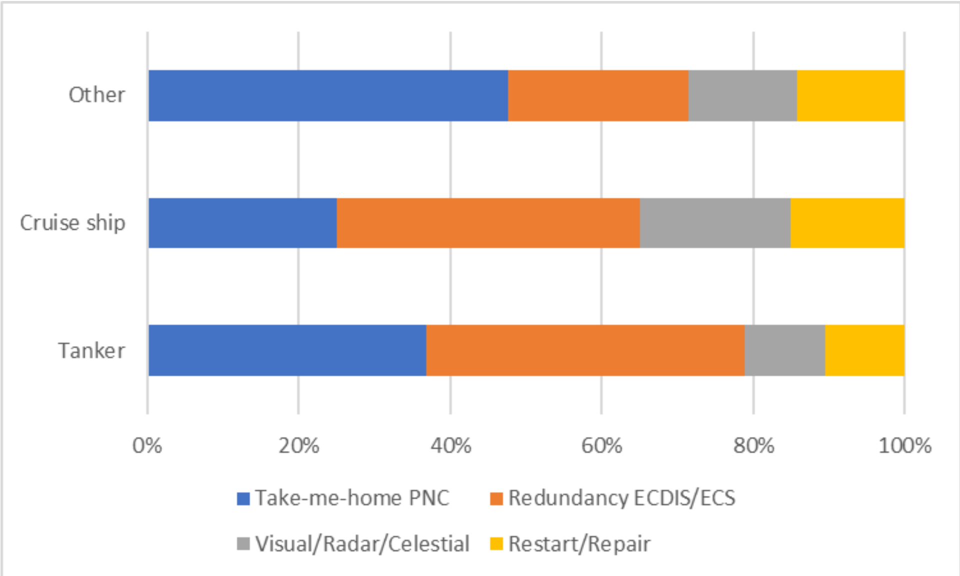

Figure 5: Distribution of answers of subgroups by type of vessel

For the analysis of the second part of question, answers of the 66 participants that responded to first part of Q1 were used. As remaining 49 respondents of target group gave no answer to first part of question, they were not further considered. Results of answers to second part of a question are shown in figure 6.

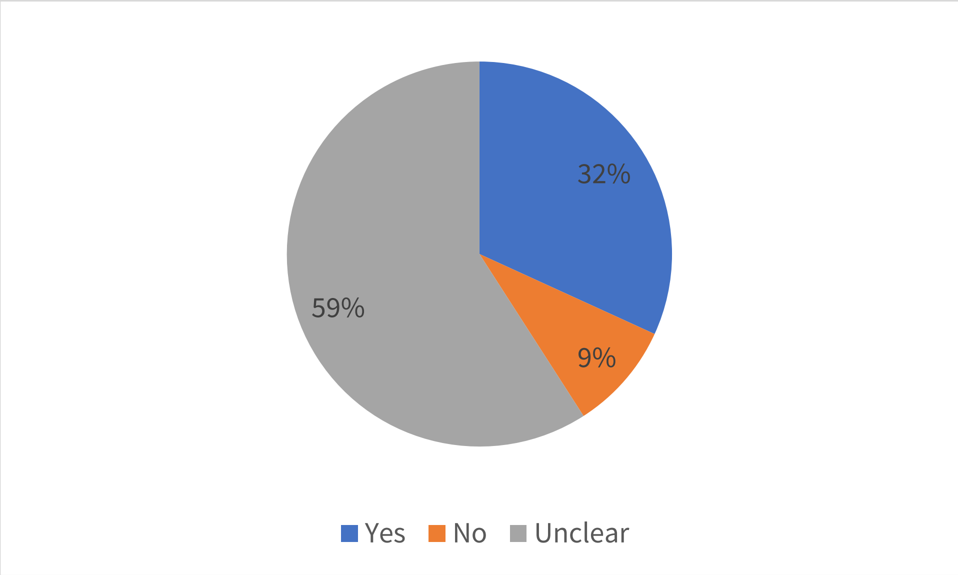

Figure 6: Result of answers on a second part of Q1

Only 32 % of respondents clearly confirmed that their companies have guidelines in case of ECDIS failure, and 9 % of respondents reported not to have a guideline. A remarkably high percentage of respondents (59 %) did not provide exact confirmation to the second part of the question. A fair share of unclear answers may be in fact confirmation of no procedure in case of ECDIS failure.

5. DISCUSSION

Generally speaking, the shipping industry is not well prepared to adequately respond to emergency arising from total ECDIS failure. On the first part of the question regarding respondents' action in case of technical failure of ECDIS system, more than 42% of respondents failed to provide any or at least any meaningful answer. Considering ECDIS as vital and central navigational aid in modern shipping, before mentioned survey participants are presenting potential problems for the safety of navigation. What is behind such a result? The percentage is too high to consider subjective reasons, so it is to assume system error. Is it failure of company to establish a procedure, failure of training and educational facilities, or both?

Another group of respondents that provided their response to hypothetical failure, mostly answered by two typical solutions: use take-me-home paper chart or redundancy ECDIS/ECS. Only eight respondents would try to restart or repair units, while nobody considered slowing down the vessel. Dropping anchor is solution for four respondents, even during time of ECDIS failure there is no chart to show if area is safe for anchoring, or what is the depth. Similarly, using celestial navigation with no chart available is not a valid option.

Response to failure at sea, normally includes set of actions, which are defined by procedure. Procedures itself are based on risk assessment that includes all kind of measures to safeguard navigational safety. Answers of respondents are just partial solution to complex situation, which must include several well-defined actions of navigator. Response should include most of answers that respondents provided.

Disagreements between groups was analysed by division of initial group to subgroups based on ship's type. The category take-me-home paper chart is the least represented on cruise vessel, and mostly on other vessels type. This is expected, as passenger ships usually have multiple ECDIS workstations, and invest more in navigational safety.
In analyse of second part of the question, only 66 respondents that answer on first part of question were considered, other 49 persons that gave no answer to first part were not included. It is logically to assume that they have no procedures as they didn't provide any clear answer to first part. Unfortunately, answers on first part of question forebode results of second part with regards to procedures on board. Only 32 % of respondents clearly answered to have procedures in case of ECDIS failure on board. Other participant did not answer or have no procedure on board.
Having result of second part of question available, it is plausible to conclude that responses on first part of question are mostly instinctive solutions to the perils of the sea, with no procedure and no training.
Finally, result of survey among navigators are confirmed by survey of industry practice conducted on four shipping companies. Only one of analysed companies has comprehensive guidance for navigators. It was interesting to find that one major shipping companies found redundancy as justification for not having ECDIS failure guidance. On modern ship redundancy is a standard, but additional steering gear for instance doesn't mean that ships are not required to train for emergency steering.
Three major findings could be presented:

- Significant number of respondents are not able to respond to ECDIS failure at sea,
- Procedures for ECDIS failure are not available to majority of navigators,
- Industry has no clear guidelines for ECDIS failure response.

While industry does not provide clear guidelines and procedure it is not possible to expect better results from navigational officers. ECDIS system is implemented globally probably faster than any other navigational aid in history and has changed radically navigator's environment and routines. This was not completely followed by proper procedures and there is still space for improvement of navigational safety.

6. CONCLUSION

The proposed paper deals with response to ECDIS failure by active navigators sailing on paperless ships. The term paperless describe vessels which ECDIS system redundancy is achieved by a second independent ECDIS workstation. For the purpose of survey, target group of respondents is selected. Only answers of respondent that are active navigators and have been sailing on paperless ship are considered for analysis. General conclusion of the survey is that navigators are not adequately trained and guided for ECDIS failure situation. Notable number of respondents could not provide any answer on question targeting their reaction to ECDIS failure at sea. Among respondents that answered first part of question, majority of them would use take-me-home charts or additional redundancy ECS/ECDIS. None of respondents provided full set of action to be taken in case of failure.
Such a result is somehow expected considering that other part of question reveals that procedures for this emergency are not well established. Most of respondent do not have procedures in case of ECDIS failure on board. Obviously, some shipping companies are reliant that technology will not fail them. However, it is obligation of shipping company under ISM to have emergency procedure on board the vessel.

Furthermore, analysis of four shipping companies confirms that procedures are still to be implemented on many ships worldwide. Without proper procedure based on detailed and ship specific risk assessment, there cannot be adequate response of navigators, this is what history of navigation has taught us so far. Future research should focus on defining factors that should be considered for comprehensive ECDIS failure procedure. This could assist the shipping industry in effort to propose suitable framework for shipboard ECDIS failure procedures.

ACKNOWLEDGMENTS
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INNOVATIVE TEACHING METHOD FOR SHIPHANDLING

– ELEMENT OF PROJECT "EURO ZA" BETWEEN SOUTH AFRICA AND EUROPE -

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Abstract

Some years ago, the SAMMON software tool box was introduced for "Simulation Augmented Manoeuvring Design, Monitoring & Conning". It is based on the innovative "Rapid Advanced Prediction & Interface Technology" (RAPIT) to simulate the ships motion by Fast Time Simulation (FTS) with complex dynamic math models and to display the ship's track immediately in an Electronic Sea Chart for any rudder, thruster or engine manoeuvre planned by the navigator. Specifically, the SAMMON Planning Tool will be shown in its opportunities for achieving new knowledge for teaching of ship's dynamic and training of ship handling elements. That system represents the full information from ship's manoeuvring documentation and from additional trial results squeezed in a ship dynamic model, capable of simulating environmental effects by using the RAPIT technology. The paper introduces the variety of opportunities of the training tools by presenting use case studies, e.g. for drifting under wind. Additionally, two complex manoeuvring strategies for a port arrival scenario will be compared for a ship with azimuth propeller to find out potential alternatives with less fuel consumptions and emissions.

Keywords

Fast time manoeuvring simulation, voyage planning, dynamic prediction, simulator training

1. Introduction

According to the IMO standards for voyage planning from berth-to-berth there is a need to prepare harbour approaches in a new quality with complete berthing plans specifically in companies with high safety standards like cruise liners. These plans are helpful in briefing procedures to agree on a concept within the bridge team and also for the discussion and briefing with the pilot. But still the plan for the potential manoeuvres could be developed in a contemplative way, only by “thinking ahead”. With the unique SAMMON software an innovative electronic tool is now available to provide support for planning those manoeuvring concepts by Fast Time Simulation (FTS). It will improve also the ship handling simulator training which has proven high effect - However, it is based on Real-Time Simulation, and i.e. 1 sec calculation time by the computers represents one second manoeuvring time as in real world. This is a very time-consuming process. In the near future FTS will be used for increasing the effectiveness of training and also the safety and efficiency of manoeuvring real ships. That system represents the full information from ship’s manoeuvring documentation and additional trial measurements, which have been condensed in a complex ship dynamic simulation model, capable of simulating environmental effects by using the innovative “Rapid Advanced Prediction & Interface Technology” (RAPIT). Even with standard computers it simulates 1000 times faster than real time: in 1 second computing time it achieves simulates a manoeuvre lasting up to 20 minutes. This technology was initiated in research activities of the “Institute for Innovative Ship Simulation and Maritime Systems” ISSIMS at the Maritime Simulation Centre Warnemuende MSCW, which is a part of Hochschule Wismar, University of Applied Sciences - Technology, Business & Design in Germany, specifically in its Department of Maritime Studies. The technology has been further developed by the start-up company ISSIMS GmbH [6].

There are several modules of the FTS simulation system: In the centre stands SAMMON as the innovative system for “Simulation Augmented Manoeuvring – Design, Monitoring & Conning”. It comprises several software modules, the two most important are (a) the Manoeuvring Design & Planning Module and (b) the Manoeuvring Monitoring & Conning Module with Multiple Dynamic Manoeuvring Prediction. These modules are made for both for lecturing and simulator training for ship handling and also to assist manoeuvring of real ships on-board, e.g. to pre-pare manoeuvring plans for challenging harbour approaches / departures.

Important tools are made to support the SAMMON, e.g. the SIMOPT software for modifying ship math model parameters both for simulator ships in SHS and for on board application of the SAMMON System and the SIMDAT software module for analysing / displaying simulation results both from simulations in SHS or SIMOPT /SAMMON and from real ship trials. [6]

Also, in ongoing research projects the SAMMON tools are being used, e.g. in the ERASMUS+ project EURO-ZA. Several partner universities are working together - from Europe: HS Wismar /Germany, SOLENT Southampton /UK and SAMK Rauma, Finland) and from South Africa: DUT Durban, CPUT Cape Town and NMU Port Elizabeth as project co-ordinator.

The aim is a detailed analysis of the curriculums and facilities to evaluate similarities, differences and opportunities for improvement for all partners. The contribution of the ISSIMS institute of HS Wismar addresses the use of SAMMON FTS methods for ship handling training as one element of the potential improvement of training.

In this paper some findings from the use of the SAMMON Planning tool will be described, e.g. on how to discuss and calculate the drift of ships under wind. Also, the first estimations will be presented to use SAMMON to compare the fuel consumption for different manoeuvring strategies. Additionally, a lot of samples for using SAMMON to explain ship’s dynamic were made to be seen on YouTube [**7**]. Other samples and details were presented at various conferences [**1**-4].

2. Familiarisation with Fast-time simulation interface and example of wind drift

2.1. Interface of SAMMON Planning Tool

The interface of the SAMMON Manoeuvring Design & Planning tool combines the following three windows (see Figure 1):

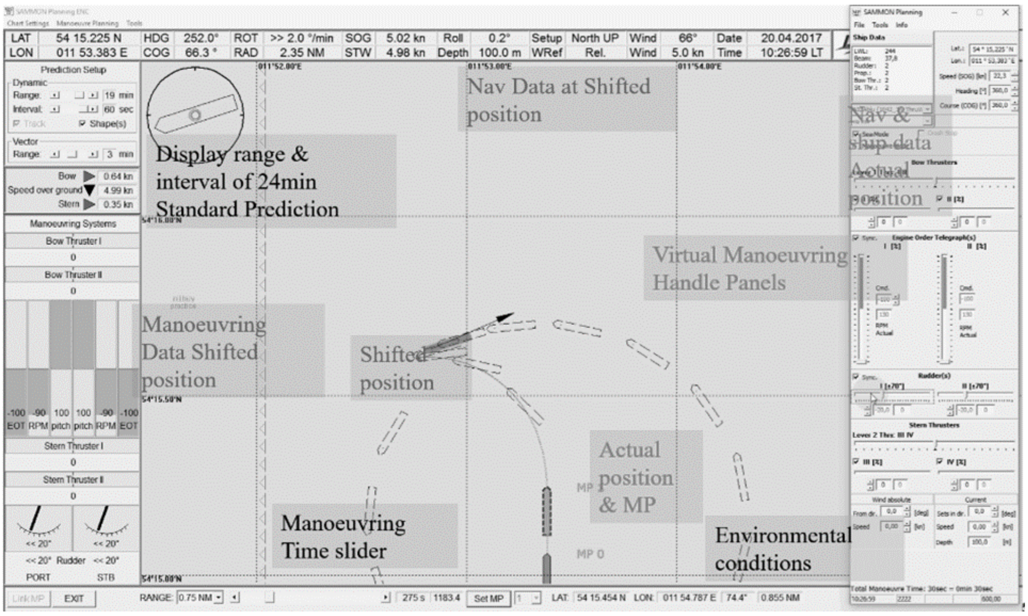

Figure 1: Interface elements of SAMMON Manoeuvring Design & Planning tool with additional comments (more information under YouTube [7])

- The right window represents the steering / control panel: this is for adjusting the controls for the selected actual Manoeuvring Point MP (actual position in red) or entering the environment conditions e.g. wind, current and water depths (bottom right),

- The centre window displays the electronic navigational chart (ENC) where the simulated ship’s motion is visualised: the ships positions are shown as black contours indicating in time intervals for the display range. The reference position can be shifted by means of the time slider at the bottom to any position of the already predicted track. There a new MP can be set and controls may be changed there,

- The left and top window display the ship status at the reference ship position on the track, indicated as ship shape in blue colour in the ENC – this status is defined by e.g. the current navigation data and actual ship manoeuvring control data.

2.2. Simulation and Formulas for pure Wind Drift Motion

In the next figures the motion of a ship is discussed under wind speed 30kn from North 0°. The sample ship is a cruise liner of 253 m in length which is not using her propulsion. In Figure 2 the ship starts drifting from stop with zero speed.

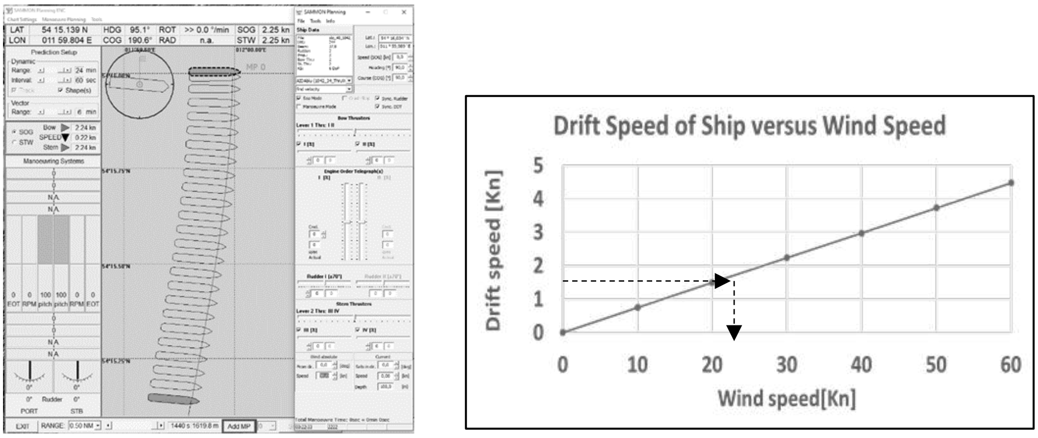

Figure 2: Transverse Drifting under Wind speed VA=30kn (Cruise ship AIDAblu). Left: situation with drift speed SOG=2.25kn, HDG 94°, COG 184°; right: diagram for drift speed versus wind speed with arrows indicating maximum drift balance by thrusters

Each shape represents her position after 1 minute, the full drifting speed is reached very fast to be SOG=2.25kn after 1 or 2 minutes (this is indicated by equal distances of the shapes). The bow falls slightly down with the wind because she has the centre of wind area ahead of midships position. The drifting speed can be reduced by the thrusters: the ship would drift only with SOG=1.51 kn if thrusters are used fully against the wind. It might be very helpful to estimate the drift speed: The drift speed is nearly linear increasing with the wind speed, as the lower diagram proves. As a consequence, only one result would be enough (maybe better two or more because of potential bias…) to estimate a constant factor to estimate the drift for other wind speeds. For instance, in this sample the linear drift speed factor C_D is about 0.075, i.e. the drift speed is 7.5% of the wind speed. As a conclusion this can be used a suitable “Rule of Thumb) to estimate the drift speed e.g. for cruise ships for a given wind speed! In which way the drift direction can be changed by using the thrusters was discussed already in [4].

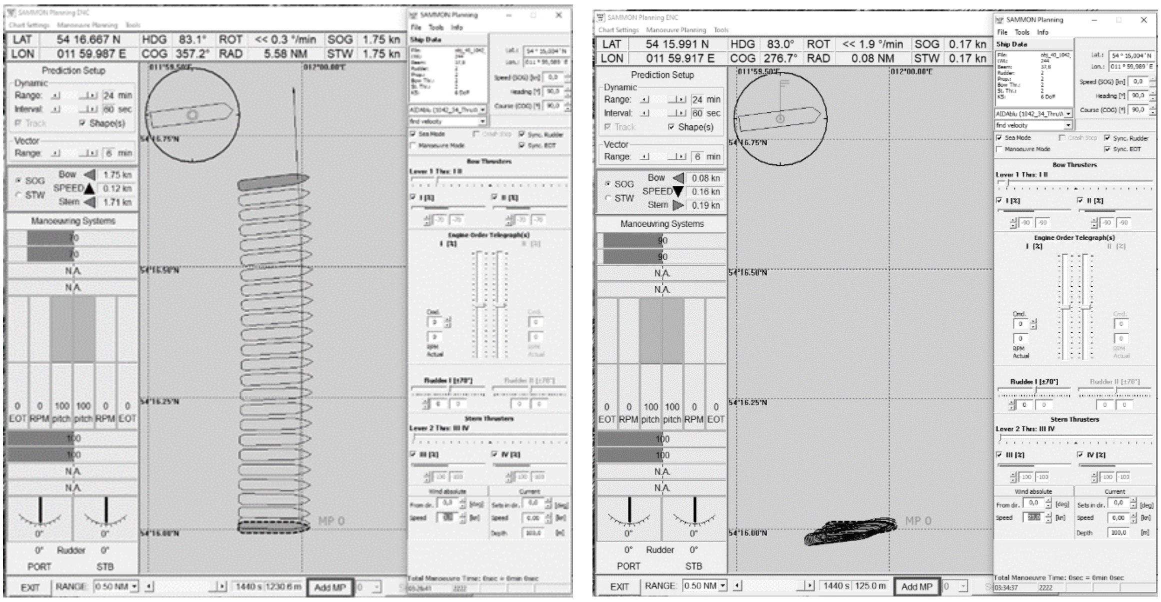

Figure 3: Experiment for Maximum Drift speed for full thruster with no wind: Result 1.75 kn (left) and test scenario to balance wind of 23kn by thruster (right)

It is also important to know the absolute limit wind speed V_{A_lim} which is possibly to be balanced by thrusters which can be estimated by measuring the Maximum Drift speed V_{D_max} for full thruster with no wind (see Figure 3). The result of 1.75 kn can be seen in the diagram as dotted horizontal line, as a result the Limit Wind speed can be seen as 23kn from the vertical arrow. Instead it is also possible to use a formula

$$V_{A\_lim}[kn] = \frac{V_{D\_max}}{C_D} = \frac{1.75}{0.075} = 23kn \qquad (1)$$

3. Planning and optimising manoeuvres for simulator training

3.1. Task Description for the exercise preparation – conventional briefing and NEW method

For preparing a simulator exercise e.g. for a port arrival, the trainee is commonly familiarised with the scenario, e.g. the port area, initial situation and environmental conditions. Normally this is done on a navigational chart, see e.g. Figure 4. In this sample exercise the ship should be brought through the fairway channel of Rostock Port from North, to be turned on the turning basin and then heading back through the channel to berth the ship with portside at the Passenger Pier. Manoeuvring sections would give a good overview on the different tasks / aims:

- 1st Section: the ship speed should slow down until around 3kn, so she is ready to be turned.
- 2nd Section: the ship starts and performs the turning manoeuvre to be adjusted ready to go back in the fairway on opposite course.
- 3rd Section: the ship slows down to be finally stopped and brought to the berth.

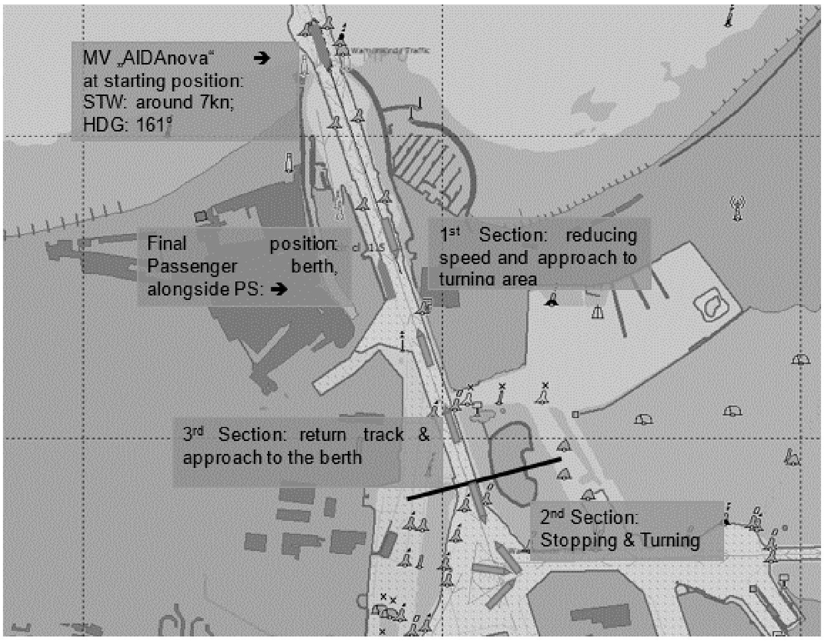

Figure 4: Sample for conventional briefing for a berthing scenario in the Port of Rostock

In the conventional briefing and exercise preparation, only guessing and these rough indications of manoeuvring conditions can be used to develop a “manoeuvring plan” - specific manoeuvres and settings controls cannot be discussed in detail. By means of the RAPIT Fast Time Simulation an individual exercise preparation with self-developed manoeuvring concepts would be possible:

- With the SAMMON Manoeuvre Planning Tool it would be easy and quick to develop a detailed Manoeuvring Plan and moreover, even the
- Improvement of the concept by several attempts or even “What-if” trials with that tool, e.g. for considering fuel consumptions and emissions is possible.

In the following section a sample will be given to develop a manoeuvring plan for a ship with azimuth propellers according to the scenario above with two different strategies to use the PODs. The topic of this investigation was to find out the most effective manoeuvre with respect to energy / consumption and emissions for Port approaches. Two different strategies were used:

1. Conventional POD strategy, similar to twin propeller / rudder configuration, i.e. speed changes by changing POD revolutions and rudder angles
2. New POD strategy, with IN-OUT configuration, i.e. speed changes by turning both PODs inward or outward, or as tandem configuration

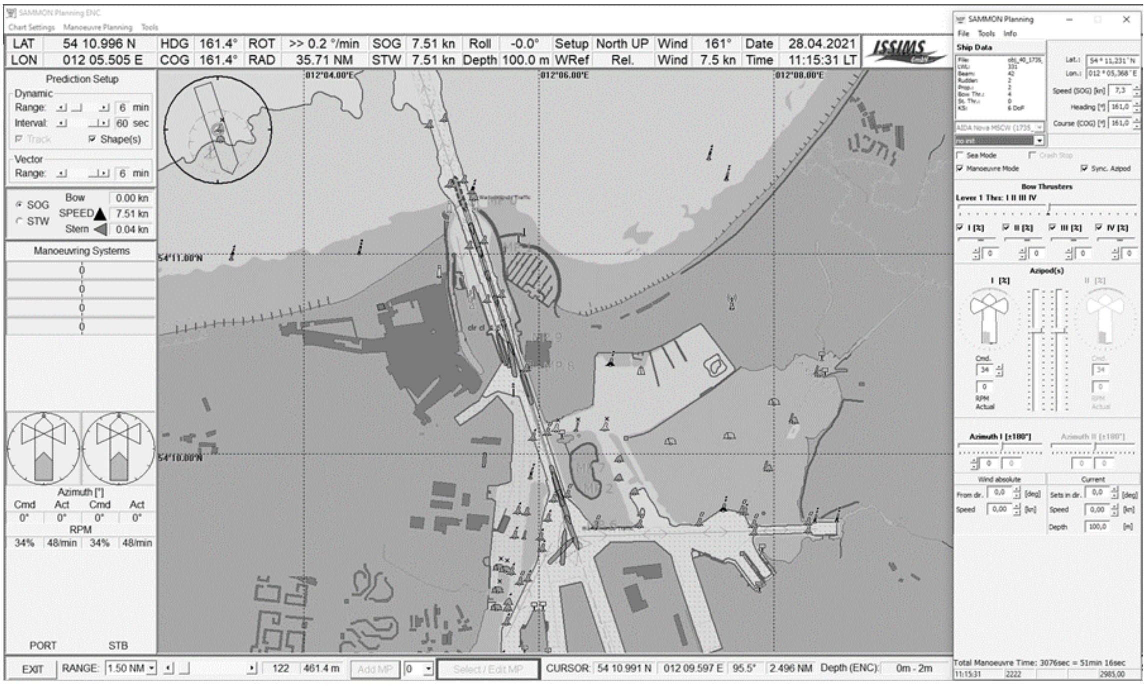

Figure 5: Sample with SAMMON Planning tool for arrival planning for Rostock port: Using new POD strategy with IN-OUT configuration, e.g. speed changes by turning PODs inward

In Figure 5 the plan for the 2nd new POD strategy is shown. It looks nearly the same as the other variant 1 (therefore not extra shown here); the difference is in the details which will be discussed separately soon. The two manoeuvres with different strategies were initially simulated with SAMMON Planning tool, resulting in two respective Manoeuvring Planning Files. Afterwards these files were taken as input to the SIMOPT/ SIMDAT tool to be analysed in detail with respect to assess the fuel consumption for further optimisation, if needed.

3.2. Planning by means of Fast-time simulation for two strategies

With the new SAMMON Planning tool there is the chance for designing a Manoeuvre Plan with the specific control settings at distinguished positions called Manoeuvring Points MP. The following sample demonstrates how to make a full manoeuvring plan by means of the suitable control actions at the MPs.

In Figure 6 the initial position MP0 is to be seen where the ship was set in the centre of the fairway before entering the moles, the speed rate is initially EOT=32%, revealing a speed of 7.2kn. The ship has already been moved by the time slider at the ENC bottom to set the next manoeuvring point MP1. There, the speed reduction manoeuvre is started:

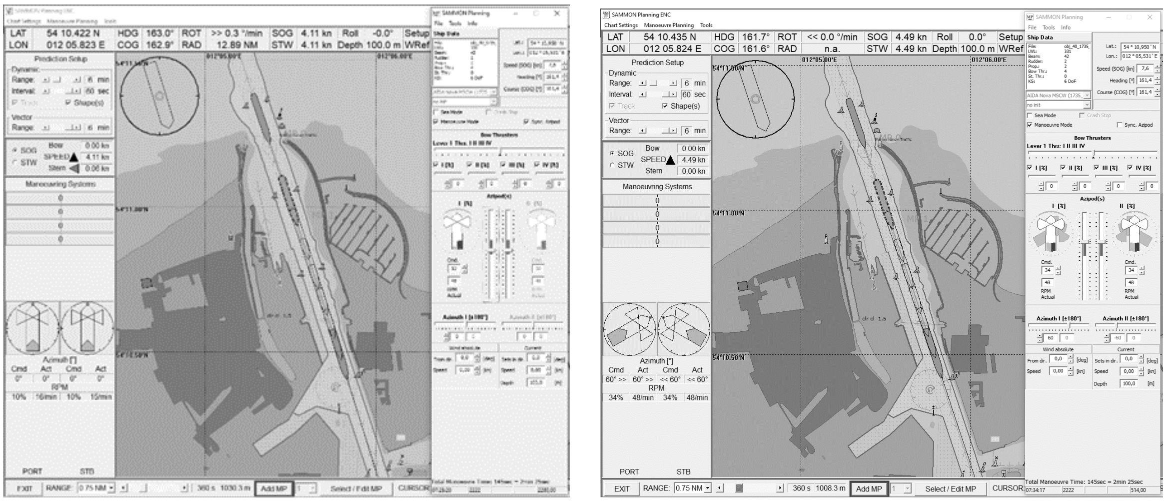

Figure 6: SAMMON planning interface: Starting position at MP0 and predicted shapes for the following slow down manoeuvre beginning at MP1: Left:: in conventional way with reducing EOT to 10%; right: turning both pods inward IN 30°

- In the left figure it is done with reducing EOT to 10%. The ship shapes of the predicted track ahead of the MP0 already show continuously reduced distances, i.e. the speed drops according to the new handle positions. And by moving the blue reference shape by means of the time slider to the new position at 360 sec, the speed there is only SOG 4.11 kn, to be seen in the top row. This is the same manoeuvre which typically would be done with a conventional twin screw vessel.
- In the right figure it is done with a typical POD manoeuvre by turning both pods inward to IN 30°. Now the thrust of the pods is not fully directed forward anymore, therefore the speed is dropping to 4.49 kn after 360 sec.

This comparison of the speed drop after 360 sec was only to show the effect of the two manoeuvres. The reference position may be moved further along the fairway to a suitable position where the next manoeuvre is necessary. A new Manoeuvring Point MP 2 can be set by pressing the button “Add MP” and then the focus is on the new MP 2 and so forth. In the next Figure 7 two different manoeuvres are shown to discuss the different turning strategies starting at position MP3:

- In the left figure it is done in conventional way by stopping the port engine and turning the ship with the SB POD IN100° with transverse thrust like a rudder.
- In the right figure the pods are used in a tandem position: PT POD IN120° and SB pod OUT60°

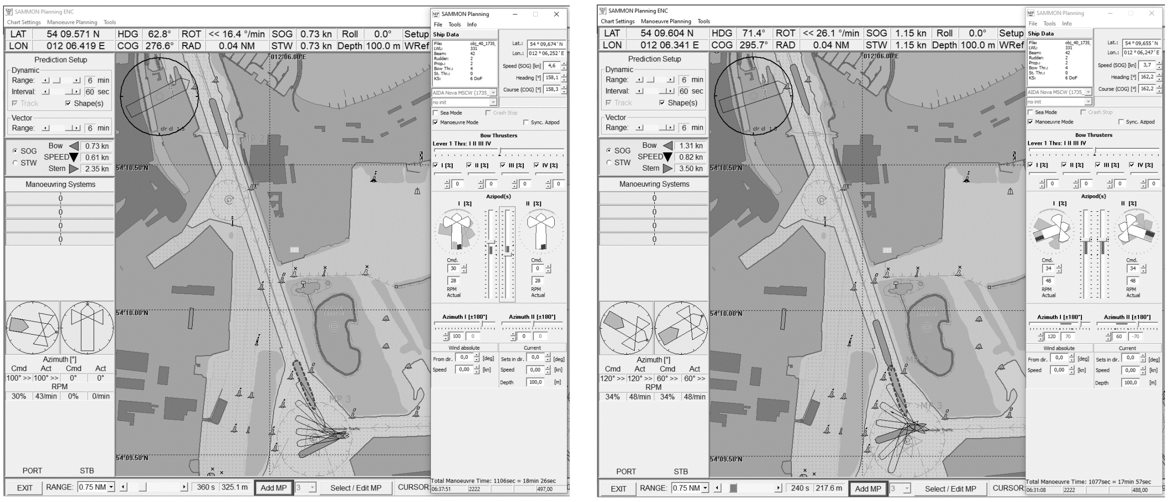

Figure 7: Two manoeuvres for different turning strategies starting at position MP3: left: conventional way by stopping the port engine PT POD EOT 0% and turning the ship with the SB POD to IN100° with EOT 30%; right: the pods are used in a tandem position: PT POD to IN120° and SB POD to OUT60°, both with EOT 34%

In the final phase of the manoeuvring plan the ship will be stopped short before the berth: also here the pods can be used in conventional way of stopping by reversing the pods to direct the thrust in astern direction or to be used inward to create maximum resistance and on the same time adjusting the EOTs so that the ship is moving in the direction of the berth, together with the bow thrusters.

3.3. Analysis of fuel consumption

The question is now to decide which of the two strategies are better? For this reason, the fuel consumption was estimated for both versions by means of the SIMOPT [6] / SIMDAT software programs. In Figure 9 a comparison of controls for both manoeuvring strategies is made, it can be seen that the conventional strategy is using much lower revolutions but achieving nearly the same speed history.

The benefit is shown in Figure 10 comparing the consumption for both manoeuvring strategies for each manoeuvre separate (left) and as a cumulative sum of all the manoeuvres (right). It can be analysed with respect to consumption:

a) Conventional POD- strategy: consumption ca. 3x106 g, i.e. ca 3 t

b) New POD-Inward strategy: ca. 9x106 g consumption, i.e. ca 9 t

Therefore, the following conclusion can be made:

- The conventional operation of PODs like for a normal Twin Screw ship has only 30% fuel consumption (and in analogy about 30% emission of CO_2), compared to the New operation: Operating the PODs against each other is a waste of energy and damage to the environment!

- It is without any doubt that the Inward strategy has a lot of advantages because the ship is much easier to control due to the immediately available steering forces when turning the pods for higher revolutions. But this should only be used if these high forces are really needed, e.g. for challenging external forces or complicated manoeuvres.

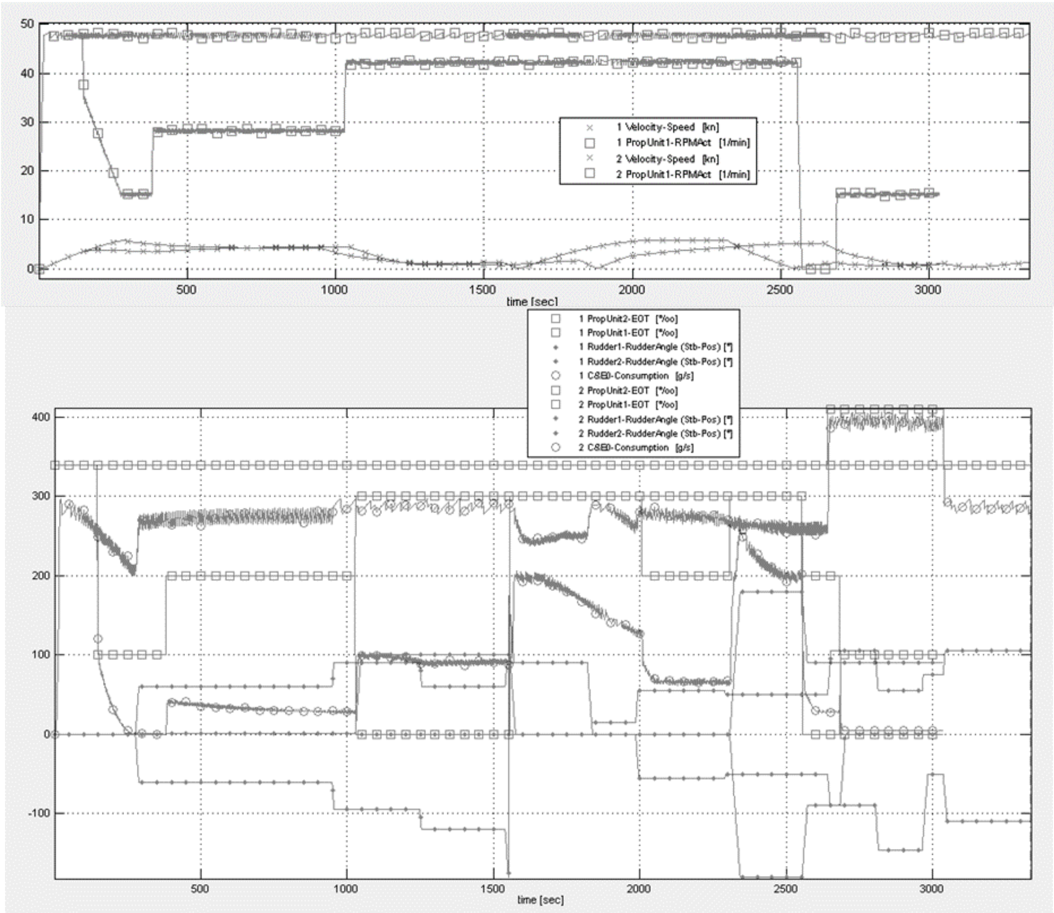

Figure 8: Comparison of controls for both manoeuvring strategies: Top: Time history of speed and engine revolutions; Bottom: pod angles together with EOT and revolutions (Blue: Conventional POD strategy, speed changes by reducing POD revolutions - Red: New POD strategy, speed changes by turning both PODs inward, shown as rudder units)

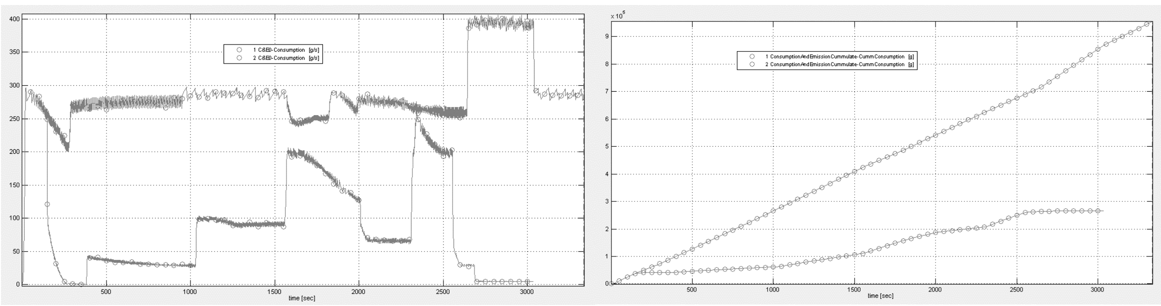

Figure 9: Comparison of consumption for both manoeuvring strategies: Left: Plot of consumption of separate manoeuvres; right: Plot of cumulative consumption (Blue: Conventional POD strategy, speed changes by reducing POD revolutions - Red: New POD strategy, speed changes by turning both PODs inward)

It should be mentioned that the models for fuel consumptions and emission used here are still simple and not precise enough the really calculate reliable results for the total values. However, they are a good estimation when comparing the relative data of consumption and emissions for two different manoeuvring strategies. For the time being the models are based on quasi-linear, steady state models, calculating of the fuel consumption is based on its calorific value, the propeller torque and its speed during the manoeuvres. New models for transient engine operation in non-steady operation are already under development, but needs much higher efforts for engine data and additional simulation parameters [3, 5].

4. Methods for calculating Fuel Consumption and Emissions during Manoeuvres

4.1. Simulation of Consumption

While the previously presented consumption calculation is derived from the delivered propeller torque and the propeller revolutions, an engine model is presented below, which calculates the consumption $\dot{m}_B$ via a PID controller algorithm [8]:

$$\dot{m}_B(t) = K_P e(t) + K_I \int_0^t e(\tau) d\tau + K_D \dot{e}(t)$$

The PID controller reacts to the deviation $e(t)$ between the current engine speed n_{act} and its commanded speed n_{cmd} , the K represent the parameters of the PID controller. The available drive power is calculated via a speed- and power-dependent efficiency and by including the fuel calorific value. The engine torque is obtained by dividing the drive power by the engine's angular frequency. Based on a system of differential equations for the engine dynamics, the difference between the propeller torque, which corresponds to the counter-torque of the engine, and the engine torque is formed and then related to the moment of inertia of the drive train. The speed acceleration calculated in the differential equation is added to the current speed.

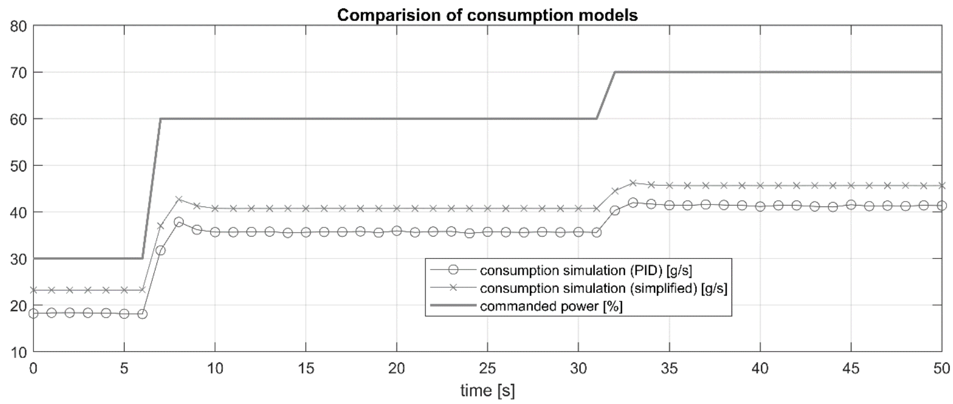

Figure 10: Comparison between the consumption calculation

Figure 11 shows a comparison between the consumption calculation using the above described PID controller algorithm (circles) and the simplified calculation (crosses). The latter method calculates slightly more consumption. Besides this deviation, the accuracy depends in particular on the propeller torque determined via a lookup table.

4.2. Data-based models for Prediction of Emissions

For seagoing vessels, CO_2, SO_X, NO_X and PM emissions are of particular interest when it comes to protecting the environment. While CO_2 and SO_X are almost proportional to consumption, NO_X and PM depend on the combustion air ratio and thus on the inertia of the system. This means that the engine model would either have to be more detailed than the one described in 3.1 [9], or that these emissions would have to be calculated via a data-based model [10]. To comply with the speed requirements of FTS, a data-based, empirical model seems appropriate. For this purpose, two approaches were investigated, both of which referring to artificial neural networks (ANN) in the form of feedforward multi-layer perceptron networks: One with external dynamics (where the engine dynamics are calculated by differential equations,), the other with internal dynamics (where the engine dynamics is calculated within the ANN). While the former is easier to program and train, the latter in general yields more reliable results. Figure 12 shows a comparison between the two approaches.

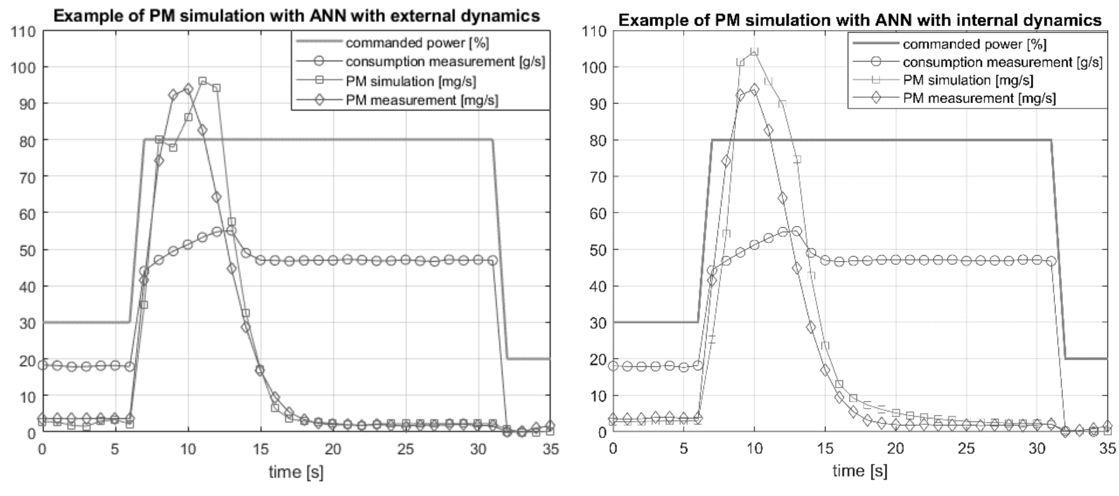

Figure 11: Comparison of two Artificial Neural Network approaches: Left: ANN with external dynamics, right: ANN with internal dynamics.

Both approaches are possible for supplementing the existing prediction software with fast-calculating emission models, provided that sufficient corresponding measurement data are available.

5. Conclusion

The examples have shown the benefits of using SAMMON Planning tool: For lecturing it is much better to use samples by Fast-Time Manoeuvring Simulation instead of theoretical explanations; they are self-explaining for specific ship behaviour and for the sample of wind drift two simple formulas could be developed to calculate the drift speed. SAMMON allows even for preparing complete manoeuvring plans very fast – same trials in a full mission SHS which would take hours. It will be a great benefit to implement fuel consumption and emissions into the simulation: For the time being simple models were used to estimate and compare the fuel consumption for different manoeuvring strategies with each other. As a result, it could be shown that conventional operation of PODs for changing speed by changing revolution like for a normal Twin Screw ship has only 30% fuel consumption compared to the alternative new operation to control the speed by turning the PODs inward for speed reduction: Operating the PODs against each other is a waste of energy and damage to the environment! SAMMON has proven already its benefits for lecturing and training and will have a great potential to increase efficiency and sustainability of manoeuvring also on-board. A comparison of simple models for engine operation and fuel consumption shows that also simple models allow for a reliable analysis of different manoeuvring strategies.

Acknowledgments

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INTELLIGENT SUPPORT OF THE USER OF THE E-NAVIGATION MARINE ERGATIC SYSTEM

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Abstract. The article proves that the issue of effective operation of the ergatic control systems in the period of digitalization of the maritime transport industry continues to be relevant. Despite the mandatory use of various navigation systems, navigation errors as a result of the human factor are one of the main causes of marine accidents. In this regard, the intelligent support of the user of the marine ergatic system E-Navigation based on the information approach requires more attention from both developers of navigation systems and educational organizations, which are to ensure the proper level of training of specialists serving this industry. Technological advancements in the field of creating visualization means and software for designing various objects and environments currently allow us to create artificial environments with any content that are indistinguishable in their impact on the human senses from physical reality, which largely contributes to the adoption of the right decision in any production process. Taking into account the increased interest in computer interfaces, the authors attempted to explain and illustrate the need to develop an intelligent interface in a mixed reality environment, which in the future will allow the user to obtain aggregated information to make the right decision intuitively. The authors consider the navigator as one of the main participants of the marine ergatic system, grounding on the fact that the human factor is decisive both in the process of creating risks for the crew, the ship, its cargo and the environment, and in making decisions to avoid or reduce these risks. The paper provides analysis of virtual educational technologies such as: computer training systems, advanced software programs, simulation tools, and associated hardware, which enable education institutions to package and deliver a range of different programs and learning options, including those traditionally considered as obligatory within regulated Certificate of Competency (CoC) courses, thus providing the flexibility that compliments the life style of modern seafarers, as well as promoting self-directed learning. The advantages and disadvantages of virtualization of the education process are disclosed. The paper shows that in spite of understanding of effectiveness of simulators for skill acquisition, considerably less attention is devoted to evaluation of the education/training methods engaged in simulation training, which indicated the needs to investigate the current methodologies with attempt to improve and enhance the effectiveness of simulator-based training. The authors prove that the quality of the simulation modeling on training equipment is largely determined by the introduction of "through" digital technologies of virtual and augmented reality. The paper stipulates the reasons why simulation in combination with real world cadet shipping experience is the most affective mean for training. The results show that the revised training method provides trainees with improved operative performance, which can be further developed and implemented as a means for ensuring proficiency.
Keywords: maritime education, virtualization, Augmented Reality, human element, interface, etc.

Introduction

The interest in the design of the ergatic technological systems is explained by the constant development and introduction of modern technologies into production and the need for the participation of a human operator in it. Solutions associated with the emergence of new tasks require accounting of a wide range of psychophysiological, psychological, biomechanical and other characteristics that ensure the professional activity of a human operator, i.e., consideration the activities of the sea industry as the ergatic system, i.e., the system «man-machine-production environment». Ignoring mentioned features can lead to a strong disruption of the normal operation of complicated technological complexes, loss of reliability and quality of their functioning, and as a result, to serious man-made (техногенным) consequences. In the shipping industry, the human element is recognized as the main source of risk for safe and efficient shipping. The most cited definition of the «human factor» applied in shipping was adopted by IMO in resolution A. 947 (23) in 2003: «The human element is a complex multi-dimensional issue that affects maritime safety, security and marine environmental protection. It involves the entire spectrum of human activities performed by ships. crews, shore-based management, regulatory bodies, recognized organizations, shipyards, legislators, and other relevant parties, all of whom need to co-operate to address human element issues effectively» [1].

The growing dependence on complex systems in the operation of ships imposes certain requirements and limitations on a human operator, whose training process can be successful only with a deep understanding of the principles of the electronic systems functioning at all levels of interaction of various elements of this system. The rational arrangement of human-operator interaction with technical means in ergatic systems contributes to the further development of communication forms between them. The neglect of didactics, the lack of understanding of its role in solving this issue is unacceptable, because the task of improving the efficiency and safety of modern commercial shipping cannot be solved only by means of widespread introduction of new equipment and technologies. Despite the use of knowledge-intensive technologies, a high level of automation in all areas of the industry, a person continues to be an active participant in the modern production process and he must be prepared for this, and he must be taught. This state of affairs forces the organizers of the educational process to look for new ways to train a specialist who can solve not only the production tasks of today, but also be ready for tomorrow.

2. The E-Navigation ergatic system as new reality

According to numerous researches, the ergatic system is a purposeful complex system consisting of a human operator, an instrument of activity, an object of activity, and an internal environment [2; 3; 4; 5]. The sea ergatic system of E-Navigation the harmonized collection, integration, exchange, presentation and analysis of marine information on board and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment. [MSC 85/26/Add.1 [6]. Among the potential users of E-Navigation, there are two groups: ship-based (different types of vessels) and shore-based users (ashore services and organizations providing the operation of ships) users.

Among the main user needs, document MSC 85/26 Add. 1 Annex 20 highlights: common maritime information data structure; automated and standardized reporting functions; effective and robust communications; human-centered presentation needs; human-machine interface; data and system integrity; maritime safety information; operational issues, etc.) [6]. Based on the identified user needs and accident analysis, the IMO Sub-committee on Safety NAV 57 decided to conduct a gap analysis to determine E-Navigation solutions to meet user needs, accounting the results of the Human Element Analysis, and document NAV58/6 was presented as the result of this analysis. This document also provides a list of practical solutions for E-Navigation in four areas: operational (efficiency/procedures/automation); technical («human element»/machinery/equipment); regulatory (rules, standards); training (marine, ashore specialists) [7].

In realization E-Navigation concept, special attention is paid to human element, both on the level of technical solution design (interface, and others) and in the aspect of seafarer training. The recommended volume of the article does not allow to disclose each of mentioned needs fully, so we will focus only on issues related to the support of the human-machine interface.

E-Navigation is a concept designed to facilitate the work of a human operator (navigator) by means of convenience and standardization of the user interface of the system. It is assumed that the user of the system will be able to control a ship or a group of ships from another ship or from the shore in the near future due to the use of smart digital technologies (artificial intelligence, augmented reality, etc.) [4; 8; 9]. This concept also includes the transition to autonomous navigation. The developed E-Navigation services, due to the introduction of communication elements of the fifth generation, are aimed at ensuring the processing of the required information flows. At the same time, it is advisable to rely on an information approach that allows us to consider the human operator as a complex computer-like system for processing input sensory information. This process can be considered as sequential or parallel stages, each of which performs specific operations to transform information. The ultimate goal of the information approach in perception is to create a structural and functional model consisting of separate blocks that perform a function similar to the construction of a perceptual image by the human operator's mind. The maritime intelligent E-Navigation system involves digitalization, integration and automation of network ship and ashore systems of marine navigation, and depending on the level of complexity of the current situation, a human operator makes a decision either independently (experience, intuition), or asks an expert for advice (pilot, captain, artificial intelligence). A technological breakthrough in the field of creating visualization tools, software for designing various objects and environments currently allows to create artificial environments with any content, indistinguishable in their impact on the human senses from physical reality, which largely contributes to making the right decision in any production process. Despite the technological advances, the decision is still made by a person, so we consider the navigator as one of the main participant of the marine ergatic system.

3. The navigator as the main component of the marine ergatic system

The peculiarity of the current moment in modern shipping is that information technologies (IT) are beginning to intensively penetrate in the shipping and the port infrastructure. However, despite the introduction of new technical means of navigation, the issue of the "human element" remains important. The most promising direction of using IT to solve the above issue is the above-mentioned concept of E-Navigation, which involves the use of modern technologies of artificial intelligence (AI) and augmented reality (AR), for example, in case of the intellectualization of the user interface. The correct use of artificial intelligence and augmented reality will allow to reach a new level of interaction of a human operator (navigator) with navigation data in a digital environment. But to improve the interaction of the user of E-Navigation with the data of the digital environment, an intelligent interface in a mixed reality environment is needed, by means of which the navigator will intuitively receive aggregated information with a large thesaurus to prepare for decision-making. To implement the concept of «human-environment» interaction, the user of E-Navigation will need to work with Big Data, where the most suitable data transfer technologies for implementing human-operator interaction with data in the augmented reality environment are wireless technologies that ensure the mobility of both users and network nodes, as well as the reliability and trustiness of data transmission. Currently, there is a trend of increasing the amount of navigation information and reducing the number of crew members on a modern merchant ship. At the same time, for a long time, the displays of technical means of navigation remain the means of displaying information for the human operator. As a result, the navigator has to constantly distract himself from monitoring the current navigation situation (the control zone) in order to analyze and compare the data of the real environment with the data displayed on the screens of navigation devices. It is obvious that the value of human operator (navigator) error is constantly growing, and, consequently, it is the navigator who needs an intelligent user interface. In this regard, it is advisable to use the «human-oriented interface» methodology, which includes the definition of the information environment that contributes to the implementation of the idea of an information approach in relation to marine intelligent systems and the development of an information standard that provides the necessary conditions for the processing of a new type of information and the development of a regulatory framework that allows the use of this concept on convention ships.

The need to introduce additional useful information into the field of perception of the human operator (navigator) was expressed by various scientists who were engaged in the analysis of emergency situations in maritime transport. For example, according to Russian scientists, one of the causes for the incorrect interpretation of SARP information by navigators is the lack of information about the nature of the manoeuvrability [10]. Therefore, there is a need to introduce more useful (from the point of view of navigation safety) information into the field of perception. This task is solved in an augmented reality (AR) environment, where the information of the virtual world (digital) is imposed on the picture of the real world (analog information). In this regard, the human operator (navigator) has an informational advantage due to the fact that digital information contains more data than analog information. Much technical means of navigation (ARPA, SARP, ECDIS, AIS, and others) on board of a modern ship causes a gap between the psychophysiological capabilities of a human operator (navigator) and a constantly increasing amount of information that needs to be processed in a short time to make the right decisions in various situations. The processing of information received by the navigator is a complex process [3; 4; 8; 9; 10; 11]. Therefore, the use of the above-mentioned technical means of navigation will give the expected effect only if the volume and nature of the information received by the human operator are consistent with his psychophysiological capabilities.

Effective use of information is possible only if its processing is automated and presented to the navigator in a form that is convenient for perception and subsequent decision-making [4; 8; 9; 11]. Therefore, it is necessary to evaluate the quality of perception in the augmented reality system. The lack of generally accepted standards for the information environment of the augmented reality and methods for assessing the quality of perception of navigation data, opens up additional opportunities for finding new solutions, for example, modifying the user interface from the category "human-machine" to the category "human-mixed reality environment". However, for a human operator (navigator), as one of the elements of the marine ergatic system, the key parameter is the quality of perception – QoE (Quality of Experience).

In augmented reality systems, the user's assessment comes out on top, because it is associated with the main errors that affect the accident rate as a whole, on the one hand, and on the other, its purpose is to create a sense of the real world (believability), which is upgraded (supplemented) to improve certain characteristics of the world around us (real environment). This can be used to improve the control of a large-capacity sea ship when maneuvering in special conditions (limited visibility, sailing in ice, etc.). Thus, in the AR environment, data must be processed quickly, displayed in time, incoming signals from sensors must be transmitted without errors, and the movements of objects must be familiar to the human eye. So, it is necessary to establish a relationship between the quality of service and the quality of perception, complementing the qualitative assessment of the environment of perception and processing of information with a quantitative assessment, with the possibility of modifying the real-virtual continuum as a whole. In this context, the user interface, which is a set of programs that implement the user's dialogue with the information system at all stages of its functioning, is of particular importance. The human-machine interface used today does not guarantee the navigator an accurate interpretation of the data, and, nevertheless, it performs the function of informing. The complex activity of the navigator requires a very responsible attitude of those who provide the level of training of such specialists.

4. Training facilities with virtual and augmented reality for future and current navigators

An important place in the training of navigators belongs to simulators that simulate conditions designed for a specific situation of a certain type of activity of a human operator and carried out with the help of automated means of presenting and processing information and electronic computing equipment. Their wide application allows to save the engine life of machines, ships and devices, fuel; it permits to simulate extreme and emergency situations that can be dangerous in a real environment, and allows to acquire the skills of correct actions in critical situations that can’t be obtained on real ships, but can only be practiced on simulators [3; 4; 11; 12].

As a rule, the effectiveness of simulator training is determined by the following indicators: the effectiveness of the training methodology; quality and adequacy of the curriculum; high professional level of the instructor staff; the effectiveness of the simulator used; the entrance qualification level of the student; the quality of the organization of the educational process, etc.

In international practice, simulator training is provided by the use of two types of simulators that differ in the principle of manufacturing and execution: computer simulators based on mathematical modeling, using advanced information technologies in a mixed reality environment and model simulators that use full-scale models made in a given scale and used in real environment. The simulation and training complex of the ship's control system is a complex hardware and software complex that includes a control center, a control and managing system, a visual environment simulation system, and an acoustic noise simulation system. The development of information and communication technologies, as well as significant methodological and didactic experience in the use of technical training tools, currently requires the implementation of new types of training equipment with elements of artificial intelligence and mixed reality [3; 4; 8; 12; 13]. The visualization system of the simulation and training complex is one of the main ones. It synthesizes the image of 3 D-space on special screens, which in the surrounding environment are represented by the portholes of the navigation bridge of a seagoing vessel. The features of existing marine simulators often include: excessive complexity; incomplete accounting of psychological and cognitive characteristics of students; limited number and efficiency of tasks to be solved; insufficient didactic capabilities of simulators as technical training tools; lag in the application of the existing advantages of info-communication technologies (artificial intelligence, augmented reality, and others) in existing marine simulators [3; 11; 13; 14; 15; 16]. Working with simulators, the learner gets the opportunity to interact with objects and their data in a virtual environment, but, unfortunately, the didactic features of the activity in immersive educational environments are often ignored.

5. Immersive learning and professional environments in ergatic systems

As a rule, educational/learning environments (in this case, they are synonyms) exist in the form of cognitive models, interpretations of theoretical and practical aspects of pedagogy. In comparison with the system, the environment often involves the inclusion of heterogeneous elements of different systems, while the functional connections among them are only partially assigned. This is due to the fact that educated learning environments, as an integrative phenomenon, acquire the qualities or features of integrated systems, and give rise to their own integrative characteristics. The main purpose of learning environments is to change the behavior of the learner in order to obtain an educational effect. The same situation arises when we mean the concept of «professional environment», which is used in various contexts related to a person engaged in labor activity. A common characteristic of training and professional environments is the fact that they are relatively passive and represent a set of external and internal conditions of activity in which a person solves educational and professional tasks. However, this is not enough for designing the effective training and professional ergatic systems that implement complex forms of human relations with the world. Immersive learning environments are referred to ergatic learning environments [2; 5]. The main idea here is the modeling of complex conditions of professional activity conditions, and the more uncertain they are, the more effective the implementation of the concept of the immersive learning environment itself.

Immersive environment is created with the help of simulators widely used in the process of learning in the Maritime universities. Simulators with low and medium immersiveness (immersion effect), as a rule, show high interactivity, which indicates the ability of operators to act in the simulator environment in ways similar to those that exist in real professional activities. This approach allows operators who have been trained on simulators to feel more prepared and confident when transporting into real professional conditions. While carrying out educational activities, the student is immersed in the environment formed by virtual reality technologies, which displays artificially created conditions, but at the same time he solves purely professional tasks. The interface offered to the learner characterizes the properties and technology of human-machine communication, which not only ensures the activity of a person in a technical or training system, but also creates conditions similar to real professional ones. Taking into account the impracticability of training navigators or ship engineers on real equipment in real activities for technical, economic and psychological reasons and the widespread use of training equipment that imitates professional environments in this regard, it is also necessary to note the fact that such equipment (computer programs, simulators, etc.) is mostly created by engineering design methods, without taking into account the psychological and even more so the pedagogical components of professional and learning environments.

Great achievements in computer modeling of poly-modal environments and the introduction of virtual reality and artificial intelligence technologies in the human-machine interface systems of the modern ergatic systems also determine the interest in computer interfaces and research on the impact of environmental content on the efficiency of operators. A modern interface often has a hierarchical organization of the image, when other fragments are placed inside one image fragment, and this hierarchy changes depending on the current state. The information systems used on board a modern ship and simulated on simulators allow to consider the whole complex of relations "man-machine" (in our case – navigator-ship). This system can be represented as the interaction of two information processors: a human and a computer, trying to communicate using the interface. It is obvious that a properly designed interface does not guarantee the correct actions of the navigator. To avoid mistakes, training in immersive environments is required, allowing the operators to immerse themselves in the proposed conditions and work out the necessary skills for several times. First of all, we assume that immersive learning environments include objects that are the conditions for the existence of education. According to I.Marichev, «... education itself is an interaction consisting of actions, and actions are distinguished by a set of features that appear in the structure of their logical connections» [17]. The consideration of the essential organizational educational actions in the learning immersive environment on the basis of educational activity of the involved parties, suggests the consideration of two groups. The first group includes the conditions for performing the leading action by an Educator, including the presence of the Educator; the presence of the trainee and the object of study; the availability of educational aids; the availability of organizational conditions for guidance; the availability of opportunities for evaluating results.

The second group assumes the presence of conditions for the implementation of the decisive action by the trainee, including: the presence of the trainee; the availability of opportunities to accept information; the presence of the object of study; the availability of tools for transforming the object of study and opportunities to identify changes in it; the availability of opportunities for correct evaluation of the results of actions. It is important to remember that always in any educational situation, the leading participant is the Educator, who uses the conditions available in the space to perform the actions of directing the trainee to actions which ensure the appearance and development of the necessary traits and personality qualities provided for by the program, the set goal, etc. [12;13; 17].

A special place in this system is given to feedback, which exists within any managed system. Issues concerning feedback have long been the focus of attention of different scientists and different sciences. We fully agree with the position of N.Wiener, according to whom «... feedback is a method of controlling the system by means of including in it the results of the previous performance of its tasks. If these results are used simply as digital data for the calculation of the system and its regulation, then we have a simple feedback carried out by the operator. However, if the information received is considered as a result of the performing or not performing tasks by machine and it is able to change the general method and form of performing tasks, then we get a process that can be called the learning process» [18, 68]. Taking into account the above said, we can assert that information exchange is not only an opportunity to receive a message from outside, but also an opportunity to influence the circumstances. And the more useful information, the more effective the decision made by the operator.

In the arrangement of training and professional immersive environments for the training of future navigators, we rely on the approach worked out by E.Malinochka, who developed a system for providing training with automated feedback, consisting of organizational, methodological and technical support. The feedback in the learning process, according to the scientist, is that its intermediate results affect its process, the fulfilment of the actions of learning, teaching and studying. Automation of feedback consists in connecting technical tools for accepting formalized information about intermediate results of activity and issuing signals that are estimation of these results [19]. The above mentioned statement helps to understand that the widespread use of immersive learning environments is based on the results of research in the field of virtual environments impact on learning effectiveness. The creation of a presence effect, the possibility of interactive and social interaction, as well as multisensory, affect the effectiveness of training.

At the same time, it is necessary to take into account the influence of the created conditions on the cognitive processes and the emotional state of a student. And, in this case, the achievement of the result can be arguable one, e.g. a high level of cognitive pressure affects the degree of multisensory and interactivity, causing stress (dizziness, increased blood pressure and heart rate, general discomfort, fatigue, difficulty concentrating and blurred vision, etc.), so it (the level) should be justified and clearly defined. Otherwise, ignoring the fact of limited cognitive processing capabilities, and therefore an excess of sensory stimuli or distractions, can negatively affect learning outcomes. Consequently, an immersive environment with a high level of immersion can increase extraneous cognitive pressure and lead to a negative effect.
The speed at which changes in maritime industry have taken place over the past few years is too high. The same is true of the nature of these changes [20; 21; 22]. In this context, it is quite appropriate and natural to prepare a specialist to work in one of the most complex ergatic systems, it is necessary to pay great attention to training immersive environments that allow to simulate future professional conditions and form professional qualities that can be transferred to real activities.

6. Conclusion

The importance of intellectual support for the user of the E-Navigation marine ergatic system based on the information approach is stipulated for the current state of the shipping industry, including, among other things, the spread of E-Navigation, which supposes improvement and increasing of traditional aids in shipping by means of human and machines opportunities integration. The use of high-tech technologies, a high level of automation, and intensive implementation of information technologies in all areas of the industry, including management, requires the presence of competent specialists who can serve it. Despite the complexity of the information technologies implemented in the industry, the prerogative of solving tasks remains with the human operator. In this regard, presented in the paper ideas on the designing the user interface, which provides not only the efficiency of the user's work, but also stimulates his personal and intellectual development due to informativeness and ergonomics, can be considered by educators. This paper covers the pedagogy and research based foundation of immersive educational environments, new opportunities to engage students in the learning process that in result can transfer the maritime education on a higher level.

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Interdisciplinary Development of Maritime Education and Training Orienting to Career Planning in the era of Artificial Intelligence

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Abstract

Artificial intelligence (AI) potential impact on the future of maritime transportation has been extensively discussed in recent years, increased autonomy of the shipping industry is inevitable. This study investigated maritime students' and educators' perception of the impact of AI influence, and explore how to optimize the maritime education and training (MET) curriculum to increase their lifelong career ability. Traditional MET focuses on the specific equipment operation and convention-required certificate examination, the result of market demand-oriented is the training institutions only pay attention to the seafarer's ship operating ability and seamanship experience, which brings challenges to the seafarer's lifelong career planning. The investigation results show that the AI-influenced MET curriculum requires multi-disciplinary integration, keeping the overall difficulty and curriculum intension significant to keep student study willing. The training schools, academic institutions, policy-making institutions, and international regulations-making institutions need to achieve unified coordination to deal with these challenges.

Keywords

Maritime education and training (MET); Interdisciplinary collaboration; Seafarers career; Intelligent ship navigation; Demand-oriented.

1. Introduction

The information technology and intelligent development have changed the operation mode and direction of many industries. Traditional maritime shipping industry also has gradually been advanced from digitization and informatization to intelligence [1]. E-navigation has been advancing for ten years, for safe ship navigation, a number of sensors have been deployed, a large of digital data can be storing and mining. Data is the energy source for the advancement of AI. With the accumulation of database scale, the enhancement of computing power, and the improvement of machine learning algorithms, shore-based long-distance monitoring and unmanned control will become possible, related service training and professional skill seafarer education will become a new trend. In the era of AI, the interaction mode of traditional shipping elements will be subverted. Market demand-oriented MET will also face new challenges [2]. The comprehensive talent of the seafarers will be required. In particular, the number of shore-based seafarer with professional skills which has maritime background will be significantly increased [3]. With the automation level of Maritime Autonomous Surface Ships (MASS) continuously being improved over the next two decades, the current MET curriculum cannot equip marine engineers and seafarers with adequate skills and knowledge to meet the needs for future intelligent shipping. Therefore, the maritime education system and training model need to be systematically reformed [4].

In 1967, the Maritime Safety Committee (MSC) of the International Maritime Organization (IMO) issued Circular No. 37 entitled "Ship Automation"; in 2018, the MSC provided some achievements on the regulatory scoping work for MASS. Indeed, intelligent ship navigation can reduce the number of maritime accidents caused by human error, reduce the number of casualties, carbon emissions; saving seafarers space, energy, and some other operating costs [5]. The goal of the International Association of Maritime Universities (IAMU) is to make tangible contributions to the international maritime community through the education and training of top-notch maritime personnel and by conducting academic research activities in maritime safety [6]. In the era of AI, IAMU and the members of maritime universities should drive and guide this reform and innovation through interdisciplinary collaboration and education institution differentiation. At present, providing the maritime certificates of competency is the main purpose of MET [7]. The curriculum has been developed focusing on ship manipulation, navigation aid devices operation, and the relevant international conventions [8]. Uniformed evaluation standards and training systems have led to a narrow career development path for seafarers, and increased homogeneity competition. Hence, maritime universities should take the development of smart ships and intelligent shipping as the main line, promote the deep integration between maritime education, cutting-edge technology and industry development, redesign the MET framework [9]. A multi-level maritime training model, from junior college, undergraduate, master to doctor degree, would be preferred to meet the future needs.

From the view of educator, interdisciplinary collaboration is required for maritime education and seafarer’s career planning in the era of artificial intelligence. The new format of intelligent shipping means that MET teachers need to integrate multiple disciplines, especially the in-depth integration of information technology, artificial intelligence and traditional maritime transportation engineering. Smart ship and intelligent shipping demand more sophisticated requirements and skills of ship manipulation, management, operation and maintenance. The teacher with other different professional backgrounds will play crucial roles in the MET.

From the view of seafarer, institutional differentiation is a useful way to realize the differentiation of seafarer’s career planning. The traditional competency of the seafarer will be transformed into a new professional model of shore-based monitoring and ship-shore interaction. The traditional training and certification standards for maritime talents divided by the attributes of the deck department and the engineering department will be changed. The intelligent transformation of the shipping industry will be able to place high-quality maritime talents in more wider fields, such as maritime finance, insurance, law, ship management, and maritime administration. For intelligent shipping, the functional settings included: intelligent navigation, intelligent ship architecture, intelligent engine room, intelligent energy efficiency management, intelligent cargo management, intelligent ship control, and intelligent integration platform, closely focus on the maritime industry chain, implement the training and differentiate development of navigation and shipping talents, make sure varied career directions of seafarer have good development prospects [10].

2. Materials and methods

2.1 related work

We demonstrate the detail of research progress and development direction of the shipping industry in the era of AI, including review the latest developments of computer vision, human-computer interaction, path planning, autonomous decision-making, and control. Identify the gap between the current developing situation and the possible development direction in the near future. How to step by step approach to achieve the goals from the technical perspective. As shown in figure 1, the whole survey map can be separated into three different modules. User interaction module including shore-based surveillance (shipping company, whole related administrations) and all possible communication (satellite, shore to ship, and ship to ship). Ship navigation module including ship bridge navigation, engine room support, and cargo & ship hull maintenance. Environmental sensing module including data platform construction and sensors data fusion. The top priority of

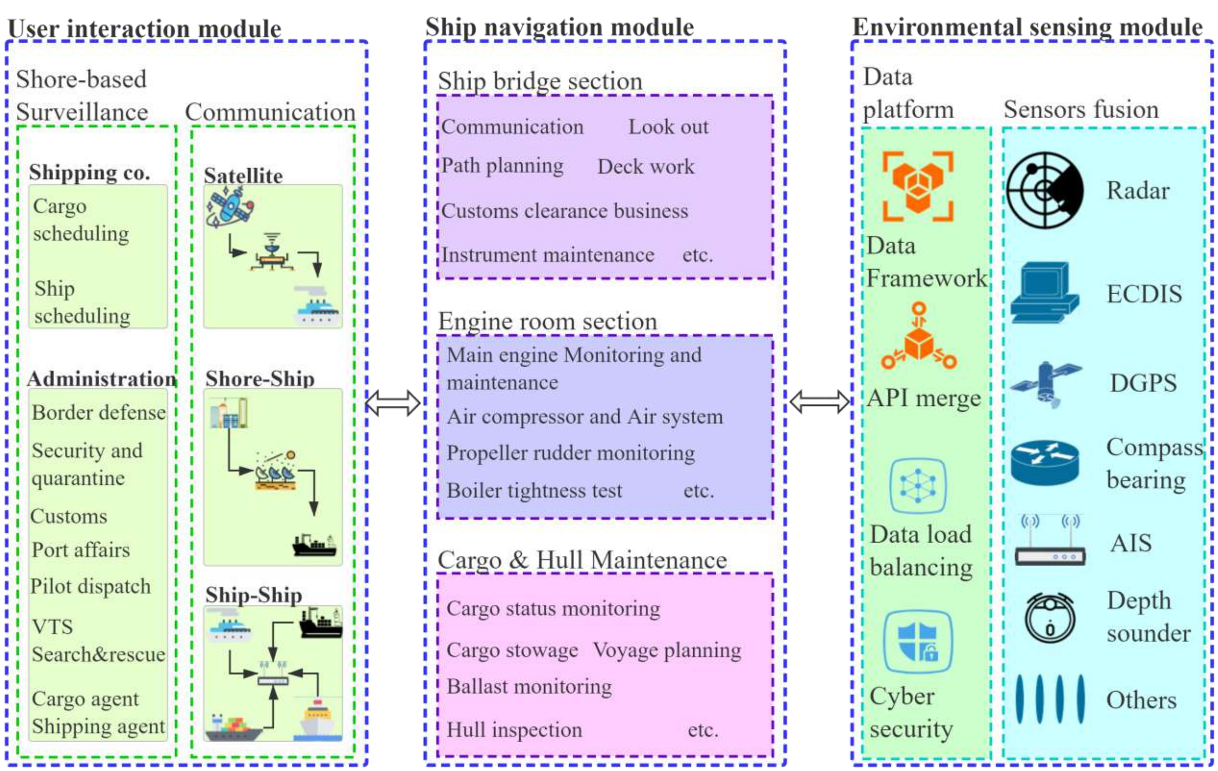

Figure 1. The elements of ship navigation and shipping business.

the project is to figure out the relationship between different modules and their involved disciplines, illustrate every potential new technology into different specific sections, evaluate its automation level, and find out the approach of complete autonomous operation without human involvement. For example, for path planning of the ship bridge section, in the past, we had to manually set a waypoint on the chart. For the unmanned ship bridge, we have to consider the way to achieve all possible waypoints based on the user interaction module and environmental sensing module information. The task will define the interdisciplinary relationship and its direction of automation.

At present, these three modules all can't be fully unmanned, and they involve different subject knowledge. If ships are truly unmanned, the maritime talents to be cultivated will need to have a good knowledge base. This means students will face more difficult and stressful courses in the future. In the next, we will conduct a survey on students to understand their thinking. Then in the context of smart ships, exploring to design curriculums that can enhance the student's lifelong professional abilities and student can accept.

2.2 Survey design

The aim of this study is to investigate the current MET curriculum, navigation knowledge and skill gaps for manipulating different level intelligent ships. Three key stakeholders: maritime education institution, educator, and seafarer should be considered in the survey questionnaire design. We explore and identify a series of new elective courses which highlight the interdisciplinary collaboration and institutional differentiation for seafarer lifelong career development in the era of AI. Before design our survey, we provided four questions for clarify our objective:

(1) Does the current curriculum of MET provide seafarer's knowledge and skills for careers planning in the future?

(2) With the increase of automation level, how to enhance the seafarer's ability to adjust lifelong careers planning?

(3) According to different levels of intelligence ships, what kind of navigation competency skills need to be acquired?

(4) To adapt to this upcoming change, how to re-design the MET curriculum to achieve the best interdisciplinary integration?

At present, we designed two questionnaires for maritime students and maritime educators, in March 2021, an anonymous online survey was distributed to students at Dalian Maritime University. We divided the students into three categories according to the type of work: on-board majors (navigation technology, engine technology, etc.), maritime-related majors and others. As shown in figure 2, we use a fishbone diagram to sort out the influence factors of the work onboard willingness, according to the five elements of "people, event, time, place, and things", find out all possible elements. Based on the survey design, we summarized the influence factors of the seafarers' career planning fishbone diagram as follows.

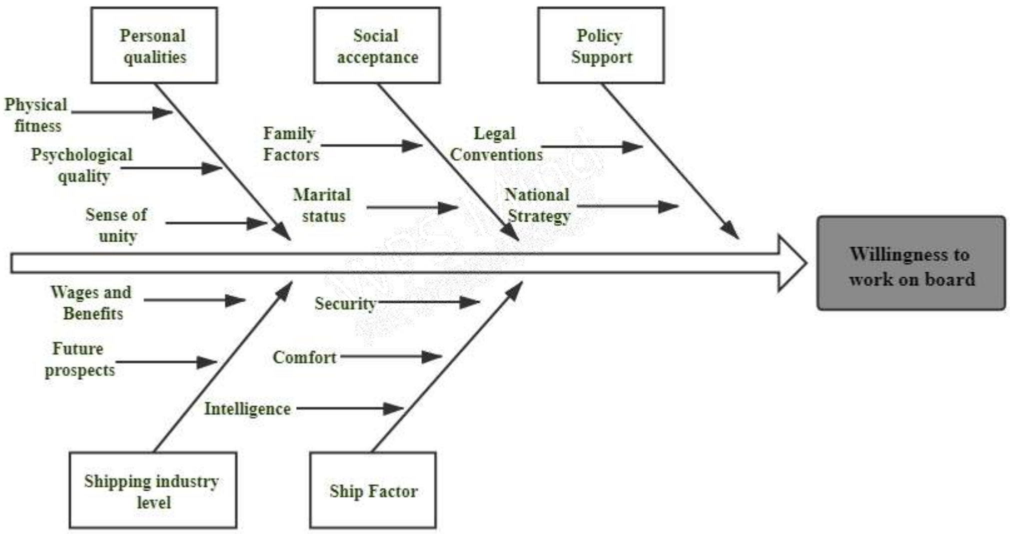

Figure 2. Analysis chart of willingness to work on board

3. Data analysis

3.1 Students state analysis

Among 266 student respondents and 43 educator respondents, we use a fishbone diagram to analyze three factors that might influence maritime students to work onboard: social recognition; salary and company brand. Chi-square test have been used to analyze the differences between these three factors. For the statistical inference of large categorical data, the chi-square test has the advantage of convenient and simple than the T-test. The analysis results shown as table 1.

Table 1: The distribution of seafarers' salary satisfaction among different majors.

Title	Options	Professional category			Proportion	χ^2	*p*
		on-board majors	maritime-related majors	others			
Salary	Very satisfied	10.64%	9.09%	21.82%	15.93%	9.376	0.154
	Fairly satisfied	51.06%	36.36%	60.00%	53.98%		
	Less satisfied	23.40%	36.36%	10.91%	18.58%		
	Dissatisfied	14.89%	18.18%	7.27%	11.50%		

As shown in table 1, maritime-related major students have less rate of salary satisfaction. Other major students have higher satisfaction level than on-board major students and maritime-related major students. However, the satisfaction of the seafarers' salary does not show significant difference for the three categories (if the probability p>0.05, it means no significant difference).

Table 2: The distribution of seafarers' social recognition among different majors.

Title	Options	Professional category			Proportion	χ^2	*p*
		on-board majors	maritime-related majors	others			
Social Recognition	Very Recognized	14.89%	0.00%	30.91%	21.24%	26.294	0.000**
	Basically recognized	31.91%	72.73%	54.55%	46.90%		
	Not very much	51.06%	18.18%	14.55%	30.09%		
	Not Recognized	2.13%	9.09%	0.00%	1.77%		

Table 3: The distribution of seafarers' company brand among different majors.

Title	Options	Professional category			Proportion	χ^2	*p*
		on-board majors	maritime-related majors	others			
company brand	Salary	65.96%	54.55%	47.27%	55.75%	24.051	0.007**
	Business Scope	6.38%	0.00%	18.18%	11.50%		
	Promotion Speed	10.64%	18.18%	1.82%	7.08%		
	Promotion Space	12.77%	27.27%	7.27%	11.50%		
	Ship condition	2.13%	0.00%	14.55%	7.96%		
	Other	2.13%	0.00%	10.91%	6.19%		

As shown in table 2 and 3, both the probabilities less than 0.05, it means the social recognition and company brand self-identity of seafarers showed a significant difference (chi=26.294, p=0.000<0.01). A significant difference analysis shows that seafarer’s social recognition is less than other careers.

Table 4: Different majors' views on unmanned ships.

Title	Options	Proportion	χ^2	p
The realization of ocean-going unmanned ships navigation	Must	29.20%	2.631	0.854
	Possible	58.41%		
	Impossible	4.42%		
	Uncertain	7.96%		
Development directions	Human involvement	50.44%	9.084	0.059
	Remote control	37.17%		
	Autonomous driving	12.39%		
Current difficulties	Unfilled and other	12.38%	15.365	0.222
	International rules	19.47%		
	Autonomous decision making	19.47%		
	Port construction	5.31%		
	Cabin Watch	17.70%		
	Information Perception	25.66%		

Table 4 shows that on-board majors, maritime-related majors and other major students have different views on the factors that affect the willingness of marine students to work on board. We use the chi-square test (cross analysis) to analyze the major categories for unmanned ships navigation. The intelligent shipping realization, development directions and current difficulties are the three significant differences.

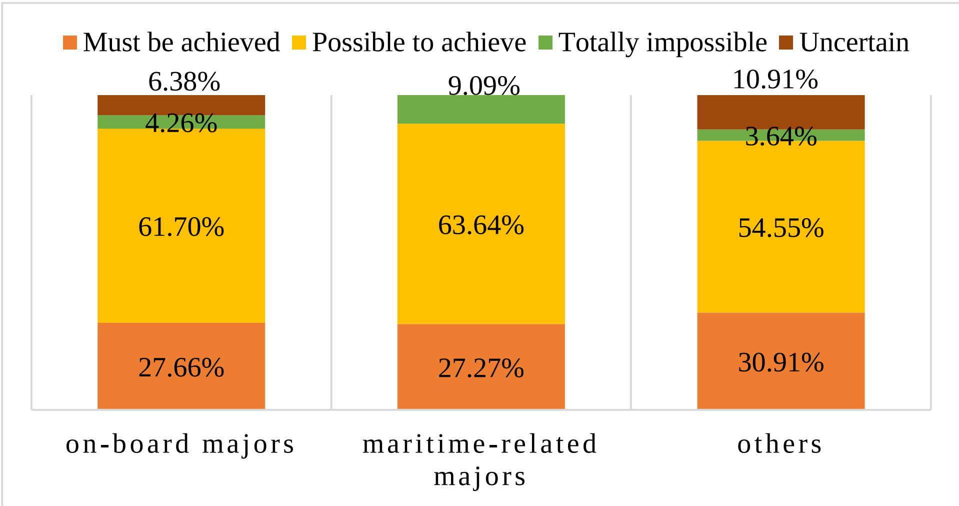

Figure 3. Unmanned ships implementation attitudes from the different majors' students

As shown in Figure 3, it is not difficult to find that the three different major categories hold a cautious attitude towards unmanned ships navigation. There are 61.7% (on-board majors), 63.64% (maritime-related majors), and 54.55% (other majors). It is believed that full unmanned ships navigation may be realized in the future. As shown in figure 4, there are also different opinions on the unmanned level can be approach: It is generally believed that ocean-going ships require human participation or remote-control. 87.23% from on-board major students, 100% from maritime-related major students, 85.25% from other major students.

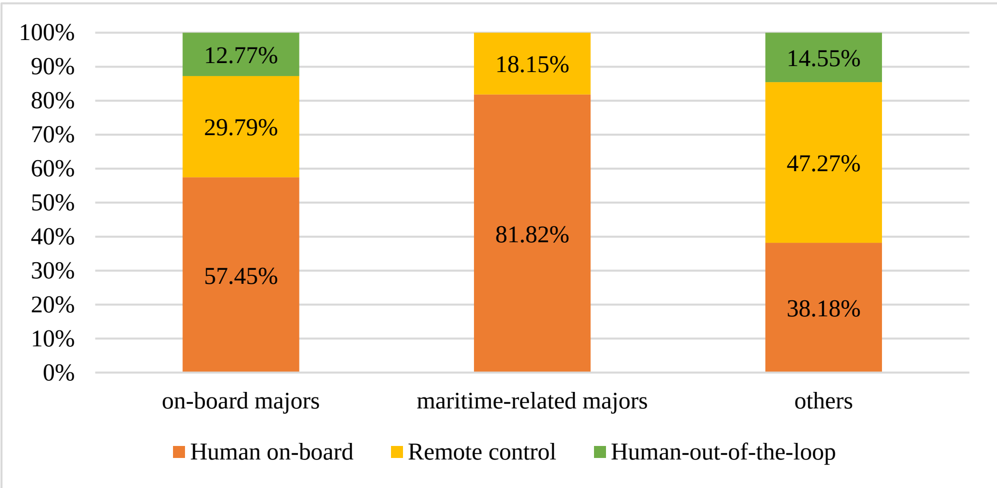

Figure 4. Intelligent shipping industry attitudes from the different majors' students

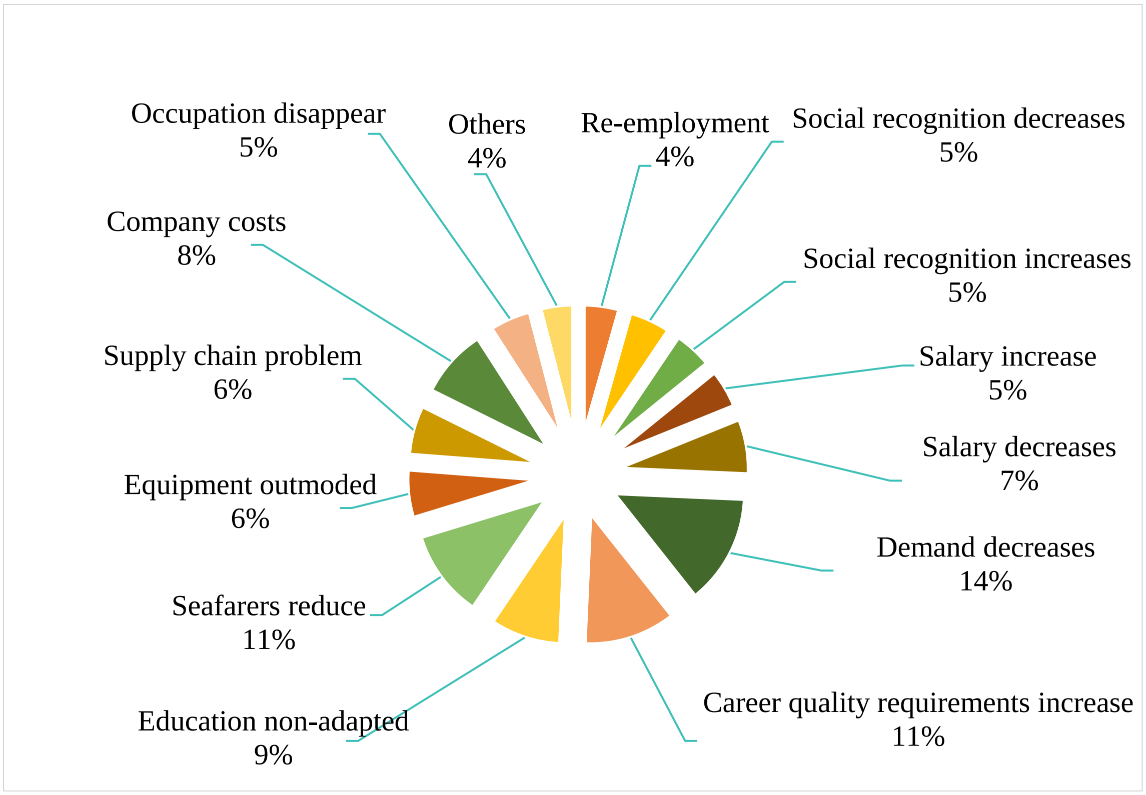

Figure 5. Response rate of the current problems and intelligent shipping

As shown in Figure 5, for the distribution of multiple-choice questions, the chi-square goodness-of-fit test was used for analysis, and response rate can be calculated by this element. The goodness-of-fit test showed significant difference (chi=94.958, p=0.000<0.05), it means that the selection ratio of each item is obviously different.

3.2 Educators state analysis

First, we validated the effectiveness of the research data. Ignore the correspondence between the dimensions and the analyzed items, the variance interpretation rate and other factors, Kaiser-Meyer-Olkin (KMO) test used to analyze the reasonable and meaningful of the collected data. The KMO value is 0.773, which is between 0.7 ~ 0.8, and the validity of the research data is Acceptable.

Table 5: Kaiser-Meyer-Olkin (KMO) test, effectiveness analysis

KMO & Bartlett test		
KMO value		0.773
Bartlett sphericity check	Approximate cardinality	67.024
	df	10
	p value	0

As shown in table 6, multi-categorical logit regression used to analyze the effect of X on Y. The Y value is the student's willingness to learn, and the X value is the relevance of course category, course difficulty, and future development. Take the very high willingness to learn near 1.0 as a reference, X has a total of 3 items and 1.0 as the reference comparison item, the final model formula as follows:

ln(2.0/1.0) = -1.437 + 0.672*course category - 0.302*3 course difficulty + 1.080*6 future development correlation.

ln(3.0/1.0) = -7.751 + 0.455*course category + 2.175*3course difficulty + 0.974*6 future development correlation.

The regression coefficient value for course difficulty is 2.175 and shows a significance at the 0.05 level (z=1.971, p=0.049<0.05), implying that high course difficulty has a significant positive effect relationship on high willingness to learn. The difficulty of intelligent ships knowledge such as artificial intelligence is higher than current MET curriculum. It should be considered how to integrate existing MET courses without increasing either the academic burden or the difficulty of the course for students is a big challenge.

Table 6. Results of multi-categorical logistic regression analysis.

	independent variables	Non-independent variables
X1: Course category	0.672	0.455
	-0.79	-0.405
X2: Course difficulty	-0.302	2.175*
	(-0.481)	-1.971
X3: Future development correlation	1.08	0.974
	-1.554	-1.064
Intercept	-1.437	-7.751**
	(-0.976)	(-2.837)
Likelihood ratio test	$\chi^2(6)=16.942, p=0.009$	

Y: Dependent variable: willingness to learn

McFadden R-squared: 0.211

Cox & Snell R-squared：0.332

Nagelkerke R-squared：0.390

* p<0.05 ** p<0.01 z-values in parentheses

4. Results

To discuss how AI could potentially affect future shipping industry, interdisciplinary collaboration as the core must be discussed. In the era of AI, the education of maritime students will not just be limited on ship bridge and engine operation, meanwhile, new disciplines will be added, unnecessary courses will be reduced. Through analyzing the interviews and questionnaires, we obtained the following consequences.

1) Consensus: the shipping industry will undergo a great change under the influence of AI.

2) Interview & investigation: the development of intelligent ships will affect the seafarer occupation, which may decrease in quantity and will increase in required quality. Most of the seafarers trained by current MET institutions have specialized technical skills, but lack many intelligent-related abilities. For example, the deck department has limited understanding of the engine department, while the engine department is not familiar with the bridge operation. Furthermore, seafarers will not be limited to the current division in the era of AI.

3) MET curriculum: MET courses outdated. Under the current MET system, related institutions have many resistances to make changes, the current MET curriculum has not been adapted to the development of intelligent shipping. Artificial intelligence courses are difficult to integrate into existing MET courses without increasing the amount of learning.

5. Discussion

The influence of AI requires two aspects to improve the current MET system: curriculum design and career orientation.

5.1 Curriculum design

The curriculum setting should correspond with the status quo of smart shipping, equip the educated seafarers with sufficient adaptability to the new shipping technology, and enable them to have the ability to engage in industries other than the shipping industry only. Currently, numbers of maritime education institutions still apply textbooks in the old version and curriculum syllabuses fail to keep pace with shipping industry trends, making it the trained seafarers hard to apply their expertise into use in many aspects. Meanwhile, we obtained that the difficulty of courses is an important influencing factor in learning willingness. Therefore, the curriculum setting should expurgate the superfluous courses, set up compulsory courses, to avoid pushing too hard on students. The specific measures are summarized as follows:

1) Heightening the frequency for textbook updating to reduce problems caused by textbook lag among the educated.

2) Increasing curriculum diversity, adding diversified compulsory and optional courses, such as AI-related and Electronic Information Basic Courses, for the potential technology updating and the competitiveness for seafarer’s reemployment.

3) Sifting out and expurgating courses which are unfit for seafarer training and lagging in smart shipping development to reduce seafarers’ pressure.

4) Offering more AI-related lectures, popularizing artificial intelligence knowledge, and uploading intelligent transportation public courses.

5.2 Career orientation

The current MET training program was formed under a long historical experience, although there is a certain lag, its professionalism and importance are still unquestionable. However, increased autonomy of the shipping industry is inevitable, our work should consider beyond the current MET system, not just focus on the certificate, but also the seafarers' career development.

1) Gradually blur the boundaries of disciplines and cultivate integrated talents. Comprehensive talents will better adapt to the ever-changing shipping industry, be more capable of more shipping jobs, and have higher competitiveness in the industry.

2) Update current discipline and incorporate new disciplines, cultivate new types of technical personnel. As intelligent shipping develops rapidly, the demand for technical talents in the

shipping industry is certain to increase. Cultivating talents with mastery in new tech will fill the talent gap and instill momentum for shipping-tech development.

3) Encourage learning outside of training and cultivate adaptable talents. Laying too much emphasis on specialized instruction may lessen seafarers' vocational adaptability. Therefore, cultivating seafarers with multiple skills and capabilities is necessary. Adaptive personnel also possess better re-employability.

6. Conclusion

AI will large-scale change the current shipping model. The career planning of seafarers needs to consider the impact of AI technology, and the development of intelligent ships will affect the seafarer occupation, which may decrease in quantity and increase the quality of the marine-related seafarer. This study investigates the maritime students and educators, the results of the investigation and SPSS analysis show that the AI-influenced MET curriculum must be updated, keep the overall difficulty and curriculum intension is a big challenge for students absorbing the newest AI-related MET courses.

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Measuring Situation Awareness in Engine Control Operation

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Abstract

Situation awareness (SA) as a framework to understand operator's behavior in doing work has been implemented well as theoretical and application in various work environments, including maritime operation. However, most SA studies in maritime operation only covered the work on the bridge and focused on the theoretical construction rather than the empirical studies. To fill the gap in the literature, this study aims to measure SA, especially in engine control operation. Two scenarios were built using the high-fidelity engine plant simulator: ocean-going scenario and entering port scenario. Students (N = 16) recruited as the participants were divided into two groups by their sea training experience. Two measurement types were used to examine the SA during each scenario: subjective measurement using the questionnaire and objective measurement using the freeze-probe technique. Also, the workload was examined using well-known workload subjective measurement. The result showed two scenarios successfully made different perceived workload; the entering port scenario was perceived with a higher workload than the ocean-going scenario. In contrast with the workload, SA was perceived higher in the ocean-going scenario than in the entering port scenario. Moreover, with the freeze-probe technique as the objective measurement, although all participants achieved the same degree in achieving the SA level 1 (perception), the participants with more extended sea training experience have higher sensitivity in achieving SA level 2 (comprehension). In summary, while the subjective measurement can only discriminate between different workloads, the objective measurement can also discriminate the level of the participant's experience. These measurement methods are beneficial for examining the non-technical skill in maritime education and training to support the cadet in recent and future work environments.

Keywords: engine control, situation awareness, workload

Introduction

SA is already known as the concept in the research literature and the seafarer's importance aspect in their work [1]. The issue of SA in maritime operations was amplified by the fact that

71% of human error in maritime operations is caused by SA failure [2]. It is supported by a statement that said the crew resources management in maritime operation is influenced by fatigue, SA, and communication [3]. To counter this issue, IMO has already included the non-technical skill into STCW by applying bridge resources management and engine resources management, where the additional point is to obtain and maintain SA [4].

SA is already known to construct human performance, besides the workload, task performance, user experience, and physiological-based measurement. Endsley defines the SA as the perception of elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status shortly [5]. By this definition, the SA is divided into three levels: perception (level 1), comprehension (level 2), and projection (level 3). This breakdown into three levels is not rigid and can be interpreted based on each work environment.

Have a good SA is a supplement to maintain a safe engineering watch for operators. Work at engine control relies on the extended vigilance task, where the portion of the operator's work in the engine control room increases as the automation puts more remotely equipment [6,7]. With the top-down sampling mechanism in engine control operation, effective monitoring tasks in process control rely on the correct and comprehensive understanding of the process parameters. By this background, the process parameter, either it digital or analog, are essential for operators to make a comprehensive overview of the process state [8]. Monitoring the parameters in engine control operation can be divided into two types: the context-sensitive, where the parameters are observed based on the overall operation state, and the fault-sensitive, where the parameters are observed based on the fault that occurred during the monitoring [9].

Several studies have been conducted to examining SA in maritime work experiments. Pazouki et al. conducted an experiment using the autopilot malfunction condition; the SA was measured when participants recognized the wrong decision of this autopilot [10]. The training effect in collision avoidance was examined by Okazaki and Nishizaki; in achieving SA, the participants need to recognize how many vessels can lead to a collision [11]. Moreover, SA was included when evaluating the Integrated Navigation System compare with the traditional bridge layout in a study by Motz et al. [12].

Literature shows the SA studies in maritime operation are very few, and most exist studies specifically examine the SA for navigation work. Thus, the recent study aims to fill the gap by examining the SA in the engine control operation environment. Through an experimental study by applying several measurement methods, the interaction between SA and the workload, also participant experience has been examined.

Method

We invited 16 undergraduate and graduate students from the marine engineering department, with an average age of 22.18 (±0.98). The recruitment was based on their training ship cadet experience. The participants were evenly divided into Group A with one month of experience and Group B with three months of experience. They have equally baseline knowledge and experience using the engine plant simulator. The recruitment and experiment procedures were under the code ethic that was proved by the faculty board. Every participant was given informed consent.

Quasi-experiment using the full-mission engine plant simulator was conducted. Two levels of scenario as within-subject variables were constructed: ocean-going scenario and entering port scenario. It aims to construct the actual engine control operation work and examine the interaction between different workload conditions with the SA. The entering-port scenario was designed to have a high task-load by mandating the participants to follow the standby engine procedure. The scenarios were made by applying the simulator function to record and replay the scenario. It prevents the process value of engine control operation changes by participation action during the experiment. Moreover, it able to create the condition where the participants deal with the same exposure and timeline of the scenario.

Figure 1. Experiment setup: a participant faced the engine control console during the scenario

Participants have to come to the simulator three times on different days. The first day was for a briefing and explanation about the experiment's aim and setup, proceed by standby engine procedure training. Within at least one day separate, the participants joined the first-time participation with two different scenarios (trials). After that, within at least six days separate, the participants joined the second-time participation, also with two different scenarios. In summary, three independent variables were included in this experiment: scenarios (ocean-going and entering port), participations (first-time and second-time), and experiences (Group A and Group B).

We employed the NASA Task-Load Index (NASA-TLX) [13] as the subjective measurement to measure workload. The six dimensions of the questionnaire in Table 1 were asked to the participants by 20-point Likert scale, ranging from low to high regarding each dimension. The total workload can calculate by summing up all dimensions after weighing with multiple comparisons of each dimension. The participants fill this questionnaire after finishing each trial in the experiment. Therefore, we collected four results from each participant.

Table 1. NASA-TLX dimensions and questions

Dimension	Question
Mental Demand	How mentally demanding was the task
Physical Demand	How physically demanding was the task
Temporal demand	How hurried or rushed was the pace of the task
Performance	How successful were you in accomplishing what you were asked to?
Effort	How hard did you have to work to accomplish your level of performance?
Frustration	How insecure, discouraged, irritated, stressed, and annoyed were you?

Table 2. SART dimensions and questions

Dimension	Question
Demands on attentional resources (D)	
Instability of situation	How changeable is the situation
Variability of situation	How many variables are changing within the situation?
Complexity of situation	How complicated is the situation?
Supply of attentional resources (S)	
Arousal	How aroused are you in the situation?
Spare mental capacity	How much mental capacity do you spare in the situation?
Concentration	How much are you concentrating on the situation?
Division of attention	How much is your attention divided in the situation?
Understanding of situation (U)	
Information quantity	How much information have you gained about the situation?
Information quality	How good information have you been accessible and usable?
Familiarity	How familiar are you with the situation?

Situation Awareness Rating Technique (SART) [14] was applied to examine the SA using subjective measurement, as shown in Table 2. Ten dimensions are categorized into three categories: demand on attentional resources (D), supply on attentional resources (S), and understanding of situation (U). 7-point Likert-type scale was employed for every dimension, ranging from low to high. The subjective SA was then calculated by eliminating the total understanding with the difference between attentional demand and attentional supply. Similar to subjective workload, subjective situation awareness was also probed after each trial was finished. In total, there were four results from each participant.

For the objective situation awareness, we modified the freeze-probe technique derived from SAGAT [5]. Although it has demerits, such as intrusive, it has the advantage of being objective and direct. Three times simulator freeze were introduced during the scenario to probe several questions regarding the operation condition. While answering the questions, the simulator was paused and participants did not face the engine control console. For each simulator freeze, there were 8 questions evenly consist of SA level 1 and SA level 2. The sample of questions is shown in Table 3. To discriminate, SA level 1 questions came from the existing parameters on the engine control console. While the parameters in SA level 2 questions were not. However, the participant can answer it by considering the existing parameter. There were three multiple choices for each question: decreasing, steady, and increasing. In total, there are 24 questions for one scenario or trial. These 24 questions have an even ratio between noise (the parameter is steady) and signal (the parameter is decreasing or increasing). To analyze the answer, signal detection theory (SDT) [15] was applied.

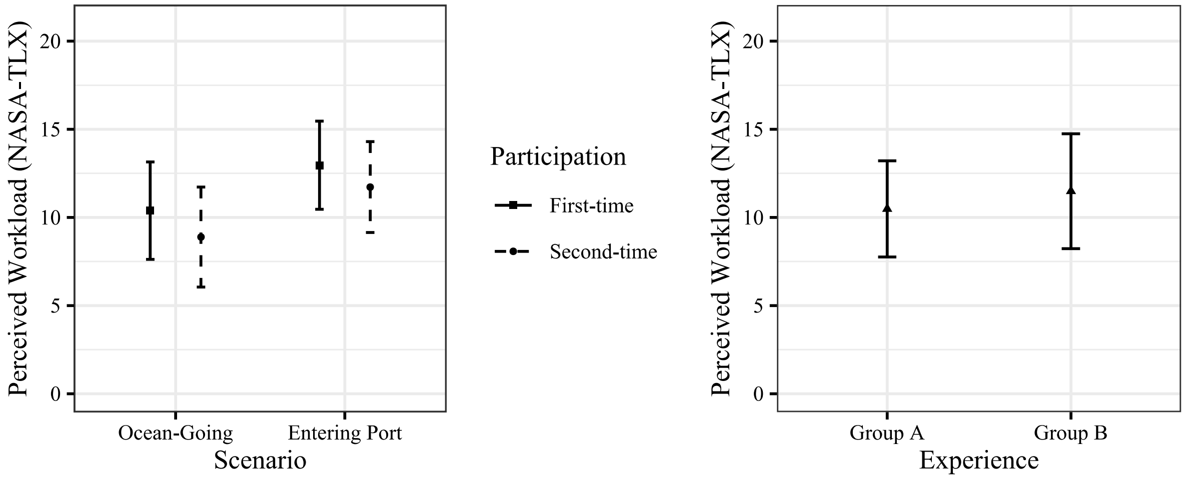
Table 3. Sample of Freeze-Probe Question

Level	Question
1	In comparison with the past, how was FO INLET TEMPERATURE developed?
2	In comparison with the past, how was FO INLET VISCOSITY developed?
1	In comparison with the past, how was CENTRAL CFW PUMP INLET TEMPERATURE developed?
2	In comparison with the past, how was M/E AIR COOLER 1 INLET TEMPERATURE developed?

Result

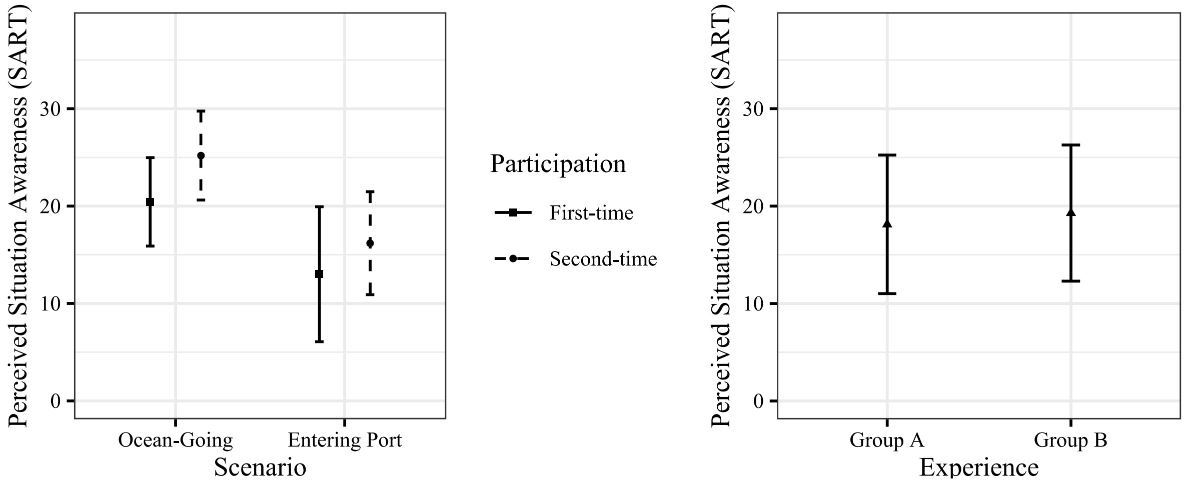
Two-way mixed ANOVA was used to compare the perceived workload measured using NASA-TLX. As the result, there was no two-way interference between scenario and experience.

For main effect analysis, the entering port scenario was perceived with a higher workload (*M* = 12.34, *SD* = 2.58) than ocean-going scenario (*M* = 9.63, *SD* = 2.86) with statistically significant difference ($F(1,15) = 31.23$, $p < .01$). The second-time participation was perceived with a lower workload (*M* = 10.30, *SD* = 3.03) than the first-time participation (*M* = 11.67, *SD* = 2.90), also with statistically significant difference ($F(1,15) = 6.73$, $p = .02$). However, the participant experience did not meet the statistically significant difference ($p = .18$) tested using a t-test. The interaction between variables are shown in Figure 2.



(a) (b)

Figure 2. The interaction perceived workload measured by NASA-TLX with (a) scenario and participation, and (b) participant's experience



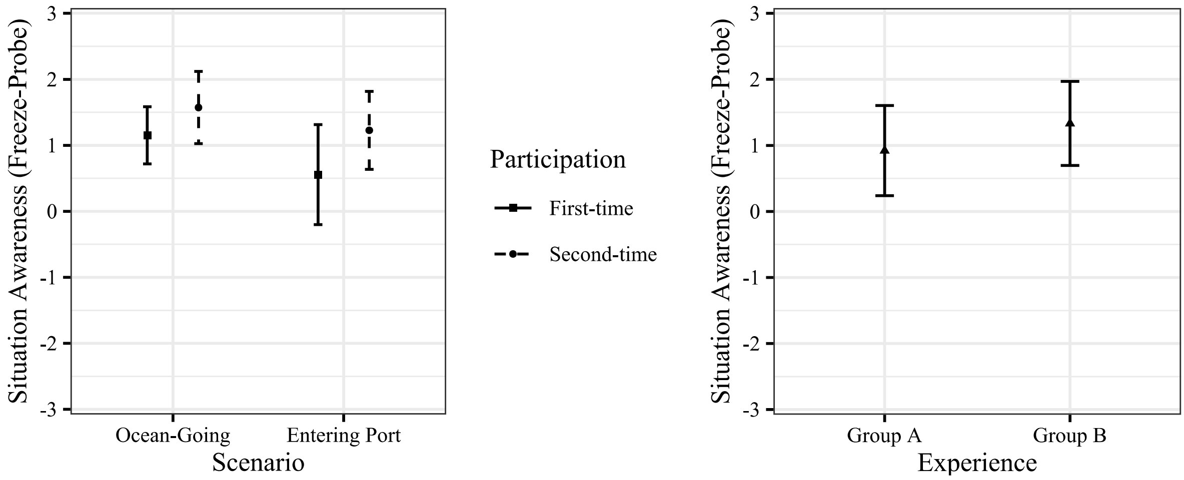
(a) (b)

Figure 3. The interaction perceived situation awareness measured by SART with (a) scenario and participation, and (b) participant's experience

Similar to subjective workload, the result from SART questionnaire was analyzed using the two-way mixed ANOVA, as shown in Figure 3. There was no two-way interaction across the scenario and participation. The ocean-going scenario was perceived with higher SA (*M* =

22.81, *SD* = 5.09) than the entering port scenario (*M* = 14.59, *SD* = 6.27) with statistically significant difference ($F(1,15) = 41.09$, $p < .01$). The second participation was perceived with higher SA (*M* = 20.68, *SD* = 6.67) than the first participation (*M* = 16.72, *SD* = 6.89) with statistically significant difference ($F(1,15) = 10.32$, $p < .01$). The participation experience did not give the different ($p = .51$) tested by t-test.

For the SA objective measurement using the freeze-probe, two-way ANOVA unveiled there were no two-way interaction between scenario and participation. For individual main effect, the participants have higher SA sensitivity during the ocean-going scenario (*M* =1.36, *SD* = 0.52) than during the entering port scenario (*M* = 0.89, *SD* = 0.75), tested statistically significant difference ($F(1,15) = 20.75$, $p < .01$). The SA sensitivity also increase in the second-time participation (*M* = 1.40, SD = 0.59) from the first-time participation (*M* = 0.85, *SD* = 0.67), tested also statistically significant difference ($F(1,15) = 20.68$, $p < .01$). The participants experience gave statistically significant difference ($p = .02$) tested using t-test. The participants in Group B have higher SA sensitivity (*M* = 1.33, *SD* = 0.68) than participants in Group A (*M* = 0.92, *SD* = 0.68). The interaction between variables are shown in Figure 4.



(a) (b)

Figure 4. The interaction situation awareness measured by freeze-probe with (a) scenario and participation, and (b) participant's experience

The analysis also conducted for each level of SA in this study: SA level 1 and SA level 2. The finding in scenario effect similar from SA in general, the SA level 1 sensitivity was higher during the ocean-going scenario (*M* = 1.70, *SD* = 0.61) than the entering port scenario (*M* = 1.23, *SD* = 0.86), with statistically significance different ($F(1,15) = 10.22$, $p < .01$). As well as SA level 2 sensitivity was higher during the ocean-going scenario (*M* = 0.51, *SD* = 0.58) than the entering port scenario (*M* = 0.25, *SD* = 0.65), with statistically significant difference ($F(1,15) = 6.01$, $p = .02$). Also, the participants have higher SA level 1 sensitivity in the second-time participation (M = 1.79, SD = 0.65) than in the first-time participation (M = 1.14, SD = 0.77), with statistically significant difference ($F(1,15) = 16.53$, $p < .01$). So it is with SA level 2 sensititivity was higher in the second-time participation (M = 0.53, SD = 0.64) than the first-time participation (M = 0.23, SD = 0.58), with statistically significant difference ($F(1,15) = 4.73$, $p = .045$). The participants experience effect on SA level 2 ($p < .01$) tested with t-test. The participants with more experience (Group B) have higher in SA level 2 sensitivity (M = 0.60, SD = 0.57) than the participants with less experience (Group A) (M =0.16, SD = 0.61). While the interaction of participant experience effect did not occure in SA level 1 sensitivity (p = .14). The interaction between variables in each SA level are shown in Figure 5.

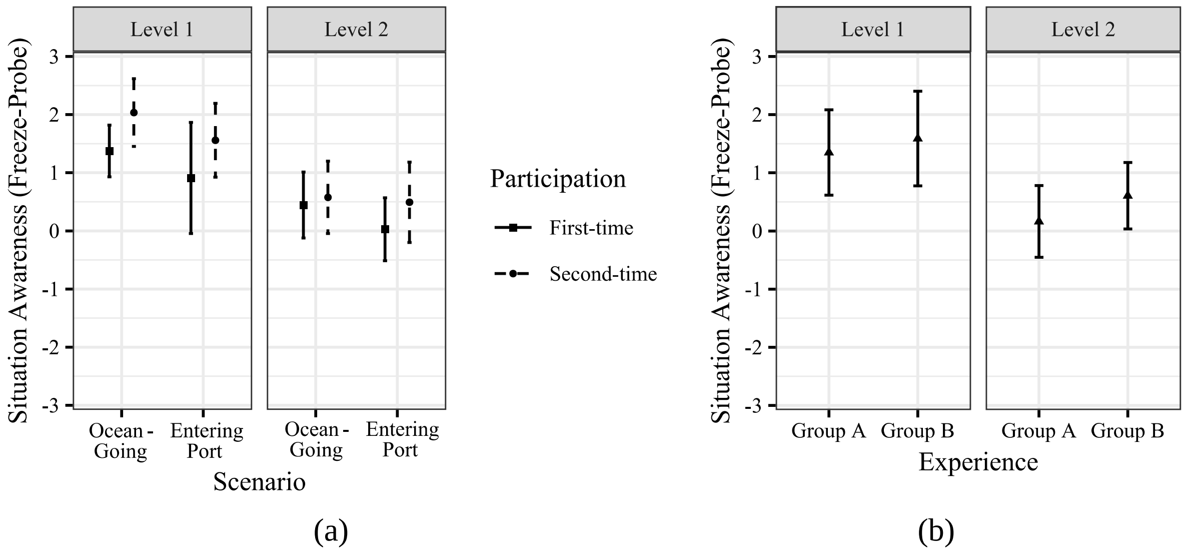


Figure 5. The interaction situation awareness measured by freeze-probe for each level with (a) scenario and participation, and (b) participant's experience

Discussion

Several studies regarding SA in maritime operation already exist, but the specific study that examines SA in the engine control operation is not specified yet. This study examined the SA in the engine control environment by applying subjective and objective measurements. The interaction between SA and workload has also been examined in this study. Using a full-mission engine plant simulator and the cadet student as the participants, the studies also aiming to provide such measurement to support non-technical skills.

Two scenarios, ocean-going and entering port, have already successfully made different workload levels, measured by subjective measurement NASA-TLX. The entering port scenario designed to have high demand was perceived with a higher workload than the ocean-going scenario in this experiment. This result is obvious because the participants were demanded by more information, such as standby engine procedure in the entering the port scenario. Moreover, the participants perceived a lower workload in the second-time participation. It reflected the familiarity effect because the participants getting used to the experiment setup and task. The results also revealed that workload, in this case, was not sensitive to the participant's experience.

Able to discriminate the workload of two scenarios made the following analysis between workload and SA can be done. In contrast with the workload, the subjective measurement of SA explained the participants perceived higher SA in a lower workload scenario. This effect was not discriminated across the participant's experience. The participants also perceived higher SA as the familiarization effect on the second-time participation. This result explains that the SART as subjective measurement was sensitive to the different task-load levels but not with the experience level.

In line with subjective measurement, the freeze-probe technique as the objective measurement in this experiment also explained that the participants have lower SA sensitivity in higher workload scenarios. The interesting finding is when the SA separated into SA level 1 (perception) and SA level 2 (comprehension). Although the participant experience did not reflect the difference in SA level 1, the participants with more sea training experience were observed to have higher SA level 2 sensitivity. This finding is prevalent because the participant with 3-month sea training (Group B) had more portion of an engine watchkeeping training.

The limitation of this study was that during the experiment, the participant's role was passive because no action to handle the alarm was needed. The future study must include the participant's active role in handling this. The second limitation was that the participant experience in this study had a slight difference in their sea training experience. Although the result can discriminate the two levels of experience in this study, it is better to compare with more experience cadets to confirm its sensitivity.

Conclusion

The subjective and objective measurements to examine the SA in this study have a different tendency in the sensitivity. Both measurements were confirmed to be sensitive to the different workload levels, but only the objective measurement is sensitive to the participant's experience. Preparing the training method for the cadets in attaining and maintaining attention during the engine supervisory work is notable in supporting the SA. Having appropriate and practical measurement methods then became the modal to evaluate its effectiveness.

Acknowledgments

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PROMETHEAS Project - Mental Health Data Research Hub for Seafarers

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Abstract

Some 90% of the world visible trade is transported by sea. It is therefore of prime importance that the mental wellbeing of all seafarers onboard ocean-going vessels is seriously taken into consideration. Mental health is a state of wellbeing in which the individual realises his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community. Research as C4FF has shown that many seafarers endure a range of stressful situation, and this is often not seriously studied.

This paper report on the outcome of an investigation carried by C4FF and its European partners into the mental health problems of seafarers focusing on identification of the problems which create or lead to mental health issues with a view to find feasible solutions hence making life on board more pleasant. There have been several studies by C4FF reviewing seafarers' difficult life on-board ocean-going vessels and looking at factors such as sleeping patterns which is known to impact on fatigue and stress in seafarers. Fatigue alone has led to many accidents and serious incidents at sea. Bullying is also a subject of interest in PROMETHEAS project but the work on bullying is planned for another paper which will explore as why it is important to study the causes and effects of bullying? The paper offers a number of practical solutions to achieve a high level of mental hygiene and have some understanding the affects of the medicinal remedies.

The main purpose of this paper is to gather sufficient data and establish a data hub for mental well-being of seafarers so that sufficient information is to gather for legislators helping to bring about new rules and regulations to improve mental health as sea. The intention also is to use the findings to develop an e-course in Mental Health and Wellbeing for seafarers with a special section for captains and shipping companies.

Keywords: mental health of seafarers; bulling; wellbeing of seafarers.

Introduction

There are a number of key aspects that affect seafarers when out at sea. These aspects that affect seafarers include; productivity levels, physical endurance, and cognitive ability. There are a number of factors that influence the above, an example of these are; changes in the environment, the specific nature of one's occupation, the desire for one's level of productivity, increased levels of fatigue from long voyages, etc. C4FF previously worked on another study, which was titled "Project Horizon - Stress at Sea". Project Horizon was a major multi- partnership European research study that brought together 11 academic institutions and shipping industry organisations. All organisations, institutions and beneficiaries shared the collective aim of delivering empirical data, to provide a better understanding of watch keeping patterns within the Maritime workforce. The broad spread of the project partners ensured expert objectivity of the project and its results, as well as widening routes for dissemination and exploitation of the findings. Project Horizon, similarly to Prometheus, looked at issues surrounding fatigue in various realistic scenarios. The study was able to capture empirical data on the cognitive performance of watch keepers and assess the impact of fatigue on decision- making performance. In response to the research findings, the Project Horizon partners have developed a fatigue management toolkit for the industry. This toolkit seeks to provide guidanceto owners, operators, maritime regulators and seafarers to assist them in organising work patterns at sea in the safest and healthiest way possible. Fatigue is generally understood to be a state of acute mental and/or physical tiredness, in which there is a progressive decline in performance and alertness. Fatigue is often considered to be a generic term, of which 'sleepiness' is one of the major sub-components. Throughout the PROMETHEAS project, we shall explore further the causes and effects of mental illness in seafarers and how to overcome this issue.

The project began with a literature review focusing on the correlation between Maritime workers and mental health realising that seafaring profession is a highly hierarchical micro- societal. What is it specifically, about working at the sea that causes such devastating emotional effects on these loyal and dedicated service individuals? We shall start by looking atthe Canadian model of occupational performance (COPM).

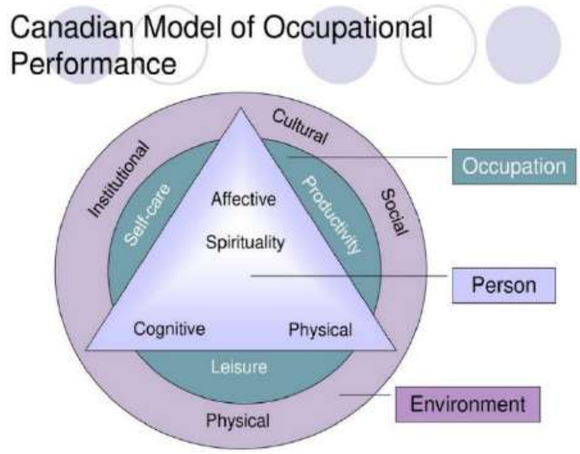

Figure 1. Canadian Model of Occupational Performance

The key aspect of COPM demonstrates how Occupation, Person and Environment relate to one another. So, in effect the environment that we are put into, or have voluntarily chosen to reference ourselves into, will have an effect upon what we do (Occupation) and can influence who we are (person). Take the example of Singh et al's (2016) research study into the effect that the Environment and occupation had on Children in India. The study showed that "a child's intelligence quotient (IQ) is determined by both genetic and environmental factors that start from the prenatal period itself". In the study, the researchers recruited "1065 schoolchildren between the age of 12 and 16 years from 2 government and 13 private schools in 5 towns, 6 cities, and 2 villages across India" (Singh et al, 2016). The results from the study were staggering, as they showed that "environmental factors such as; place of residence, physical activity, family income, parental education, and occupation of the father had an impact on the IQ of the children" (Singh et al, 2016). Children living in cities, having physical activity of more than 5 hours weekly, whose parents had a postgraduate or graduate level of education, whose father held a professional job and lastly, those with a higher family income were more likely to give the child a high IQ over children that did not share these environmental and social factors (Singh et al, 2016). This example from Singh et al (2016) proves the theory of the Canadian model of Occupational Performance. In relation to our own research project, the effect of a seafarers' environment on his occupation and as a result, himself, could be relativelysignificant. We will work through this study to discover more in relation to mental health and its connection to the Maritime industry, in order to accurately research, any missing gaps in the pre-existing studies. There are many assumptions of the Maritime industry, including sex, race, social-economic status of workers and behaviour. An assumption of the Maritime industry is that it is largely male dominated, this assumption would be correct according to Kitada (2013). A study by Sailors' Society and Yale University (2018) reported of 26% of seafarers showing signs of depression and half of them not asking for help

(SAFETY4SEA, 2018). Branney and White (2008) argue that “excess female depression could, for example, be an artefact of how depression is recognised and treated or of how men self-diagnose and seek help”. This statement theorises how arguably, men with mental health difficulties are less likely to seek help or be treated, due to how they categorise their emotion. There are many acclaimed social researchers who do an excellent job at explaining how life at sea can be difficult, challenging and even sometimes, unbearable. One of these is Social Scientist, Baygi et al (2018) who argued “Seafaring is a highly physically demanding profession in a risky environment.

Seafarers face tough working conditions when they are on board. Working far from home for several months can lead to some difficulties for their overall health”. Iverson (2012) reports onthe findings from the International Maritime Health Association which states that “seafaring isone of the most physically demanding professions in one of the most dangerous work environments: the sea”. “Being far from home for a long period of time, long working hours, heavy workloads, accidents, maritime disasters, communicable diseases and pirate incident aresome of the main stressors, risks and challenges of seafarers on board ships that can cause some consequences for their physical and mental health” (Baygi et al, 2018). Therefore, one would argue that these findings from the Social Researchers (as mentioned above) highlight how mental illness or poor states of mental health can be a consistent issue in Maritime workers. In researching mental health and its effects on Maritime staff, we came across a blog written by Kelsey, a female seafarer, who works aboard cruise ships. She writes, “Who I am today is a direct result of my 18 months lived at sea and the sobering emotions I felt, like:

- The sadness of being so far from home and family.
- The isolation of living detached from the life on land.
- The fear of a rough night at sea spent sleepless amid pitching and rolling.
- The tension that mounts among roommates and the confinements of your cabin becoming unbearable.
- True cabin fever
- The loneliness felt as you stare out into an ocean with no visible end or beginning.
- The gravity in realising your true size, bobbing atop a world covered in blue.(Life of a Seafarer: The Original Traveler, 2020)

Research has shown that the occupation of a seafarer put the individual as one of the most “at-risk” categories for committing suicide, with perhaps the most obvious cause; drowning.

Szymanska et al (2006, in Iverson, 2012), has studied suicide trends among Polish seamen from 1969–1999. The researchers found that out of “324 total deaths there were 33 suicides – 10.2% of seafarer deaths, which was significantly higher than the incidence of suicides among the male Polish population over 20 years of age” (Szymanska et al, 2006, in Iverson, 2012). In the past 40 years, the maritime industry has seen a steep decline in the level of suicides at workin this industry. Some might argue that the reasoning for this is the increase of aid and support for the maritime industry, for example; a reduction over time in long intercontinental voyages and changes of seafarers’ lifestyles (Roberts et al, 2010, in AndruŁkienė, Barsevičienė and Varoneckas, 2016). AndruŁkienė, Barsevičienė, and Varoneckas, (2016) conducted a study based around the mental health of maritime students and the relationship this held to sleep. Thefindings of the research study indicated “close relations among sleep quality, anxiety and depression, especially among third (fourth) year students and studying in the programmes, where practices were held on ships”. Henceforth, after all of the research we have gathered within the paper, one argues that there is a correlation between mental health and maritime workers. So far, we have largely looked at the relationship between occupation and fatigue, andhow this might affect ones overall health. Nevertheless, there are many more factors involved at play in terms of the overall influences that may affect ones mental health. Some other examples of these influences, which we may briefly bypass throughout this study, are; social- isolation, drug or alcohol misuse, also previous struggles with dominance or management priorto taking on the role.

In terms of further guidelines which are more specific to seafarers, the International Seafarers Welfare and Assistance Network (ISWAN) Mental Health Guidelines 2016 provide really thorough and specific information about the risks, signs and symptoms of difficulties that can be experienced at sea. It also highlights what can increase the likelihood of these difficulties occurring and thankfully, what to do to improve these effects. These points can be used to cover some of the unit content that will be specific to seafarers. The other key information, more specific to seafarers, is derived from a bulletin from March 2018. The Maritime Safety Awareness Bulletin, Issue 7, March 2018 shares its knowledge of mental health, what is it, howit is related to seafarers, what the risk factors are and how best to combat difficulties. It provides take away messages and resources for further consideration.

PROMETHEAS Project

The project’s key aspects are described in its extended logo as shown below:

Figure 2. Key aspects of PROMETHEAS project

As shown in the figure above, seafarers work on a hierarchical macro society where crew members work long and often irregular hours in an isolated and multicultural environment where bullying and harassment can be a major issue.

The first part of PROMETHEAS research involved carrying out survey and a desk research to outline the main problems and solutions applied to the problems identified. The problems found and solutions prescribed are listed in Annex 1 of this paper. The next step was to find a methodology to cross-reference the identified problems and solutions found and present themas key factors including organisational and provide possible remedies for them and then through several quizzes ensure a greater understanding of the problems and solutions.

The ultimate aim of this research is to improve mental health as sea and seek ways to eradicate bullying and harassment. To this end, the findings from this project are used to develop an e-course in mental health and wellbeing for seafarers with special sections for shipping companies and Captains.

The earlier research by C4FF and its EU partners had clearly identified fatigue, poor organisation procedures and inadequate training as the three main contributory factors in mental health illnesses as well as in accidents at sea. It was on this basis that C4FF welcome the formation of Special Interest Group (SIG) for Mental Health and Wellbeing in the UK whohave been supporting the

IMarEST conference. It is hoped that by forming a formidable consortium of key seafaring and health specialist organisations there will be opportunities of improving mental health in shipping industry through learning from each other and acting together particularly finding way to improve legislation concerning work pattern and self-improvement on board vessels. The key organisations to target are IMO and ILO.

Improving Mental Health

The preliminary stage was to use the findings from the literature search and prepare a list of problems and solutions. The following is an example of the format of the how problems were identified and numbered and solutions were found and listed (Ziarati, et al. 2021).

Table 1. Identified problems and solutions (International Maritime Health 2019; 70(2):82-87)

Identified Problems and Solutions	
ID P_001 Title Boredom Description - Boredom is usually experienced when workers face a monotonous life along with frustration, according to the paper. This combination is often found among seafarers, because of the monotony of work onboard, routine deck-work or using machinery, being on watch, or doing maintenance tasks, especially at sea. Solutions: S_001, S_002, S_004, S_005, S_007-015 Related documents - D_001 Don't forget about seafarer's boredom	ID S_001 Title - Take time out Description - Taking up a hobby can help in order to relax and take the mind off negative thoughts – card games, puzzles, reading, table tennis are good examples. It is necessary to try doing it during the free time. Related documents: Information on Reading material, Internet resources, Yoga, Martial Arts, Music and so forth. Sample Document: By Dominique Jegaden, Myriam Menaheze, David Lucas, Brice Loddé, Jean- Dominique Dewitte - DOI: 10.5603/IMH.2019.0013 Pubmed: 31237666

The intention is to develop depository of problems and by using intelligence means to cross-reference problems with a list of possible solution under a given category.

The next stage was to initiate a series of steps is to find key factors which improve Mental Health as shown below. The important consideration was to find the factors that put pressureon mental health and then find the main divided these into Organisational factors and how to mitigate them followed by other ways and means to counter mental health issues such as physical exercises, reflecting on situation, and so forth as outline below:

1. Factors putting pressure on mental health at sea.
2. Organisational factors and how to mitigate them.

3. Positive attitude and tips to think positively.
4. Physical exercise and its impact.
5. Reflection on the situation.
6. Distinction between facts and statements.
7. How to think constructively.
8. Human relations.
9. Group Dynamics.

Table 2. Factors putting pressure on mental health Indicators of poor mental health

Physical	Psychological	Behavioural
Fatigue	Anxiety or distress	Increased smoking and drinking
Indigestions or upset stomach	Tearfulness	Using recreational drugs
Headaches	Feeling low	Withdrawal
Appetite and weight changes	Mood changes	Resigned attitude
Joint and back pain	Indecision	Irritability, anger or aggression
Changes in sleep patterns	Loss of motivation	Over-excitement or euphoria
Visible tension or trembling	Loss of humour	Restlessness
Nervous trembling speech	Increased sensitivity	Apparent over-reaction to problems
Chest or throat pain	Distraction or confusion	Working far longer hours
Sweating	Difficulty relaxing	Intense or obsessive activity
Constantly feeling cold	Lapses in memory	Repetitive speech or activity
	Illogical or irrational thought processes	Impaired or inconsistent performance
	Difficulty taking information in	Uncharacteristic errors
	Increased suicidal thoughts	Increased sickness absence
	Responding to experiences, sensations or people not observable by others	Uncharacteristic problems with colleagues
		Risk-taking
		Disruptive or anti-social behaviour
		Lateness, leaving early or extended lunches

To understand the nine steps outline above there are a number of quizzes to fully understand the significance of each step and what outcome is expected at each stage.

Several quizzes have been prepared to help understand how to avoid mental stress and means of mitigating mental stress when it occurs. The quizzes also help learning process and a way todo some self-assessment. An example is given below:

Table 3. Factors putting pressure on mental health at sea: Example Quiz

Physical	Psychological	Behavioural
Lateness, leaving early or	Uncharacteristic problems with	Illogical or irrational thought

extended lunches	colleagues	processes
Resigned attitude	Mood changes	Visible tension or trembling
Changes in sleep patterns	Loss of motivation	Distraction or confusion
Fatigue	Feeling low	Appetite and weight changes
Withdrawal	Sweating	Irritability, anger or aggression

The following at Table 4 list are indicators of poor mental health, group them under Physical, Psychological and Behavioural categories

Table 4. A Sample Quiz: Answers:

Physical	Psychological	Behavioural
Visible tension or trembling	Illogical or irrational thought processes	Lateness, leaving early or extended lunches
Changes in sleep patterns	Mood changes	Uncharacteristic problems with colleagues
Fatigue	Loss of motivation	Withdrawal
Appetite and weight changes	Distraction or confusion	Irritability, anger or aggression
Sweating	Feeling low	Resigned attitude

Conclusions

PROmoting MEnTal HEAlth at Sea (PROMETHEAS) is an Erasmus+ KA2 Strategic partnership for VET, development of innovation project. The central aim of this project is to develop a training course and learning resources for seafarers and maritime workers concerning the preservation and improvement of their mental health. It focuses on the various issues that derive from mental health problems and provides learners with necessary information and consultation on how to deal with these problems. PROMETHEAS is a sector specific project. It is based on the matter of fact, supported by hard evidence, that mental health problems constitute one of the main risks of seafarer professions, yet neither initial nautical studies nor VET have dealt with this problem up to now. This has as a result that seafarers lack the knowledge and skills that would have helped them mitigate this risk. The project aims at developing these skills through joining deep knowledge and expertise on the maritime sector of 7 institutions coming from 6 European countries. More specifically, PROMETHEAS will produce three core intellectual outputs: 1. Repository of resources on mental health for maritime staff; 2. E-learning training course for captains & seafarers; 3. Digital app- self evaluation.

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REDEFINED DEFINITION OF THE STCW COMPETENCES

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In this paper, the authors propose a new approach to defining competences according to which a competence is a defined set of three elements: executors of the actions, on board processes and objects needed to execute a task or a decision within one process. Each of the elements has to be defined separately. Correlation between the competences' elements should be defined as well. Generic competences are of the extreme importance for the successful on board processes. Therefore, a correlation between the generic competences' elements should be defined as well. These definitions' application has been shown on the examples of professional and generic competences. As has already been mentioned, objects have become a part of the new, redefined and improved definition of competences. Objects can be divided into the ones referring to generic competences and the ones referring to professional competences. They are devices, machines, tools, persons, groups of people and concepts. They change significantly under the influence of technological development and automation, which, consequently influences the whole process as well as task executors.

Key words: professional competences, generic competences, group competences, on board team's competences, on board processes

1. Introduction

Since its entering into force, the STCW Convention has been amended several times. One of the most significant amendments as far as the seafarers' education is concerned is the introduction of the competence-based education into the Convention [1]. The competence concept was introduced into the Convention as a part of the 1995 amendments. The STCW

Convention has prescribed professional competences that refer to deck department, engine department, radio operators, different types of ships, emergency actions, safety, security, first aid and medical care and survival at sea.

There are many competence definitions and classifications in usage today. However, the basic classification of competences into generic and professional competences can be pointed out [2; 3; 4]. Generic competences are the ones needed in various everyday situations and are not necessarily profession related [5]. However, professional competences always refer to knowledge and proficiency typical for a particular profession [6].

Competences as defined by the STCW Convention are a combination of knowledge, understanding and proficiency needed for on board jobs and duties [7]. They are closely linked with nautical science concepts as well as technological development on board. Definition and explanation of generic and professional competences in the STCW Convention is not clear enough. However, a number of generic competences is present in the STCW Convention. The competences in question are *Teamwork* and *Team Management,* whereas the other generic competences have not been mentioned [8; 9]. According to the analysed literature, a special attention has been given recently to acquiring generic competences needed for jobs on board.

It is important to emphasize that competence concept has so far referred to one crew member only [8]. However, a model of defining competences could refer to a group of people i.e. to an on board team. Therefore, in a larger sense a competence can refer to the competence of an on board team which is involved in decision-making and task execution. An on board team has its own competences that are the same as one crew member's competences. They also have the same characteristics. The main difference between the on board team's competences and one crew member's competences lies in the fact that knowledge, understanding and proficiency can be differently distributed within a team [8].

Competences, prescribed by the STCW Convention, have nowadays been related to different ship function [1] and ship functions have been determined within ship departments. However, competences needed by the crew can be determined on the basis of the analysis of processes on board. It means that every operation, its executors and devices used within a process on board should be analysed [8]. It is important to emphasise that a part of the processes would be the same for various types of ships. However, processes typical for the particular type of ships should be pointed out. After this type of analysis, it would be possible to determine competences needed by the crew within a particular process. Similar analysis has already been used in the STCW Convention.

Generally speaking, operations and decisions within an on board process have a precisely determined time of execution. They can be made by one or more members of a small, middle-size or large team. If subjects are small, middle-size or large teams, interrelations between team members can be vertical or horizontal. Vertical relationships refer to formal hierarchical relationships with a defined chain of command [10], whereas horizontal relationships refer to relationships between members of the same rank/level [11], and, they generally refer to a task execution [10].

Therefore, this paper proposes a redefined approach to defining competences based on the analysis of processes on board. The approach refers not only to one crew member, but to a whole team as well. The ambiguities referring to the method of determining knowledge, understanding and proficiency within particular competences were analysed in this paper as well.

2. Competences in STCW Convention

For deck and engine department, the STCW Convention has classified competences into the ones needed at operational, management and support level. Such a classification's flaws (the ones the authors think are important) are emphasized in the text that follows and they refer to:

1) Prescribing competences at the management and the operational level, and

2) The method used to prescribe knowledge, understanding and proficiency.

Ad 1) Competences, as prescribed by the STCW Convention, have not been classified on the basis of the processes within a system. As for deck department, ship operations have been defined and within them, competences have been prescribed. The same operations have been prescribed at the operational and the management level, which has led to the classification of competences that is not clear enough and, that is not suitable for processes on board.

For example, competences have been determined for the operation *Navigation* at the operational and the management level, which has resulted in prescribed knowledge, understanding and proficiency at the operational level. As for the management level, new knowledge, understanding and skills, that should have already been included at the operational level, have been added.

As an example, a competence *Voyage Planning* within the operation *Navigation* was described in this paper. The first officer usually makes a voyage plan. He has to be able to do that upon completion of programmes prescribed for officers of watch on ships of 500 BT and more. Therefore, the afore-mentioned competence cannot be classified in this way since the second deck officer has to possess all knowledge, understanding and proficiency needed to make a voyage plan from the moment he takes up that position.

The STCW Convention has prescribed knowledge, understanding and proficiency for the afore-mentioned competence at the operational and the management level, as shown in the Table 1.

Table 1. Competence *Voyage Planning*

Operational level	***Management level***
Celestial navigation - Ability to use celestial bodies to determine the ship's position	*Restricted waters*
Terrestrial and coastal navigation - Ability to determine the ship's position by use of landmarks, aids to navigation, including lighthouses, beacons and buoys, dead reckoning, taking into account winds, tides, currents and estimated speed	*Meteorological conditions*
Thorough knowledge of and ability to use nautical charts, and publications, such as sailing directions, tide tables, notices to mariners, radio navigational warnings and ships' routeing information	*Ice*
Electronic systems of position fixing and navigation - Ability to determine the ship's position by use of electronic navigational aids	*Restricted visibility*
Echo-sounders - Ability to operate the equipment and apply the information correctly	*Traffic separation schemes*
Compass – magnetic and gyro - Knowledge of the principles of magnetic and gyro-compasses. Ability to determine errors of the magnetic and gyro-compasses, using celestial and terrestrial means, and to allow for such errors	*Vessel traffic service (VTS) areas*
Steering control system- Knowledge of steering control systems, operational procedures and change-over from manual to automatic control and vice versa. Adjustment of controls for optimum performance	*Areas of extensive tidal effects*
Meteorology - Ability to use and interpret information obtained from shipborne meteorological instruments. Knowledge of the characteristics of the various weather systems, reporting procedures and recording systems. *Ability to apply the meteorological information available*	*Routeing in accordance with the General Provisions on Ships' Routeing*

Source: [7]

It is not very clear why, for example, the competence *Vessel Traffic Service (VTS) Areas is* repeated at the management level if knowledge, understanding and proficiency, for that competence, can be a part of the competence *Ability to use nautical charts, and publications, such as sailing directions, tide tables, notices to mariners, radio navigational warnings and ships' routeing information.* The above-mentioned does not mean that ship's operation *Navigation* should not consist of the operational and the management level. It means that this classification should be made according to the processes and operations on board.

Ad 2) The already existing method of prescribing knowledge, understanding and proficiency has not been standardized and is not clear enough.

For example, UKC *(Under Keel Clearance)* is important when planning a voyage. However, it has not been prescribed neither at the management level, nor at the operational level for the competence *Voyage Planning*. It has been prescribed for the competence *Manoeuvring and Ship Handling* at the operational level and for the competence *Manoeuvring and Ship Handling in all Situations* at the management level.

Furthermore, a method of prescribing knowledge, understanding and proficiency has not been standardized. For example, in some parts of the STCW Convention only knowledge, in others only understanding, proficiency or elements' identification etc. fall into the category knowledge, understanding and skills. One of the examples of the above-mentioned situation is the competence *Carriage of Dangerous Goods.* The STCW Convention has determined the following knowledge, understanding and proficiency for that competence: international regulations, standards, codes and recommendations on the carriage of dangerous cargoes. It has also included the International Maritime Dangerous Goods (IMDG) Code and the International Maritime Solid Bulk Cargoes (IMSBC) Code; carriage of dangerous, hazardous and harmful cargoes; precautions during loading and unloading and care during the voyage. To conclude, codes are not and cannot represent a competence *Carriage of Dangerous Goods,* which is the case in the described situation.

Another example is the competence *Watchkeeping and Procedures.* The STCW Convention has determined the following knowledge, understanding and proficiency for that competence: thorough knowledge of the content, application and intent of the International Regulations for Preventing Collisions at Sea, 1972, as amended; thorough knowledge of the principles to be observed in keeping a navigational watch. Knowledge, understanding and proficiency needed to prepare watchkeeping procedures have not been listed for this competence as well.

Apart from the STCW Convention's mandatory regulations, the International Maritime Organisation has recommended the IMO Model Courses usage when carrying out programmes referring to gaining competences prescribed by the STCW Convention. The institutions carrying out such programmes can use IMO Model Courses when introducing new programmes or when upgrading or improving the already existing ones. IMO Model Courses contain the curriculum, teaching goals as well as the number of hours needed to achieve the goal etc.

IMO Model Course that refers to the operational level is 7.03 (*Officer in Charge of a Navigational Watch),* whereas the one referring to the management level is 7.01 (*Master and*

Chief Mate). IMO Model Courses are only a recommendation, i.e. their usage is not mandatory. However, even IMO Model Courses have not solved the problem of prescribing competences at the operational and the management level. For example, *Integrated Navigation System* – INS and *Integrated Bridge System* – IBS are not mentioned in the IMO Model Course 7.03 [12] but in the Course 7.01 [13] . Therefore, it could happen that an institution, that applies IMO Model Courses uncritically in the programmes for officers of watch, does not include INS and IBS contents in the programmes. Moreover, it could happen that officers of watch who complete such programmes do not know the systems' basic concepts and limitations as well as how these systems work.

3. Redefined definition of competence

In order to improve the existing definition of competences and to avoid ambiguities mentioned in the text, the authors have proposed a redefined definition of competences. The redefined definition of competences, as proposed in this paper, is based on the analysis of on board processes. In a broad sense, a competence refers to the competence of a group of people – a team that executes operations, does tasks or makes decisions together. A team has its own competences that coincide with the competences of an individual. They also have the same characteristics. Major difference between a competence of a team and a competence of an individual lies in the fact that knowledge, understanding and proficiency can be differently distributed within a team.

A concept of an object has been introduced into the redefined definition of competences. In this paper, objects are devices, machines, tools, persons, teams and concepts. Objects needed to execute operations or to make decisions within one process can be divided into the ones typical for generic competences and the ones typical for professional competences. The objects change significantly under the influence of technological development and automation, which, consequently has an impact on the process as well as on the subjects.

Therefore, competences depend on the subject, on the on board process and on objects used. Taking into consideration the above-mentioned, and for the purpose of this paper, competences (C) represent a defined set of three elements:

1) Subject (e_1)
2) On board process (e_2), and
3) Object (e_3).

This set of elements can be represented like this:

$$C = \{e_1, e_2, e_3\}$$

Subject is an element that does *m* of operations with *n* of objects. For the purpose of this paper, a subject can be one crew member (e.g. deck officer) or a group of people with the same goal. Depending on the number of its members, a group of people can be divided into:

1) Smaller teams, e.g. bridge team,
2) Middle-size teams, e.g. deck crew, and
3) Large teams, e.g. ship crew.

An on board process is a set of operations, decisions and tasks within operations whose time of execution *t* has been implicitly or explicitly set.

$$e_2(t) = \{O_1, O_2 \dots O_j; D_1, D_2 \dots Dn\}\ t$$

$$\sum t_i < t_g$$

Where:

t_i – *time of execution*

t_g – *limited time of execution*

3.1. Differences between generic and professional competences

As far as generic competences are concerned, the object is usually a person, a team, a concept or a device, whereas as far as professional competences are concerned, it usually represents a device, machine or a tool[1].

Difference between professional and generic competences:

- As far as professional competences are concerned, e_3 = an advice, number of devices, machine, number of machines, tool or number of tools.
- As far as generic competences are concerned, e_3 = a person, team, concept or device.

This relationship is shown in Figures 1 and 2.

[1] For the purpose of this paper, the term tool refers to an instrument (e.g. a pair of compasses, a set square); the term machine refers to every piece of equipment that turns one type of energy into the other or that carries out a mechanical work (e.g. turbine, pump, engine); device replaces complex human operations (e.g. ECDIS).

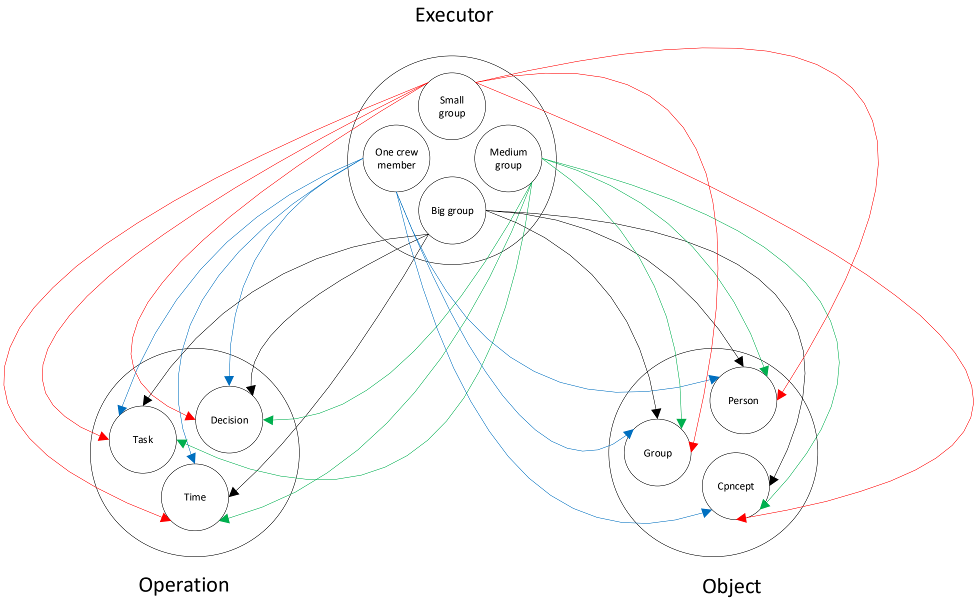

Figure 1. Generic competences

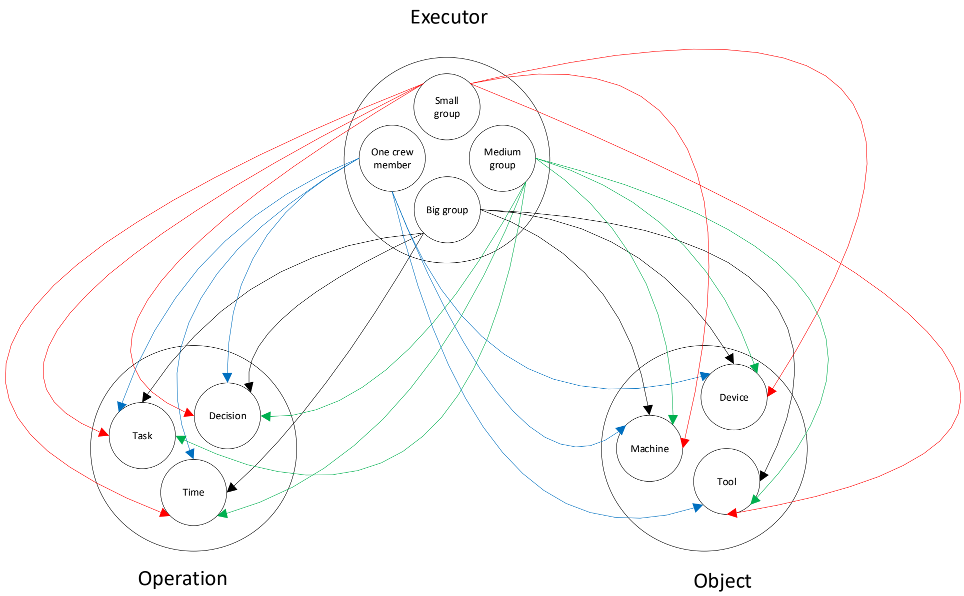

Figure 2. Professional competences

3.2. Testing the proposed definition of competences on the process called *Pilot Boarding*

The proposed definition of competences will be tested on a process called *Pilot Boarding*. This process is a part of the already existing competence M*anoeuvring and* H*andling a* S*hip in all* C*onditions* prescribed by the STCW Convention. Subjects, executing a task in this case, are bridge team and deck crew. Objects they use are manoeuvring system, navigation system, communication system and equipment needed for pilot boarding. Bridge team and deck crew prepare themselves for pilot boarding according to the prescribed procedure on pilot boarding. Upon receiving a pilot boarding position from the authorities in charge, the bridge team has to determine ship's position, course and speed with reference to boarding time. The position is checked according to defined voyage plan and time intervals. Before reaching the agreed position, a contact with pilot boat has to be made. Pilot boarding position should be confirmed as well as boarding time and the ship's boarding side. Furthermore, the ship's speed has to be in accordance with pilot ship's demands. Manoeuvre is carried out in cooperation with a pilot boat and administration responsible for pilot's activities. Pilot boarding should be visually followed and helped. It is important to emphasize that, at the same time, the ship is being manoeuvred in restricted waters, very frequently under the influence of strong wind and currents. Therefore, it needs continuous speed and steering corrections. After the safe pilot boarding has been confirmed, the master himself manoeuvres the ship until the pilot takes charge of his advisory position.

At the same time, deck crew prepares pilot boarding station. It has to mark and illuminate boarding location, set up pilot ladder, and ensure the shortest, illuminated passage from the pilot boarding station to the bridge. The equipment used to set up pilot ladder differs on the basis of the way it has to be lowered, i.e. manually or automatically.

Pilot Boarding is shown in Figure 3.

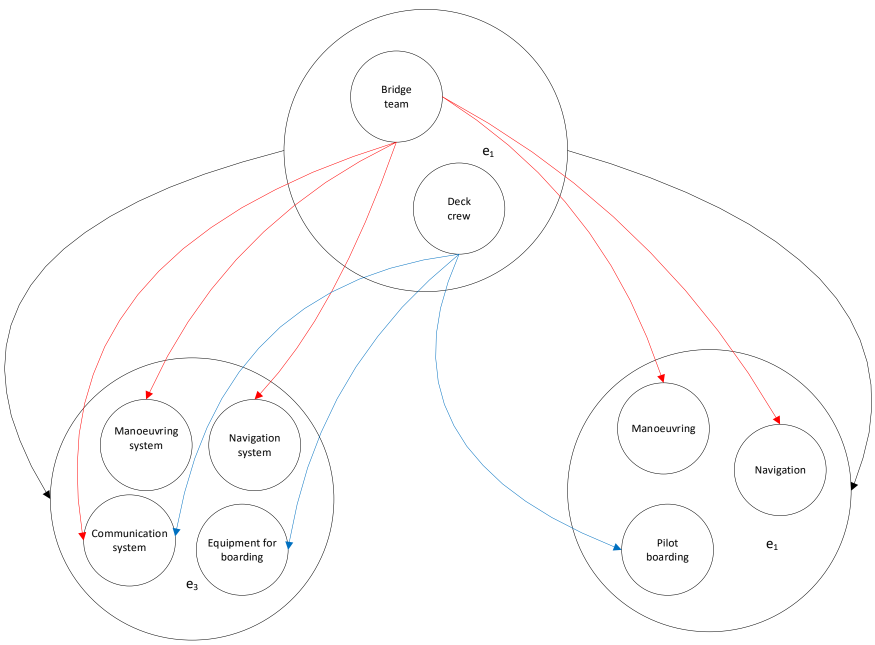

Figure 3. Pilot Boarding

In this example, the term knowledge refers to the type of objects (e.g., communication resources are the UHF resources, used for the internal communication on a ship, and VHF resources, used for the communication with pilot ship and authorities in charge). It also refers to elements the objects consist of (e.g., manoeuvring system can be divided into propulsion system and steering equipment), elements' work principle (e.g., propeller thrust) and their existing limitations (e.g., radar reflected images and photos' limitations – a false reflection could appear or, due to heavy traffic, the ship's reflection does not have to be seen). The term understanding refers to the relationship between:

1) Bridge team and manoeuvring system, navigation system, communication system and lifesaving equipment,
2) Deck crew, communication system, and pilot boarding equipment, and
3) Bridge team and deck crew.

4. Conclusion

STCW Convention's classification of competences was based on functions on board. On board processes and the accompanying equipment were not analysed at all. Competences do not have to be determined and classified on the basis of on board functions. They can be determined on the basis of the crew's environment analysis i.e. on the basis of the analysis of on board processes. Such an analysis encompasses tasks that have to be done, decisions that have to be made, their executors as well as the equipment needed to do a task or to make a decision.

In order to improve STCW Convention's description of competences, a method of determining competences on the basis of processes on board has been proposed. Activities and tasks that a master and first deck officer do, but did not perform at lower levels of responsibility should be defined more precisely. Only afterwards, competences needed at higher levels of responsibility that were not needed at lower levels of responsibility, could be determined. Furthermore, a more clear and precise listing of knowledge, understanding and proficiency referring to the particular competence should be determined.

So far, the method of prescribing competences has referred to an individual only, i.e. to a crew member. Therefore, this paper proposes a redefined approach to defining competences, which interrelates competences and processes on board as well as devices used. Moreover, a concept of an individual widens to a concept of a subject. In doing so, a subject could be an individual or a team carrying out the same process by using one or more devices. Therefore, not only competences of a crew member should be analysed in the future, but of the whole team participating in the particular process on board.

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Sustainable development processes of education technologies - A multiple case study

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Abstract

The purpose of this study is to identify sustainable development processes of education technologies. The theme of the IAMU AGA21 targets innovation and sustainability, including innovative MET environment and GMP applications. It is, however, a known issue that the outcomes of research and education technology development projects do not sustain beyond the lifetime of the projects. This research study is a multiple case study of education technology development at three different Maritime Education Training institutions. The cases are analyzed using a framework of sustainable participatory processes of education technology development. The individual cases show the need for and dynamics of integrated e-learning infrastructure; empowering teachers with new e-learning activities and resources; and enabling students to contribute to educational capacity-building as part of their studies. The study highlights key considerations to sustain the results of research and development projects. The results are valuable to maritime education and training institutes to enhance their study programs with online, blended, and distance delivery modes.

1. Introduction

The starting point of this paper is building educational and technical capacity at Maritime Education and Training Institutes (METI), beyond isolated research and development projects. The International Association of Maritime Universities (IAMU) has a capacity-building role, and each year IAMU supports research and development projects. The theme of the IAMU AGA21 targets innovation and sustainability, including innovative MET environments and Global Maritime Professional (GMP) applications. The recently published GMP initiative and book of knowledge develops and systemizes IAMU's commitment to joint capacity-building and provides a framework to support and coordinate such future efforts (IAMU 2019)[1]. The commitment to capacity-building research and development projects makes it crucial that the results are of practical and sustained value to the maritime universities. The research question guiding this study is how do research and development projects inform sustainable development processes of education and technologies at METIs?

The study uses a multiple case study to examine sustainability issues at three maritime universities that participated in a joint development project about educating the GMP using new e-learning technologies. The paper is structured as follows: Section 2 situates the study in concurrent research on education technologies and sustainable development processes; section 3 describes the multiple case research approach and the analytical framework that is used to analyze the empirical data; section 4 presents the empirical findings; Section 5 concludes the paper.

2. Background

2.1 Education technologies

The usefulness of education technologies has early on been of interest to METIs. Muirhead (2004) and Ircha and Balsom (2005) recognized the qualities of different types of technologies, such as the difference between "push-based" one-directional and "pull-based" learner-centered approaches. Muirhead (2004) also recognizes key development considerations such as the need for staged growth and planning to achieve educational usefulness. Bolmsten and Manuel (2020) and Ahvenjärvia et al. (2019) indicate how the GMP learning outcomes and taxonomies prompt the development of new educational approaches and the usefulness of e-learning technologies. In the context of the maritime competency-based approach to education, the interrogation of online constructivist learning approaches is especially relevant. According to the constructivist learning approach, the learning process is complex and multifaceted, where learners, based on personal reflection, seek new information and test ideas together with others (Vygotsky 1978; Rogers 1969). Bolmsten et al. (2021) develop an online constructivist approach using the rapidly developing affordances of online technologies. Based on earlier research on online collaborative learning by Bates (2018), it is shown how a synchronous live mode of delivery and an asynchronous anytime and anywhere mode of delivery can be blended.

[1] Other concurrent capacity-building projects include e.g. Skillsea: https://www.skillsea.eu/

2.2 Sustainable participatory processes of education technology development

To build capacity, GMP projects relating to the development of education technologies need to provide practical and sustained value to the project participants. Capacity-building through education technologies is at the center of UNESCO (2015) and related policy documents. The importance of a participatory process is highlighted for the design, implementation, and framing of education. UNESCO's policies and guidance relate to research concerning the sustainability of education, focusing on optimum educational development, leadership, and innovation practices (Davies and West-Burnham 2003; Alharthi et al. 2019). Mednikarov et al. (2016) provide a practical account of the need to increase the sustainability of research and development of applications and infrastructures to benefit MET systems. Several research studies put forward frameworks for the development of sustainable education technologies, including the interrogation of institutional embedment (Casanova and Price 2018) and learning and power dynamics at individual, collective, and networked levels (Alharthi et al. 2019). This research study uses a framework based on the sustainable participatory processes of education technology development (see *Figure 1*), where the joint knowledge development of domain experts and technical experts is in focus (Bolmsten and Manuel, 2020). The framework relates to research on Participatory Design (Poderi and Dittrich 2018; Bødker et al. 2004) and "infrastructuring" depicting procedural, ongoing, and multi-relational development activities, which unfold over extended periods of time (Star and Bowker 2002; Simonsen et al. 2020).

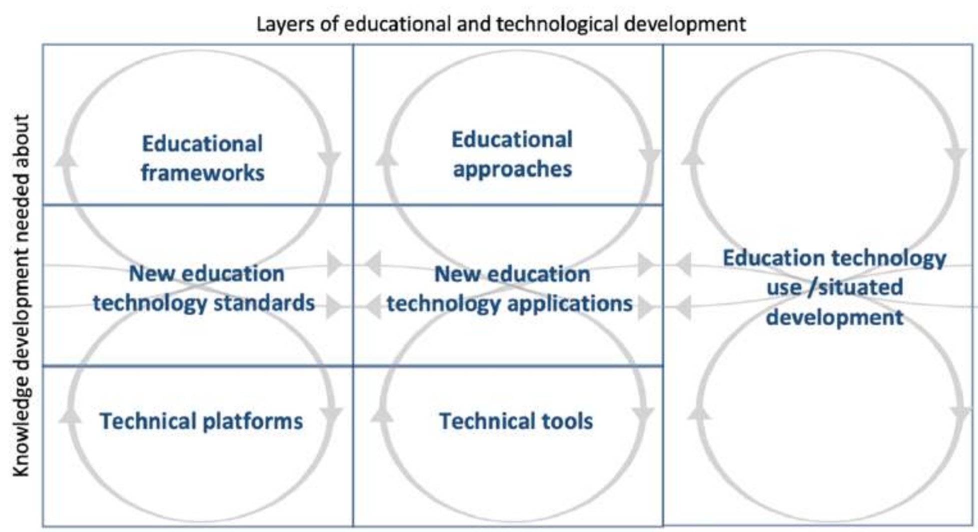

Figure 1. Framework on the sustainable participatory processes of education technology development.

The horizontal layers in the analytical framework denote the need for participatory knowledge development processes relating educational knowledge (top horizontal layer) and technical knowledge (bottom horizontal layer), which, when combined, result in knowledge development about new education technologies (middle horizontal layer). This knowledge development process, in turn, relates to standards (left vertical layer), applications (middle vertical layer), and in-situ development (right vertical layer). The evolutionary process in the framework links educational and technical know-how in the layers of standards, applications, and in-situ development. The evolving cycles highlight how a general understanding of technical provisions or educational matters is not enough. The focus is on the new knowledge development needed in the interfaces between education and technical knowledge.

3. Research Approach and setting

This research study is a multiple case study of education technology development at three different METIs. A common way to aggregate qualitative research is through multiple case studies (Yin 2013). The evidence from multiple cases is often considered more robust than a single case study to build theory and develop policy implications (Yin 2018).

The three METIs participated in a two-year research and development project to build young maritime professionals' capacity in Maritime Innovation Management (MIM) using blended-learning education technologies. The MIM project's work packages started with the analysis of educational needs. Three onsite partner workshops were carried out - one in each METI – to gain the perspectives of the faculty, students, and administrators. Participatory workshop techniques/activities were used to understand the issues at hand and aid the development of solutions. These included a SWOT analysis that was developed throughout the project and workshops, rich pictures to gather additional relevant descriptions of existing work practices and design visions and proposals, and onsite tours. The last part of the project was an action research study that tested the results from the analysis of the educational needs by designing and delivering a new blended e-learning course with student groups from each partner university.

This study follows up on the project results to understand how they informed capacity-building at the participating universities. Although all the three METIs participated in the same project activities and the development of the same education technology solution, during the project, there was already a realization that these were of different practical value to the METIs. Therefore, this multiple case study was initialized based on the assumption that each case provided different but complementary insights (Yin 2018 p55) into the issue of sustainable development. The study revisits the empirical data to understand how the unfolding of topics and issues during the workshop and action research informed the development processes at the respective institutions. The study also follows up with the project participants and key stakeholders to gain their perspectives on the project's value after its completion. The analysis is structured with the framework on sustainable development processes of education technologies developed by Bolmsten and Manuel (2020) to make cross-case comparisons and draw conclusions (Yin 2018 p58). Each METI is treated as a case study where the analytical focus is how the project activities and results informed different points of innovation or breakdowns at the METIs (Pipek and Wulf 2009). The cases were first coded separately to be sensitive to the specifics of each case, using the qualitative analysis software NVIVO. The analysis was then iteratively developed, where the authors compared the cases to arrive at the findings presented in the following section.

4 Result

4.1 Case 1: The need for new knowledge of linking educational frameworks to technical platforms

The first case gave evidence to an METI that had started to apply the GMP educational framework in practice. From the students' perspective, for their future maritime careers, they placed a high value on acquiring knowledge beyond the essential STCW competencies to cope with the maritime industry's rapid technical development and globalized nature. The students needed to expand their knowledge in areas such as new autonomous technologies and soft skills such as teamwork, leadership, and cultural awareness. To meet these educational needs, the university’s overall strategy included using new blended-learning approaches, and complementing existing classroom teaching with new e-learning delivery options to expand their educational offering.

In this case, using the framework for sustainable development processes (Bolmsten and Manuel, 2020), the follow-up analysis came to focus on the need for developing new education technology standards. The analysis showed that the METI faced constraints in meeting its educational needs and putting the MIM project results into practice due to the lack of an e-learning platform. During the MIM project’s onsite workshop and action research, the project participants build their understanding of new constructivist educational approaches using new e-learning tools, where students could collaborate with each other on practical cases and access new industry and academic expertise. To make use of these results after the project ended, the METI needed to additionally build their capacity of the underlying e-learning platforms and the linkages to local educational frameworks, including quality assurance standards of online delivery and assessment. The MIM project revealed a specific need for local capacity-building by showing how a general-purpose e-learning platform could be used, including technical standards to share and co-create content with industry and academic experts. The MIM project, thereby, informed the development of education technology applications and highlighted the need to develop underlying linkages to the local implementation of educational frameworks and e-learning platforms to sustain the results. The continuous development process thereof and developing these linkages over time is key for the METI to sustain the MIM project results, and the results of future education technology capacity-building projects

4.2 Case 2 - Empowering instructors

In the second case, the key issue was empowering instructors to develop educational approaches to the GMP educational framework. The results from the second case centered around the needs of a group of instructors teaching management specialization topics, including innovation management in the maritime industry. The instructors were already teaching these courses at an advanced level, and developed lectures combining theoretical issues with practical tasks, cases, and assignments. One of the instructors commented that the challenge was in each new semester to "try to update the material, add something new and interesting, so that students can get useful and up-to-date information about innovations and areas in which innovations can be applied […] I learned a lot of useful information [during] the project and [I am] ready to cooperate". Both the instructors and students recognized how the issue concerning topics such as innovation management - given the globalized nature and rapid technological development in the maritime industry - was that the METI operated in too much isolation in its national jurisdiction.

In this case, the follow-up analysis using the sustainable development framework (Bolmsten and Manuel, 2020) shows that the design and testing of the constructivist e-learning mode of delivery during the MIM project provided practical insights for the instructors to develop educational approaches for specific learning outcomes in their courses concerning

- Accessing new topical expertise using e-lessons: E-lessons dynamically combine learning activities and resources, such as recorded videos, reading resources, and assessments. In this case, the e-lessons showed how new academic and industry expertise could be provided to the

METI students; and the possibility to blend the e-lessons with established classroom teaching activities to gain a deeper understanding through reflection between the students and teacher.

- Enabling new collaboration through online video and forums: Another insight was using online video tools beyond a one-way lecture delivery mode. Of relevance to the management and innovation studies at the METI, the MIM project showed how students could collaborate and undertake case studies with students from other METIs through the advanced use of synchronous video collaboration tools and asynchronous forums to apply their knowledge, innovate, and analyze the outcome.

In this way, the second case shows how new education technology applications were in focus and how instructors evolved their established educational approaches through the utilization of new technical tools. In this case, by linking to their existing education frameworks and technical platforms, the instructors could sustain the MIM project results by continuing to build their educational capacity using new technical tools.

4.3 Case 3: Making use of students' input in educational activities

In the third case, making use of students' input in educational activities was in focus. The METI was already using the GMP educational framework to develop curricula with advanced use of its e-learning system to deliver courses across the institution. Different e-learning usage levels were established, ranging from basic course information, study materials, and literature to advanced additional plugins to support the learning process either in parallel to classroom lectures or through complete distance studies. The development of the e-learning courses and platform was also part of the quality assurance system. Students, for example, provided feedback after the end of each course about the visual appearance, structure, accessibility of materials, and additional plugins. The concurrent challenge concerned developing student projects and involving them in the development of education at the METI. This challenge relates to inputting user experiences and situated development into the sustainable development of educational and technical application and institutional standards (Bolmsten and Manuel, 2020). For the METI, already for basic seafarer education, the development of analytical skills is an important part, considering the rapidly developing maritime sector and labor market. The students' projects take the form of course-based challenges wherein the students undertake inquiries and developments that, in turn, input and develop the educational activities at the METI. At a Bachelor or Master level of education, this relates to the students' thesis work and the undertaking of more advanced independent inquiries.

Overall areas of student projects concerned maritime service design, entrepreneurship, managing innovation, and business model development. In the third case, the participatory workshop techniques deployed during the MIM project provided new knowledge about the possibility of developing the students' projects related to the METI's work with the surrounding maritime cluster. The MIM project showed the possibility of how to include new cutting-edge knowledge and create synergies through new collaborations with the maritime industry and other METIs. The possibility to make use of the students' input indicates how the METI can continuously input new knowledge to inform the sustainable development of its educational and technology applications and platforms.

5 Conclusion

The results from this multiple case study improve the understanding of how research and development projects build educational and technical capacity at METIs, based on the analysis of sustainable development processes (Bolmsten and Manuel, 2020). Figure 2 summarizes the results from the three METIs.

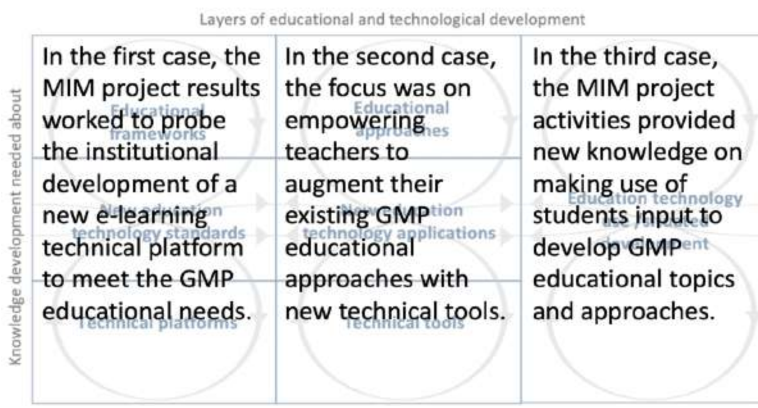

Figure 2. Summary of results in the framework on the sustainable participatory processes of education technology development (Bolmsten and Manuel, 2020).

The combined results show how a research and development project does not build *de novo* capacity but needs to relate to the *installed base* (Star and Bowker 2002) at the METIs. For this purpose, the analysis shows how it is key to understand how capacity-building occurs through situated education and technical knowledge development in layers of standards, applications, and situated development. The contribution of this multiple case study, thereby, systemizes and sensitizes how research and development projects on education technologies trigger capacity-building at METIs.

The results can strengthen the process of how the annually funded IAMU research and development projects define proposals with common objectives and work packages and how the results contribute to sustained capacity-building at the partner universities. To further develop theory and policy implications for IAMU and its member universities, it is recommended that additional case studies are added to the results of this study through new and multiple case studies (Yin 2013 2018), action research (Robson and McCartan 2016), and synthesizing the results of already published cases (Hoon 2013). The results of this multiple case study will be developed using a longitudinal empirical case study design. Based on the concurrent conceptual development of "infrastructuring" (Simonsen et al. 2020), the objective is to develop the framework of sustainable participatory processes of education technology development to determine the outcome of capacity-building projects and support the design of new ones.

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THE EVALUATION OF PROFESSIONAL PRACTICE IN MARITIME EDUCATION: A CASE STUDY AT FACULTY OF MARITIME STUDIES IN THE REPUBLIC OF CROATIA

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Abstract: Professional practice in higher education has a threefold function: it enables students to gain practical knowledge and skills needed to enter the job market, it provides employers with access to human resources, and universities offer better study programs. Professional practice at the Faculty of Maritime Studies in Rijeka (Croatia) is conducted as part of five undergraduate and five graduate study programs and is organized through activities that enable the acquisition of practical knowledge, such as laboratory exercises, simulators, polygons, practicums, practice grounds, study visits, training ship and in maritime shipping companies. The paper presents the results of research conducted within the Pandora project, funded by the European Social Fund, Operational Programme Efficient Human Resources 2014-2020. The Pandora project aimed to explore existing forms of professional practice at the Faculty of Maritime Studies Rijeka-Croatia, evaluate and make recommendations for improving existing forms of professional practice. Interview and survey methods were used for data collection. The research was conducted on 100 respondents, of which 50 respondents were students, 17 respondents were professors, and 33 respondents were maritime companies. Constructive recommendations are provided to contribute to the higher quality of different forms of professional practice. The results show that the organization of professional practice has no logistical-administrative support and is often individualized, mechanisms for the evaluation of professional practice are not established, an insufficient connection of the tripartite student-teacher-employer relationship leads to an underdeveloped mentoring system, and there is a lack of bachelor's and master's theses written in collaboration with the maritime shipping industry.

Keywords: higher education, professional practice, maritime education, experiential learning

1. INTRODUCTION

The promotion, development and continuous improvement of professional practice and practical teaching as an integral part of study programs, i.e. the acquisition of knowledge and skills through work-based learning, is an ongoing process by which the Faculty of Maritime Studies in Rijeka (FMSRI) seeks to expand the students' knowledge acquired in classical forms of teaching and at the same time to test the acquired knowledge in the work environment. Professional practice (PP) at the Faculty of Maritime Studies in Rijeka is carried out in 5 undergraduate (UG) and 5 graduate (GR) study programs within the courses and independently as stand-alone courses.

Forms of professional practice carried out at the FMSRI include both technical skills like laboratory exercises, work on various simulators, work on various computer programs but also more general educational activities such as field trips and guest lectures. Of the above forms of teaching at the FMSRI, special emphasis is placed on work on various simulators aimed at acquiring knowledge and skills about business processes on board and in port.

First and foremost, the focus of PP must be on the acquisition of practical knowledge, typically defined as a repertoire of examples, metaphors, images, practical principles, situations, and rules of thumb used in PP [1]. The aim of professional practice is to gain extensive experience working on real problems in a professional environment to improve various skills, knowledge and abilities of students [2].

The importance and role of simulators in maritime education has been proven by numerous scientific studies. The University of Minuto de Dios, Bogotá, the Technical Faculty of Munich and the University of Southeast Norway concluded that the use of simulators in maritime education and training is an essential component for the development of seafarers' competencies, noting that simulators and virtual reality facilitate the acquisition of practical skills [3]–[6]. From the Department of Science Education at the University of Genoa concluded that the practicum gradually influences students' reflective practice, which promotes the acquisition of new knowledge [4]. Findings from Edith Cowan University and the American University for International Service show that appropriately informed, qualified, interesting and engaging guest lecturers play an important role in active learning through practical examples to enhance students' competencies [7], [8]. At Bryansk State Technical Faculty and University of the Aegean it is claimed that the constant improvement of the quality of professional practice and study programs has a positive impact on the professional development of students [9], [10]. The University of Plymouth at United Kingdom is one of several educational institutions that train maritime professionals. Students on the courses use ship simulators and sail on training vessels [11]. For practical training, London John Moores University offers unique laboratories, training equipment, various simulators and a comprehensive ship simulation model that emphasizes the importance of professional practice [12].

To conclude, various forms of professional practice are carried out not only at FMSRI, but also at numerous other universities. Which forms of professional practice are carried out at a particular faculty is determined by the faculty itself, depending on the competencies they want their students to have upon graduation. For example, a student of FMSRI will find professional practice on a navigation simulator useful, while a medical student will find it completely useless for their future field of work. Due to the dynamic nature of the maritime industry, the developments achieved through problem-based learning practices in maritime education will not only help to improve the outcomes of the industry's education systems, but will also make a significant contribution to professional practice in general [13].

Forms of PP conducted outside the Faculty include training grounds, navigation on a school ship, visits to maritime companies, ports and terminals, and professional practice in maritime companies. All these forms of PP enable students to acquire and develop practical knowledge and skills. Professional practice at the FMSRI is an important part of the curriculum which, according to previous research, encourages students' creativity and facilitates the acquisition of theoretical and practical knowledge [14]–[16]. The knowledge and skills acquired in the course of study should be acceptably and effectively integrated into the business environment and ensure that future graduates are integrated into the business and work processes as painlessly and quickly as possible when they are employed [17], [18]. Such a system should allow the acquisition of new and practical knowledge specific to the work process itself, but also the acquisition of some general skills and social competences such as: adaptability, communication, teamwork, decision making, etc.

2. METHODOLOGY

Due to the awareness of the importance of the implementation of the PP in maritime education, the FMSRI, within the Pandora project, conducted an extensive research on the representation and implementation of the PP, the main results of which are presented in this paper. The paper presents a detailed analysis of the representation of professional practice in FMSRI study programs. Current study programs, previously reaccredited and accredited by the University of Rijeka, were used to prepare an analysis of the representation of PP. Data on study programs were obtained from Students' Record Office and on their basis a statistical analysis of the representation of professional practice at the FMSRI was carried out. Statistical processing of data regarding the presence of PP was performed for 5 bachelor's and 5 master's degree programs.

In addition, the results obtained based on workshops with students and teachers are presented. A total of three workshops were conducted with a total of 50 students and 17 teachers. Focus group interviews - teachers and students - were conducted at the workshops. The aim of the interviews was to gather opinions and attitudes towards satisfaction with the implementation of PP. The forms of PP that the students evaluated were navigation practice, work on a simulator, work on a training ground/ practicum, field trips, professional practice in maritime companies and guest lectures. The survey took an average of 10 minutes per participant. The answers were recorded in writing.

A survey method was used to collect the opinions of maritime companies on ways to improve professional practice. The questionnaire contained 27 questions, 11 of which required a short answer from the respondents, 12 multiple choice questions and 4 questions rated on a scale of 1 to 5. The questionnaire was completed by 33 companies. Based on the processed data from the questionnaire, a SWOT analysis was developed that identifies strengths and opportunities for improvement PP as well as weaknesses and threats that make it difficult for the FMSRI to achieve the desired goals.

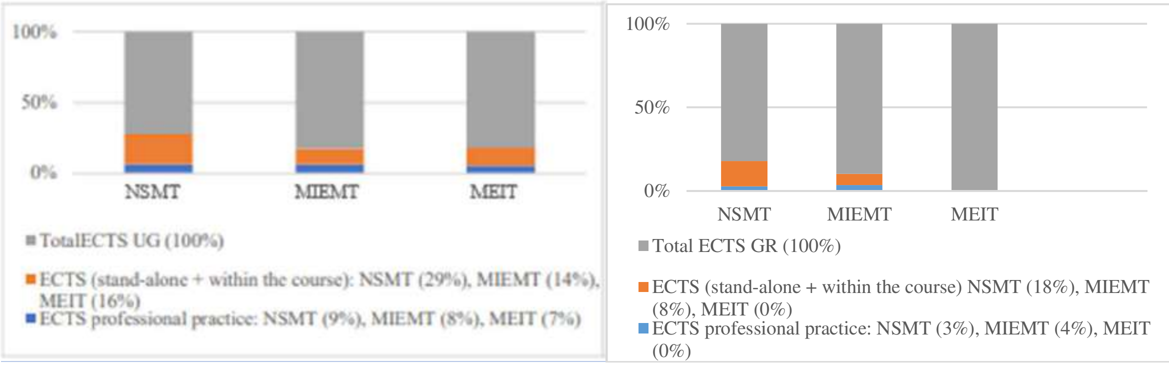
The detailed abbreviations and definitions used in the paper are listed in Table 1.

Table 1 List of abbreviation and acronyms used in the paper

ABBREVIATION	DEFINITION
FMSRI	Faculty of Maritime Studies in Rijeka
PP	professional practice
UG	undergraduate
GR	graduate
NSMT	Nautical Studies and Marine Transport Technology
MEMT	Marine Engineering and Maritime Transport Technology
MEIT	Marine Electronic Engineering and Information Technology
STCW 1978	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
TOT	Technology and Organization of Transport
LMIT	Logistics and Management in Maritime Industry and Transport
ECTS	European Credit Transfer and Accumulation System

3. REPRESENTATION OF PROFESSIONAL PRACTICE BY STUDY PROGRAMS AND LEVELS OF STUDIES

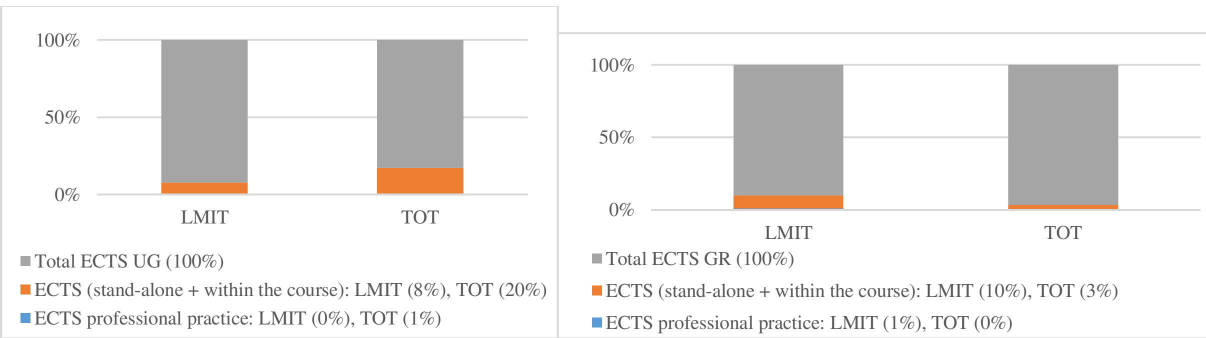
Professional practice in the FMSRI is part of 5 undergraduate and 5 graduate level of study. The degree programs Nautical Studies and Marine Transport Technology (NSMT), Marine Engineering and Maritime Transport Technology (MEMT), and Marine Electronic Engineering and Information Technology (MEIT) train students to work aboard ships as deck officers, engine officers, and electrical engineering officers. These fields of study are harmonized and compatible with the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW 1978). The FMSRI also includes fields of study that educate students for land-based professions through the programs Technology and Organization of Transport (TOT) and Logistics and Management in Maritime Industry and Transport (LMIT). A detailed analysis of the representation of professional practice in the study programs of FMSRI is presented below.



(a) (b)

Chart 1 Representation of PP within NSMT, MEMT, and MEIT programs at (a) undergraduate level; (b) graduate level.

Chart 1a shows that the percentage of European Credit Transfer and Accumulation System (ECTS) of all courses that conduct PP (stand-alone and within courses) at the undergraduate level of study, by study program, is as follows: NSMT (29%), MEMT (14%), and MEIT (15%). Looking at the proportion of ECTS related solely to PP in relation to the total number of ECTS at undergraduate level, the proportion of PP is as follows: NSMT (9%), MEMT (8%) and MEIT (7%). From the presented chart 1b, the percentage of ECTS of all programs that carry out PP (stand-alone and within courses) is for: NSMT (18%), MEMT (8%) and MEIT (0%). Looking at the percentage of ECTS related solely to PP relative to the total number of ECTS at the graduate level of study, the percentage of PP by program of study is: NSMT (3%), MEMT (4%), and MEIT (0%).



(a) (b)

Chart 2 Representation of PP within the LMIT and TOT programs at (a) undergraduate level; (b) graduate level

Chart 2a shows that the percentage of ECTS of all programs that conduct PP (stand-alone and within the course) is for undergraduate programs: LMIT (8%) and TOT (20%). On the other hand, if we consider the proportion of ECTS related solely to PP in relation to the total number of ECTS at undergraduate level of the program, the proportion of PP is: LMIT (0%) and TOT (1%). Chart 2b shows that the percentage of ECTS of all courses that include PP (stand-alone and within course) at the graduate level of study program is: LMIT (10%) and TOT (3%). Looking at the percentage of ECTS related solely to PP relative to the total number of ECTS at the graduate level of the program, the percentage of PP is: LMIT (1%) and TOT (0%).

The results of the detailed analysis indicate the following: insufficient representation of professional practice at the FMSRI, especially in the areas that educate students for land-based professions, and insufficient evaluation of professional practice carried out within the courses.

4. GUIDELINES FOR IMPROVING PROFESSIONAL PRACTICE

The aim of the interviews at the workshop with students and the questionnaire sent to maritime companies was to conduct a detailed analysis of all forms of PP in different study programs at the FMSRI and later to develop guidelines for their improvement at the workshop with professors. The questionnaire sent was used to gather employers' opinion about the current way of conducting the professional practice, possible ways of improvement and their opinion about the students coming to their company to complete the professional practice and the competencies required for the PP. The main research findings are presented below.

4.1. GUIDELINES OBTAINED BY THE METHOD OF INTERVIEW IN WORKSHOPS WITH STUDENTS AND TEACHERS

The students' opinions are summarized below and presented in Table 2.

Table 2 Summarized students' opinions after the workshop.

TYPE OF PP/ STUDY PROGRAM	**Navigation practice**	**Work on the simulator**	**Work on the training ground / practicum**	**Field trips**	**Professional practice in maritime companies**	**Guest lectures**
LMIT, TOT	POSITIVE: x	POSITIVE: x	POSITIVE: x	POSITIVE: - visits to various ports and terminals - useful and interesting - increased student-professor communication	POSITIVE: x	POSITIVE: -new and useful information -easier acquisition of practical knowledge -interesting lectures and examples of
	NEGATIVE: - missing	NEGATIVE: - only in the 2nd year of graduate study	NEGATIVE: - missing	NEGATIVE: - insufficient frequency - unprofessional guidance	NEGATIVE: - missing - insufficient readiness for the job market.	NEGATIVE: x
NSMT, MEMT, MEIT	POSITIVE: -acquired practical knowledge - teamwork -insight into ship systems	POSITIVE: - increased skills - facilitated acquisition of theoretical material - availability	POSITIVE: - useful - instructive and interesting - new knowledge and skills gained	POSITIVE: - interesting, useful and instructive - facilitates the acquisition of practical knowledge - well organized	POSITIVE: x	POSITIVE: - facilitates the acquisition of new knowledge - received numerous tips - interesting and instructive
	NEGATIVE: - short duration - insufficient preparation in class	NEGATIVE: -short duration -insufficient number of simulators	NEGATIVE: - short duration	NEGATIVE: - short duration - only theoretical part -lack of practical part	NEGATIVE: - lack of competences which would be remedied with PP	NEGATIVE: - short duration - only theoretical part

						- lack of practical part

Guidelines for improving certain modalities of professional practice were obtained based on students' opinions and then analyzed and synthesized in the workshop with professors according to the form of professional practice.

Guidelines for improving Navigation practice:

- it is necessary to increase the duration, i.e., the days of stay on the school ship
- it is necessary to improve the laboratory exercises at the faculty to better prepare the students for navigation practice
- it is necessary to offer more practical work at Faculty
- in study programs that do not go on a navigation practice it is necessary to organize field trips to the shipyard and / or to the ship

Guidelines for improving the work of the simulator:

- it is necessary to increase the duration
- it is necessary to increase the number of courses with simulator work
- it is necessary to provide more different simulators
- it is necessary to reduce the number of students per group to increase the quality of teaching.

Guidelines for improving work on the training ground/practicum:

- it is necessary to increase the duration, i.e., the days of the students' stay
- there is a need to include this form of PP in the LIMT and TOT study programms

Guidelines for improving field trips:

- it is necessary to organize more frequent field trips
- it is necessary to organize the field trips better and to include more practical work
- they should be led in the future by port or terminal staff and not by professors

Guidelines for improving professional practice in maritime companies:

- it is necessary to organize PP to increase students' skills and readiness to enter the labor market and perform work tasks

Guidelines for improving guest lectures:

- it is necessary to organize a larger number of guest lectures
- it is necessary to organize guest lectures based on practical knowledge

4.2. GUIDELINES OBTAINED ON THE BASIS OF A SURVEY QUESTIONNAIRE SENT TO MARITIME COMPANIES

The Faculty of FMSRI conducted a survey as part of the project PANDORA. Based on the completed questionnaires, the opinions of the employers who participated in the survey were presented and then analyzed. The most interesting results are presented below.

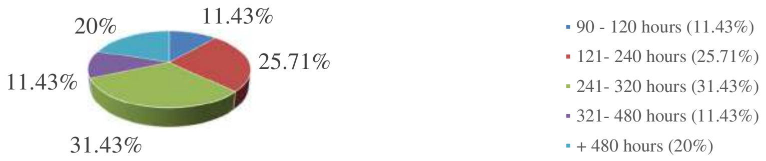


Chart 3 Optimal duration of professional practice

Chart 3 shows the opinions of the surveyed companies regarding the optimal duration of PP to familiarize students with the company's business processes. For 11.43% of the respondents, the optimal time is between 90 and 120 hours. The percentage of companies who think it is sufficient between 121-240 hours is 25.71%. 241-320 hours is the choice of the largest number of companies, 31.43%. The percentage of companies that think it takes between 321-480 hours of practice is 11.43%, and 20% think it takes more than 480 hours to familiarize a student with the company's business processes. Moreover, 97.14% of employers think that the course of PP should be compulsory during the study, while 2.86% disagree.

Chart 4 Criteria for selecting students for professional practice

Chart 4 shows the opinion of the companies surveyed on the criteria for selecting students who would undertake a PP in their company. Firstly, 88.57% are of the opinion that the selection of students should be based on the assessment of the students in the interviews. The average grade as a criterion is mentioned by 2.86% of the companies and 8.57% are of the opinion that selection should be done based on certain other criteria which are not known. None of the respondent companies mentioned work experience as a criterion. Considering that even 88.57% of employers think that assessment in interviews is the most important criterion for selecting students, it is not surprising that 85.71% of them want to be involved in selecting students for internships.

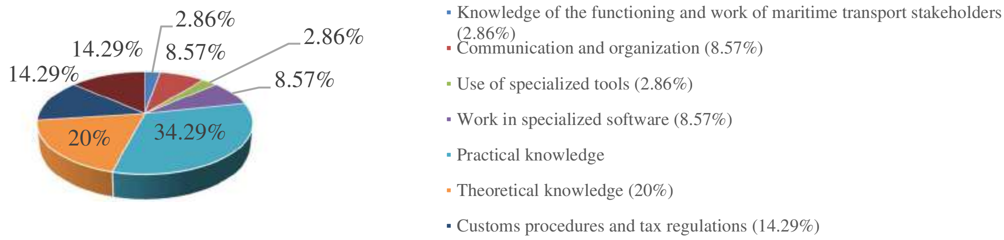


Chart 5 Knowledge that needs to be supplemented within study programs

It is evident from Chart 5 that the largest percentage, 34.29% of the respondents are of the opinion that practical knowledge should be supplemented. This is followed by theoretical knowledge which 20% of the companies feel needs to be supplemented. Knowledge of customs procedures and tax regulations should also be supplemented according to 14.29% of the respondents. The same percentage of companies did not respond or could not determine a specific area of knowledge that should be supplemented. Furthermore, 8.57% of the companies consider that it is the knowledge area of communication and organization, and the same percentage of the companies consider that working with specialized software is a knowledge area that should be supplemented. The use of special tools is a knowledge area that 2.86% of the companies consider to be complemented and the remaining 2.86% believe that it is knowledge about the functioning and work of maritime transport stakeholders.

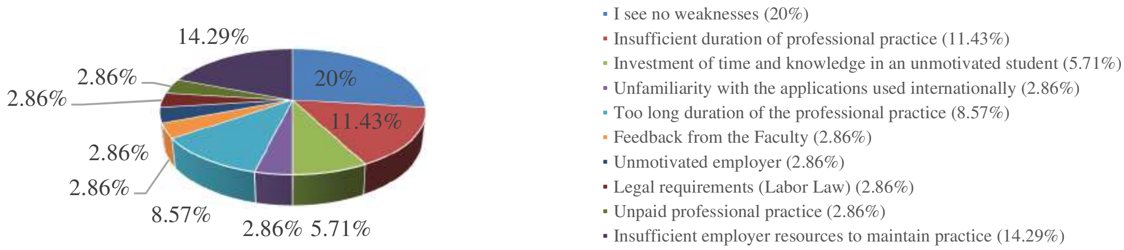


Chart 6 Disadvantages of conducting professional practice

Chart 6 expresses the opinion of employers on the main shortcomings in the implementation of the SP. The largest number of respondents, 20%, see no weaknesses in the implementation of PP. The main drawback for 14.29% of employers is the lack of resources to maintain the professional practice. Insufficient duration of the PP is the main disadvantage for 11.43% of the companies and 8.57% of the companies consider the duration of the PP to be too long. For 5.71% of the companies, the main disadvantage is the investment of time and knowledge in unmotivated students. Unfamiliarity with internationally used applications is a disadvantage for 2.86% of companies, while 2.86% of companies believe it is faculty feedback, i.e., lack of it. Unmotivated employers are the main drawback for 2.86% of the companies, legal requirements for 2.86% of the companies as same as unpaid professional practice.

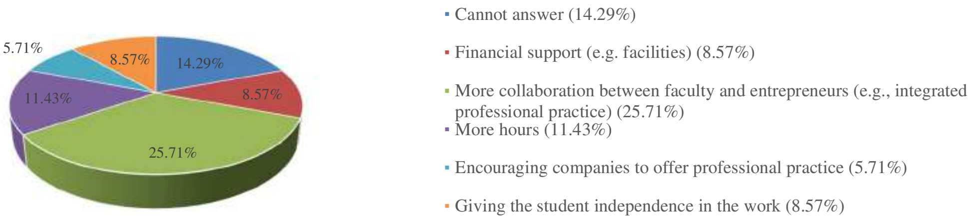


Chart 7 Ways to improve professional practice according to the opinions of employers

Chart 7 shows the opinions of employers about ways to improve PP. 25.71% of them believe that one of the possible ways to improve PP is greater collaboration between faculties and entrepreneurs. A larger fund of hours of PP is the opinion of 11.43% of the companies. Giving students independence in work is a way to improve it according to 8.57% of companies. Encouraging companies to provide internships for students is the opinion of 5.71% of the companies, while 14.29% of the companies could not give an answer to this question.

5. SWOT ANALYSIS

Based on the obtained data, the FMSRI can use the SWOT analysis as a starting point within their own strategic thinking on improving professional practice. The analysis of the obtained research results as the main strengths and weaknesses (internal factors) and opportunities and threats (external factors) are presented in Table 3.

Table 3 SWOT analysis of professional practice at the Faculty of Maritime Studies in Rijeka

STRENGTHS	WEAKNESSES
- Diversity of forms of professional practice undertaken within study programs - Recognizability and uniqueness of most study programs - Qualified teaching staff - Many experts from industry are involved in teaching - International mobility of staff and students - Many different simulators for acquiring practical skills in the study programs: NSMT, MEMT, MEIT - Use of e-learning systems - Continuous investment in equipment - Close cooperation with the business community - Continuous training of professors for the use of special tools - Sources of funding from EU funds - Continuous investment in equipment - Training grounds outside the faculty - Use of the ship "Kraljica mora" for professional practice	- The organization of PP has no logistical and administrative support - Inadequately developed models of student practice in all study programs - Mechanisms for evaluating PP are not established - Insufficient interest of employers in the implementation of PP - Underdeveloped mentoring system - Lack of master's and bachelor's theses prepared in collaboration with companies - Financial constraints in obtaining equivalent complementary systems to acquire practical knowledge and skills - Lack of systematic linkage in the employer-teacher-student triangle - Inadequate number of teachers involved in the implementation of PP - Inadequate attendance and activity of students in class
OPPORTUNITIES	**THREATS**
- Willingness of employers to collaborate with the Faculty of Maritime Studies in implementing professional practice - Willingness of employers to cooperate in establishing criteria for selection of candidates - Availability of EU funding - Development of modern technology to support the teaching process - Demand of the labor market for employees with specific professional skills	- Shortage of employees on the labor market - Unstable epidemiological situation - Growth and intensification of competition in the field of higher education - Rapid obsolescence of technology - Dominant share of micro and small entrepreneurship, because of international segmentation of the maritime market

- Cooperation with alumni of the Faculty - The desire of employers to hire the best students - The possibility of increasing the number of hours of the PP - Most employers do not have students at the PP	- Limitation of space for mass placement of students into professional practice in maritime companies - Lack of time for employers to devote to students

6. CONCLUSION AND DISCUSSION

Based on the research and analysis carried out in the project PANDORA, the existing forms of implementation of professional practice at the Faculty of Maritime Studies were identified, the representation of professional practice in the curricula by all study programs and study levels carried out at the Faculty of Maritime Studies was analyzed, the students' satisfaction with the current forms of PP according to the currently available data, the documentation of PP was analyzed and the shortcomings and limitations in the implementation of professional practice were identified. During the workshop with the students, the students' opinions were collected and then analyzed in a workshop with the professors. After the workshops, the guidelines for improving PP were developed, which will serve as steps to improve professional practice. Based on the opinions of employers collected through the questionnaire, it was found that most companies do not have students in professional practice. Those who have internships say that they want to give students the opportunity to gain professional experience, while most companies that do not have interns agree that they cannot involve students in their daily work.

Most of the companies surveyed believe that internships should be mandatory for students during their studies. Various criteria related to professional practice were also mentioned by employers. In addition, employers have emphasized that they would prioritize interview skills over grades when hiring applicants. Study programs should hold more frequent workshops, such as "How to shine in a job interview?" or "Psychological factors in job interviews" to improve the interview skills of students entering the job market. Also, respondents expressed their opinion on the necessary knowledge and skills that they consider important for the quality of PP and the knowledge and skills that the faculty should complement. They expressed their opinions on the shortcomings in the implementation of professional practice, which provided direct insight into the areas of knowledge and skills that should be part of new programs and/or the improvement of existing programs. In addition, the companies expressed interest in possibly collaborating with FMSRI on specific activities and expressed personal opinions about what professional practice should look like.

The results show that the organization of professional practice lacks logistical-administrative support and is often individualized, that mechanisms for evaluating PP are not established, making it difficult to implement PP, that the inadequate linkage of the tripartite student-teacher-employer relationship leads to an underdeveloped mentoring system, and thus a lack of bachelor's and master's theses written in collaboration with the maritime industry.

Based on the data obtained directly from companies that carry out and / or would carry out professional practice and those obtained during the workshops, a starting point for further training and design of professional practice at the FMSRI was obtained, which can greatly influence the quality of professional practice, but also the satisfaction of all participants in the process of carrying out professional practice.

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THE FACTORS AFFECTING THE MET INSTRUCTORS' EFFICIENCY

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The instructors who teach professional courses at maritime education and training institutions play an important role in the process of acquiring new and/or upgrading existing competences of seafarers. Both the instructors' and the seafarers' standards of competence must meet the requirements of the STCW Convention. The implementation of the education system that complies with these requirements is responsibility of each Party of the STCW Convention. If there are discrepancies, the maritime education and training system will not deliver intended learning outcomes, with highly probable negative impact on the motivation of learners and teachers participating in the process. The IMO has identified the problem and supported development of the different IMO Model Courses to help the instructors at MET institutions to deliver the curriculum in accordance with expectations.

The main goal of the research presented in this paper was to identify the current situation and the key factors that influence the learning outcomes in different countries. The research lasted one year, from January 2019 through January 2020. It included 113 MET instructors from 26 countries. All the data were collected by means of a questionnaire.

For the purpose of this paper, the key factors affecting the intended learning outcomes have been divided into two main categories: the factors referring to the MET instructors and those referring to the trainees. The organisational segment (duration, costs of education process, etc), although indirectly influencing the intended learning outcomes, has not been analysed in this paper.

The key factors identified as relevant for instructors' competences are sea service time, and additional training (both professional and educational). The factors referring to the trainees' competencies are their personality and cognitive abilities of a person or a group, motivation and communication skills. The last part of the research deals with opinions of the MET

instructors regarding the usability of the IMO Model Courses as a practical tool in MET processes.
The paper presents the findings of the research but also indicates the most important conclusions and recommendations supported by the findings.

Keywords: STCW, IMO Model Courses, Competences, MET instructors

1. Introduction

The International Unification Standards of Maritime Education and Training (MET) programs is vitally important for the seafarers' knowledge, skills, and competence. Training and assessment requirements for the qualification of instructors and assessors in MET are specified in the STCW Regulation I/6 of Chapter I – General Provisions, and Quality Standards in the STCW Regulation I/8. The mandatory technical standards are contained in Part A of the STCW Code STCW 78/95 [6]. Guidance regarding training, assessment and quality standards is specified in the non-binding Part B of the STCW Code that provides effective suggestions for member states in terms of best compliance with certain requirements. The requirements of the STCW convention are quite general, thus it is on each Party to assess the instructor's competences. The same applies to the choice of the quality standard model.

The Administration of each Party shall decide which model to apply, but should incorporate quality policy, quality management, quality system coverage, quality control, quality assurance processes and periodic external quality evaluation. Quality standard system requirements shall apply to all the stakeholders involved in the implementation and activities of the STCW Convention including MET institutions, administrations, ship operators, assessment of competences, certification, endorsement or revalidation of certificates [3]. In accordance with the principle of autonomy, each higher education institution can choose a quality assurance system suitable to their needs [15]. The International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) form a specialised system for standardisation. They collaborate with national bodies in the particular fields of activity and set the standards for institutions [11, 12, 16]. Most MET institutions use a quality standard model according to or related to a certain ISO quality model [14]. Quality assurance in MET consists of the following three elements: l) the proposed curriculum 2) teaching methodology and assessment and 3) adequate resources [13]. A comprehensive and proper adoption of IMO Model Courses could help to effectively implement the STCW Convention and support training providers and competent teaching staff in designing and delivering new training courses. International Maritime Organization (IMO) enforced model courses as an aid to instructors and trainers in their work [5, 16, 17]. IMO Model Course 6.09 includes planning and preparation for effective teaching, methods and instructions, and evaluation of the teaching and learning process or responsibility of instructors. Specific IMO Model Courses (1.30, 3.12, 6.10) could help instructors prepare and conduct the official assessment of seafarers' competence [3, 4, 7, 8, 9, 10, 16]. To investigate crucial factors affecting MET instructors and current global requirements for maritime university and training centres, the authors prepared a survey questionnaire entitled ”Assessment for adequately qualified instructors in MET institutions”.

2. Research Methodology

The authors conducted a survey to determine the current situation and the factors affecting the MET instructors' efficiency within institutions. The data were collected by means of a survey questionnaire designed by the authors. It was based both on literature review and authors' experience and expert opinions. Participation in this study was anonymous and voluntary. Before the final survey, a pilot survey was prepared to avoid response bias. The authors did not offer any incentive since it could result in speed runs of some respondents. All questions within the survey were as neutral as possible to avoid stereotype bias. A survey questionnaire was available at Google Forms, through various on-line channels, social media networks, and in a paper form. It was disseminated to different MET institutions with the aim to compile answers from as many institutions as possible. The questionnaire was available from January 2019 through January 2020. The questionnaire contained a total of 20 questions designed to gain insight into the MET instructors' opinions and attitudes. The respondents for this study were instructors working at MET institutions. The survey questions were demographic, open and closed-ended, simple yes and no/I do not know questions and five-point Likert scale questions. The first 5 questions were demographic to determine the general profile of participants. The other 15 questions (Q1 to Q15) were designed to obtain information on respondents' experience and observation regarding courses, training and the teaching process. To pool opinions relevant for the discussion in terms of gaps occurring within institutional procedures or the reasons for potential problems arising during the training process, the authors based their questions on the practical aspect and the quality method tools.

Most of the academic and non-academic ranks represented in the survey were aged between 35 and 55 (59.3%). Academic ranks were Full Professor, Distinguished Professor, Associate Professor, Assistant Professor, Lecturer and Assistant employed at different Faculties of Maritime Studies or Universities. Non-academic ranks in the maritime training centres were Training instructor in the maritime training centre and Marine training development superintendent working in maritime training centres.

3. Results and Discussion

This section contains the main findings obtained for each question along with the related discussion. The authors presented the results in a group of questions to facilitate the presentation and understanding. Table 1 presents respondents' demographic data.

Table 1. Demographic questions

Questions	Offered answers	Percentage
Age of respondents	*24 and younger*	*0%*
	25 – 34	*14.2%*
	35 – 45	*34.5%*
	46 – 55	*24.8%*
	56 and older	*26.5%*
Academic rank or position	*Maritime lecturer*	*23%*
	Full professor	*19.5%*
	Assistant	*16.8%*
	Assistant professor	*15.9%*
	Training instructor	*15%*
	Distinguished professor	*6.2%*
	*Others**	*3.6%*
Course trainer or assessor at	*Faculty of Maritime Studies*	*82.3%*
	Maritime High School	*13.3%*
	Maritime Training Centre	*30.1%*
Certificate of Competency (CoC)	*Master*	*38.9%*
	Chief Eng.	*11.5%*
	Chief Off.	*9.7%*
	OICNW (Officer in charge of navigation watch) (OICNF)	*17.7%*
	*Other***	*11.5%*
	*No rank****	*10.7%*

* Relatively small sample of participants (PhD research fellow, Marine training development superintended, Associate Professor) does not significantly change the results of survey.

**Relatively small sample of participants (Electro Technical Officer, Second Engineer, Officer in charge of an engineering watch (OICEW)

***Non response

A total of 113 instructors of different nationalities and ranks working in MET institutions responded to the survey. The nationalities of respondents were the following: Croatian, Turkish, Montenegrin, Panamanian, Singaporean, British, Latvian, Indonesian, Polish, Italian, Russian, Spanish, Japanese, Georgian, Filipino, Swedish, Vietnamese, German, Canadian, Peruvian, Egyptian, Bangladeshi, French, Dutch, Norwegian and Indian. As shown in Table 1, from the total number of participants (26 countries), 81.4% were scientific or academic ranks in MET institutions, 15% were the training instructors in MET and 3.6% were others. The age distribution of 34.5% of instructors was between 35 and 45. As for employment, 82.3% were employed at the Faculty of Maritime Studies, 30.1% in Maritime training centre and 13.3% in Maritime High school. The capacity in which the holder of a certificate is authorised to serve showed that the majority of respondents held CoC Master Licence.

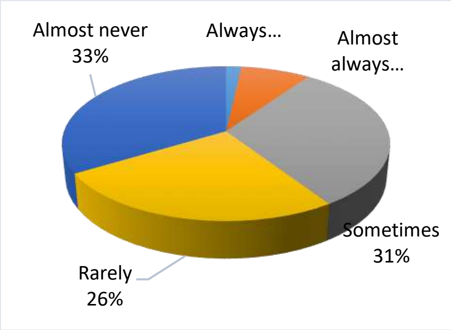
Respondents sea experience and additional education are presented in Table 2.

Table 2. Sea experience and additional education

Questions	Offered answers	Percentage
Q1: How long have you been holding classes?	*Less than a year*	*1.8%*
	1 – 5 years	*25.7%*
	5 – 10 years	*28.3%*
	More than 10 years	*44.2%*
Q2: Do you have any navigational experience?	*Yes, more than 10 years*	*37.2%*
	Yes, 5 – 10 years	*18.6%*
	Yes, 1 – 5 years	*21.2%*
	Yes, less than 1 year	*5.3%*
	No	*17.7%*
Q3: Have you sailed on ships of 3000 GT (3000 kW) or more in last 5 years and how long?	*More than 1 year*	*24.8%*
	6 months – 1 year	*9.7%*
	Less than 6 months	*8%*
	I have not	*57.5%*
Q4: Have you received any additional training on other institutions since the day of your employment? How long?	*More than 1 year*	*31%*
	6 months – 1 year	*7%*
	3 – 6 months	*8%*
	Less than 3 months	*23.9%*
	No	*30.1%*
Q5: Have you attended any of the courses for seafarers since the day of your employment?	*Yes, more than 5*	*32.8%*
	Yes, 5 courses	*5.3%*
	Yes, 4 courses	*9.7%*
	Yes, 3 courses	*11.5%*
	Yes, 2 courses	*10.6%*
	Yes, 1 course	*5.3%*
	No	*24.8%*

As shown in Table 2, the question *How long have you been holding classes* (Q1) illustrates that 44.2% of respondents have held classes for more than 10 years, 82.3 % of respondents had prior sailing experience, while 42.5% of respondents have had sailing experience in the last 5 years (Q2 and Q3). Responses to the question *Have you received any additional training on other institutions since the day of your employment* (Q4) show that MET institutions tend to send their teaching instructors (69.9%) to other institutions for additional training, while 30.1% do not do that. This corresponds to answers to the question *Have you attended any of the courses for seafarers since the day of your employment* (Q5), where respondents stated that 24.8% of them have never attended any courses since the first day of their employment.

In the questions *Have you noticed any problems during the courses (e.g. attendees disrupt the classes, etc.)* (Q6) and *Can you guess the reasons for that kind of behaviour* (Q7), presented in Figure 1, respondents were asked to tick if they had noticed any problems during their courses in terms of disruptions and to tick the possible reasons for that.



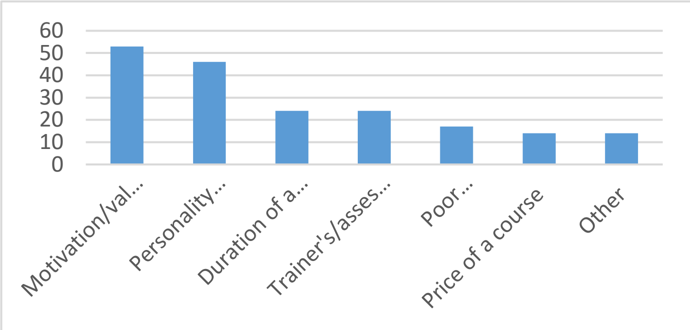


Figure 1. Problem notification (Q6 and Q7) during the courses and the most frequent causes

Figure 1 shows that 67% of maritime instructors have noticed some problems. The main causes of disruptions during courses were first of all motivation, then personality and cognitive abilities, duration of courses, instructor’s competence, poor communication skills and the price of courses. It can be proposed that each institution has to look into other factors affecting motivation and try to find the best solution for improvement. These factors can be prejudice, instructor’s (in)competence, insufficient education in teaching and practice methods, long duration of the courses and high prices etc. It is well known that all topics covered by the STCW Convention Part A have to be presented to trainees, but the time frame depends on each Party. Part B of the STCW Convention recommends the adequate use of IMO Model Courses with a recommended time line for each topic.

IMO Model Course(s) could serve as a tool and thus assist in the preparation of training courses. The model course programs are neither mandatory nor supposed to be a *blindly followed teaching package* that instructors must abide by. The reason for this lies in the fact that educational systems vary in each country with different cultural background. The following courses include the teaching methods and factors relevant to the efficient teaching process. IMO Course 6.09 includes the planning and learning environment, training aids, teaching activities, subject related planning strategies, teaching and learning evaluation, and assessment techniques (IMO 2017c) [7]. IMO Model Course 6.10 provides necessary knowledge and skills in instruction techniques using simulators. The importance of teaching and evaluating using the approved simulators was specified in the STCW 2010. The simulator instructor should be a facilitator, dedicated teacher, manager, flexible and adaptable, learning strategist and organiser, motivator and native psychologist [8]. IMO Model Course 1.30 On board assessment and 3.12 Assessment, examination and certification of seafarers could be directly relevant for experienced shore-based instructors with sufficient on board experience and for the MET staff who hold examinations for Certificates of Competency (CoC) and other documents [9, 10, 16].

Responses to question Q9 referring to IMO Model Courses will be presented in the following part. The first question was: *Please tick the courses you have attended* (Figure 2). As analysed and presented in Figure 2, from the total number of 113 respondents, 49 (43.4%) of them never attended any of the courses above. IMO Model Course 6.09 was attended by 54 (47.7%) respondents, while 22 (19.4%) respondents attended only that course. IMO Model Course 6.10 was attended by 36 (31.8%) respondents and 13 (11.5%) respondents attended only 6.09 and 6.10 Courses. Furthermore, IMO Model Course 1.30 was attended by 9 (8%) respondents and IMO Model Course 3.12 by 21 (18.6%) respondents. The second question pertaining to IMO Model courses was the following: *Do you use adequate IMO Model courses when organising and holding training* (Q10). As shown in Table 3, the highest number of respondents (42.5%) use adequate IMO Model Courses when organising and holding training.

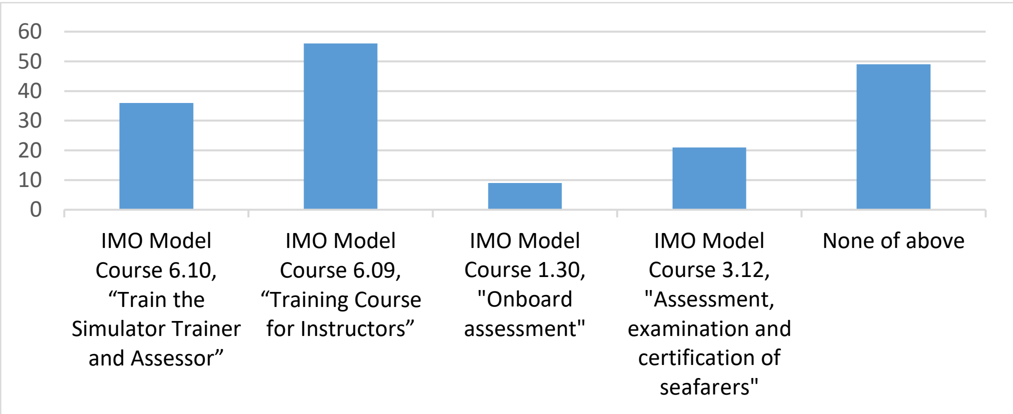


Figure 2. Instructor attendance to IMO Model Courses (Q9)

Table 3. Survey results Q10-Q14

Question	Offered answers	Percentage
Q10: Do you use the adequate IMO Model courses when organising and holding training?	*Always*	*42.5 %*
	Often	*27.4 %*
	Sometimes	*21.2 %*
	Never	*8.8%*
Q11: Have you ever used a simulator as a necessary part of the teaching program?	*Yes*	*82.3 %*
	No	*17.7 %*

Q12: Are you satisfied with the available teaching materials you use?	*Yes*	*72.6 %*
	No	*27.4 %*
Q13: Do you think that trainers should be more familiar with the implementation of IMO Model Courses prescribed by the STCW Convention and its annexes?	*Yes*	*81.4 %*
	No	*18.6 %*
Q14a: Do you evaluate your teaching?	*Yes*	*94.7 %*
	No	*5.3 %*

As for the question *Have you ever used simulator as a necessary part of the teaching program* (Q11), 82.3% of respondents use a simulator when teaching. Since only 36 respondents (33% of the total number) attended IMO Model Course 6.10 (pertains to simulator training), this should be introduced as a teaching aid. In their answers to the question *Are you satisfied with the available teaching materials you use* (Q12), respondents stated they were generally satisfied (72.6%) with the teaching materials. For those who were not (24%), it is highly recommended to elaborate on their problems. Responses to the question *Do you think that trainers should be more familiar with the implementation of IMO Model Courses prescribed by the STCW Convention and its annexes* (Q13) suggest that IMO Model Courses should be more straightforward so that those who use them become easily familiar with them. IMO model Courses propose teaching aids, IMO references and Publications to provide a competence based course. Furthermore, IMO Model Courses welcome users to provide feedback to keep the training programme up to date.

To meet STCW Requirements, every Party will propose the standards of competence for instructors. These requirements are defined under Regulation A-I/6 (Training and Assessment), A-I/8 (Quality standards), A-I/12 (Standards governing the use of simulators). Recommended guidance regarding proposed requirements in section B (STCW Code) can be helpful to Parties in the implementation of these requirements.

As for the question *Do you evaluate your teaching* (Q14a), the majority of respondents (94.7%) stated they evaluated their teaching process. In the following question *Please tick the box(es) with method(s) you use for evaluation* (Q14b) most of respondents (74.3%) said they used written questionnaires, followed by oral questionnaires (37.1%), and assessment by supervisor (25.6%). A small percentage of instructors (13.2%) reported they used other means of evaluation. Hence, it is evident that MET instructors use various methods to assess their work and receive useful feedback from their trainees and thus improve the weak points of the teaching process.

In the final question *For the courses prescribed by the STCW Convention (including the course that includes work on a simulator), my institution requires (circle all the answers that refer to your institution* (Q15), respondents were asked to tick all requirements that refer to their institution. Results are presented in Figure 3.

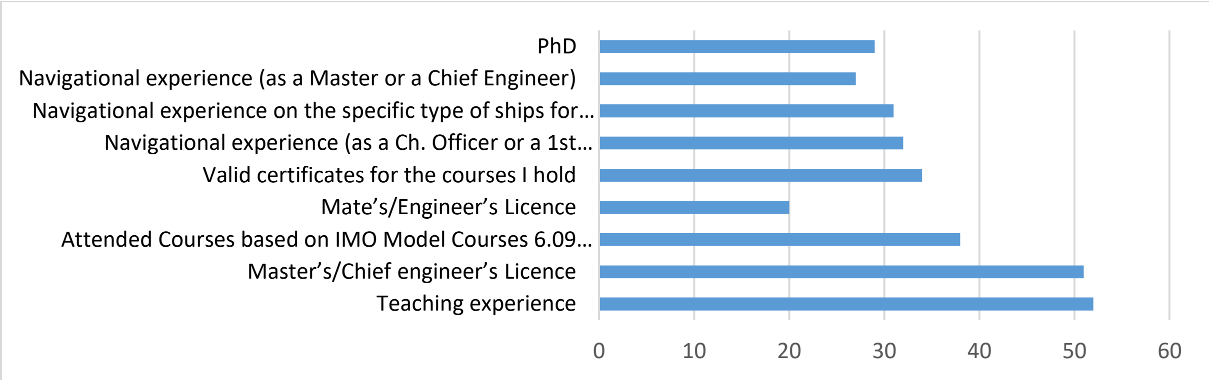


Figure 3. Competences required by MET institutions (Q15)

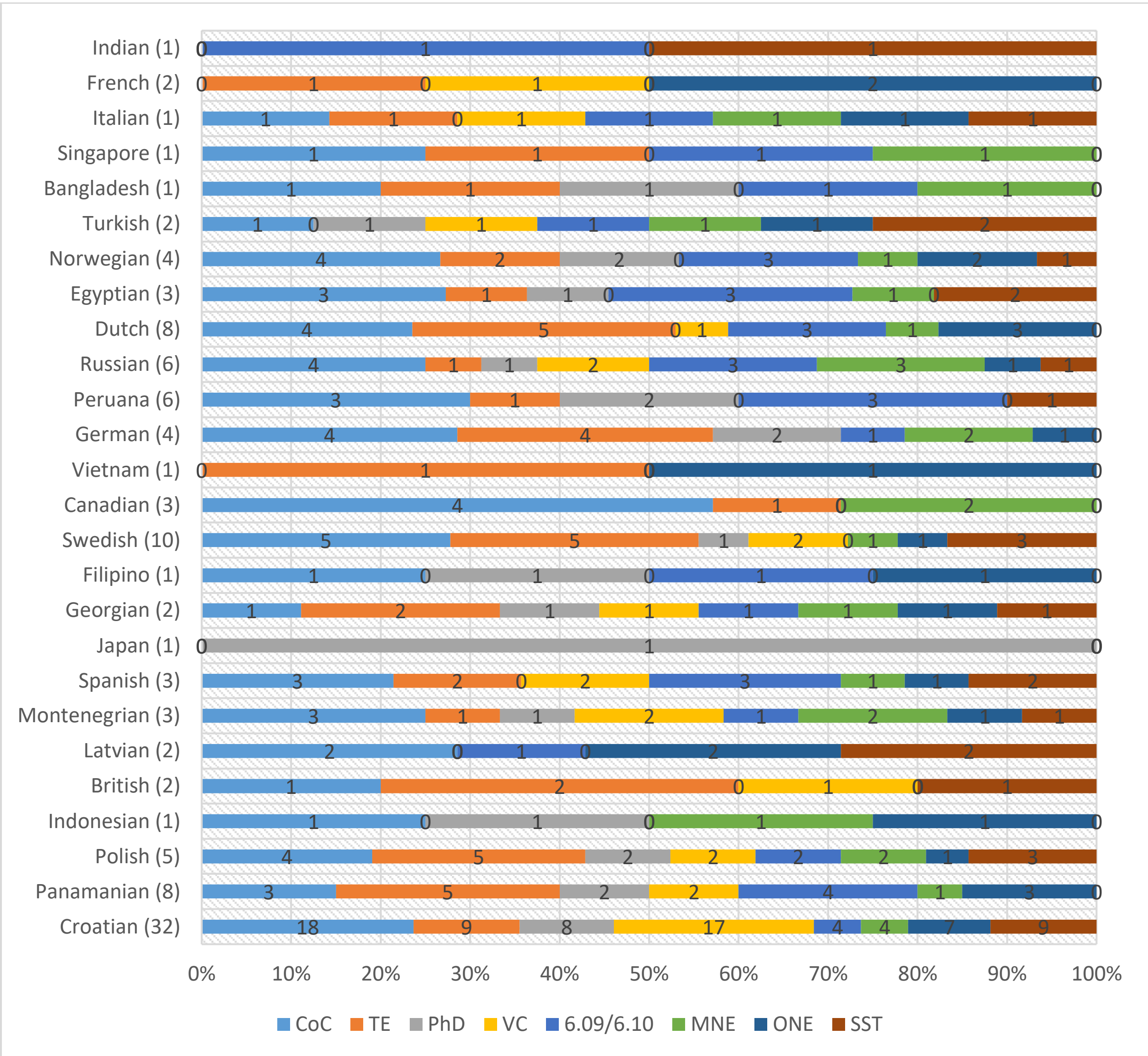


Figure 4. Competences required by Parties according to nationality

Finally, the authors made a thorough analysis (Figure 4) to get more information on the competences required by MET institutions and organised them according to respondents' nationalities. Unfortunately, there is no equal number of respondents from each Party. Numbers next to nationalities represent the number of survey participants, while numbers in bar chart show the number of participants who selected the elements from a list required by their MET institutions.

It is visible from Figure 4 that CoC (Certificate of Competency) is the most important factor, followed by the teaching experience (TE). Many institutions require the proposed IMO Model Courses and valid certificates (VC) for the specific courses. Practical navigation experience (MNE – Master with navigational experience and ONE – Officer with navigational experience) is on the same footing as academic positions. Specific ship type (SST) experience is one of the competences that has been required by some Parties when their instructors delivered specific type courses. From a total of 26 countries included in this study 84.6% require Certificate of Competency (CoC), 65.4% Teaching Experience (TE), 61.5% PhD, 50% Valid certificates for the courses they hold (VC), 73 % IMO Model Courses 6.09 and 6.10 (6.09/6.10), 69.2% Master's/Chief engineer's experience (MNE), 69.2% Mate's/Engineer's experience (ONE) and 50% Navigational experience on the specific type of ships for the courses they hold (SST).

4. Conclusion

This paper presents survey findings and results conducted to investigate the main factors that affect teaching in MET institutions. Efficient teaching in any MET institution requires elimination of all possible factors with a negative influence on the teaching process. Students' or seafarers' motivation, engagement in various tasks, good instructor's interaction with students by implementing reflective teaching practise, or appropriate transformation of instructor's practice could be a key to success.

Some limitations of this research should be noted. Proper and objective assessment of a MET instructor's competence is a sensitive and difficult task not only for Parties to the STCW Convention, but also for any MET institution. It is particularly difficult to draw conclusions without a statistical analysis that would determine the correlations between individual responses and the demographic profile of respondents and/or their competencies.

Research results point to the importance of IMO Model courses in the instructors' education, especially in terms of competence requirements presented in this research and prescribed by the majority of Parties. It is evident that STCW Parties mostly require CoC, IMO Model Courses 6.09 and 6.10, and experience on board as a Master or a Chief Engineer and/or deck or engine officer. An objective assessment of the instructor's competence can only be obtained if the quality standards system provided for in the STCW Convention is implemented in the best possible way. Factors affecting the process of knowledge transfer and the acquisition of new skills cannot be generalised as they are diversified. However, the authors suggest that those who do not have teaching experience attend courses that help acquire new knowledge regarding teaching and effective group work.

Our next step in further research shall be data analysis using adequate statistical software for descriptive statistics and Chi-square test. The research will focus on the correlations among specific groups of respondents and among specific questions.

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THE USE OF BLENDED LEARNING APPROACH TO IMPROVE THE STUDENTS' ACADEMIC PERFORMANCE IN METEOROLOGY AND OCEANOGRAPHY 1

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Keywords: quasi-experimental, blended learning, meteorology and oceanography

Abstract

This quasi-experimental study aimed to determine the effectiveness of blended learning approach to the academic performance of the first year Bachelor of Science in Marine Transportation (BSMT) students in Meteorology and Oceanography 1 at JBLFMU-Arevalo during the second semester of school year 2018-2019. The participants of this research were the two sections comparable with each other who were enrolled in the course Meteorology and Oceanography 1. There were 30 students composed of 15 in the experimental group and 15 in the control group. Validated and reliability-tested researcher-made questionnaire was utilized to gather the data needed for the study. The independent variables were the blended learning approach and the lecture-class discussion method while the dependent variable was the academic performance as scores in Meteorology and Oceanography 1. The statistical tools used were mean, standard deviation, Mann-Whitney test, and Wilcoxon-Signed ranks test set at .05 level of significance. The effect size was computed to determine the effectiveness of the intervention which is the blended learning approach to students' academic performance in Meteorology and Oceanography 1. Results showed that in the pretest, though the experimental group had a higher mean score than the control group, the Mann-Whitney test showed no significant difference in the mean scores of the two groups. When blended learning approach was introduced, findings showed that there were significant differences in the mean scores of pretest and posttest of experimental and control groups as well as in the posttests of both groups. Furthermore, a significant difference was observed between the mean gains of both groups. Lastly, the Cohen's d effect size revealed a 2.22 (>1.0) which has a very large effect size indicating that 98% of the control group (lecture-class discussion method) who are below

the average person in experimental group (blended-learning approach). This simply means that blended-learning approach is an effective way to improve students' performance in the course Meteorology and Oceanography 1. It is recommended that this approach may be utilized to complement other method of teaching and learning as well as for individual learning.

Introduction

According to Sethy (2008), everyone should adapt to the continuous change of the world. A pronounced number of studies have aimed at determining whether computer-mediated education in the form of e-learning, blended learning or hybrid learning is better than traditional face-to-face (F2F) teaching in relation to the academic performance of students in their course. However, Azizan (2010) stated that both pure e-learning and traditional learning hold some weaknesses and strengths, it is better to mix the strengths of both learning environments to develop a new method of delivery called blended learning.

The mixed learning setting to succeed in a harmonious learning equilibrium between face-to-face interaction and on-line access is crucial (Badawi, 2009).

This study is anchored under the learning theories for online education specifically the Theory of Connectivism that learning and knowledge exists within networks by George Siemens (2004). This is because this study determines the academic performance of students in Meteorology and Oceanography 1 with the use of the IDIG e-learning materials through Blackboard OLMS.

This study aimed to determine the effectiveness of blended learning approach to the academic performance of the first year BSMT students in Meteorology and Oceanography 1 during the second semester of school year 2018-2019.

Specifically, this study sought answers to the following questions:

1. What are the pretest score performance of the experimental and control groups?
2. What are the posttest score performance of the experimental and control groups?
3. Is there a significant difference in the pretest score performance between the experimental and control groups?
4. Is there a significant difference in posttest score performance between the experimental and control groups?
5. Is there a significant difference in the pretest and posttest performance of the experimental group?
6. Is there a significant difference in the pretest and posttest performance of the control group?

7. What are the mean gains of the experimental and control groups?

8. Is there a significant difference in the mean gains of the experimental and control groups?

9. How effective is the blended learning approach in terms of students' performance in Meteorology and Oceanography 1?

Methods

Research Design

The quasi-experimental method of research was employed in this study specifically the Non-equivalent Control Group design. A pretest-posttest randomized experiment was designed, but it lacks the key feature of random assignment (Trochim, 2020).

The Non-equivalent Control Group design was used because it utilized an instruction-related treatment or intervention (blended learning approach) in one student group known as experimental group but no such treatment (lecture-class discussion method) in another comparable group known as control group. Both groups were not randomly assigned but rather selected through match-group technique using the students' general weighted average of the previous semester.

The data collected from the pretest-posttest were intended to find answers to questions concerning the effectiveness of blended learning approach to the academic performance of first year BSMT students in Meteorology and Oceanography 1 during the second semester of school year 2018-2019.

Participants

The participants of this research were two sections relatively comparable first year Bachelor of Science in Marine Transportation sections of the JBLFMU-Arevalo in Iloilo City, who were enrolled in the course Meteorology and Oceanography 1 during the second semester of school year 2018-2019. They were selected through match-group design using their General Weighted Average (GWA) in the previous semester. A total of 30 students composed of 15 in the experimental group and 15 in the control group. A toss coin was used to determine the experimental and control groups. The head and the tail was assigned for experimental and control groups, respectively.

Instrument

A researcher-made pretest and posttest were used to gather data. It is composed of 60-items multiple choice test. A Table of Specification (TOS) was made to guide in constructing the instrument in Meteorology and Oceanography 1. The topics were taken from the prelim, midterm, and finals lessons. It underwent content validity from the three jurors and as well as reliability-testing through Kuder-Richardson 20 which is 0.74 using SPSS.

Data Collection

The study was conducted from November 2018 to February 2019 of the school year 2018-2019. The data needed for this study were gathered through the use of researcher-made pretest and posttest that were administered to both experimental and control groups.

During the first-class session, the researchers administered the pretest to the experimental and the control group. This first result of the pre and post-tests of the experimental and control groups was identified as the "pre-course" data.

The experimental and control groups were handled by C/M Eleuterio P. Fernandez, Instructor of the course. The blended learning group/experimental group of section Blackwall was taught such as group work, reporting, demonstration, plus online learning through Blackboad OLMS or mrooms. The topics were identified and each topic contains learning objectives, lesson proper/content, teaching and learning activities (e.g. video presentations and assignments), assessments, and references. The intervention lasted for three months and a half during the second semester of school year 2018-2019.

On the other hand, section Bowline in its non-blended learning group/control group was taught the course employing only the traditional lecture-class discussion method using the instructional/workbook for the course also lasted for three months and a half during the second semester of school year 2018-2019.

Data Analysis

The following statistical tools were used in the study:

Mean was used to determine the students' performance in the pretest and posttest. The mean scale, descriptive rating, and indicators for interpreting the pretest and posttest scores are shown in Table 1.

Table 1

Mean Scale, Descriptive Rating, and Indicators for Interpreting the Pretest and Posttest Scores

Mean Scale	Descriptive Rating	Indicators
48.04 – 60.0	Excellent	Students have mastered all the competencies
36.03 – 48.03	Very Good	Students have mastered most of the competencies
24.02 – 36.02	Good	Students have mastered at the average competencies
12.01 – 24.01	Fair	Students have mastered few competencies
1.0 – 12.0	Poor	Students have mastered very few competencies

Standard deviation was used to determine the level of the students' homogeneity in their Meteorology and Oceanography 1 performance.

Mann-Whitney test was used to determine the significant differences in the pretests and posttests between two groups in Meteorology and Oceanography 1 and for the significant difference in the mean gain of the pretest and posttest of the experimental and control groups was set at .05 level of significance.

Wilcoxon-Signed ranks test was used to determine the significant differences in the pretest and posttest of each group in Meteorology and Oceanography 1 set at .05 level of significance.

Cohen's *d* effect size was used to measure the effectiveness of blended learning approach to the academic performance of the first year BSMT students in Meteorology and Oceanography 1. This is done by using the means and standard deviations in the posttest among the experimental and the control groups.

Results and Discussion

Pretest Score Performance of the Experimental and Control Groups

Table 2 shows the pretest scores among the experimental and the control groups. Fifteen students composed the experimental group and another 15 for the control group. The experimental group's pretest means score is 29.07 while the controls group's mean score is 26.87. Both mean scores are described as "Good" which means that students have mastered at the average competencies.

It is noted that the experimental and control groups registered comparably the same mean scores in the pretest, indicating their almost identical cognitive levels before the experiment.

Table 2

Pretest Score Performance in Meteorology and Oceanography 1 of the Experimental and Control Groups

Compared Group	n	M	Descriptive Rating	SD
Experimental	15	29.07	Good	2.46
Control	15	26.87	Good	4.03

Posttest Score Performance of the Experimental and Control Groups

Table 3 shows the posttest scores among the experimental and the control group. Fifteen students composed the experimental group and 15 for the control group. The experimental group's posttest means score is 40.47 described as "Very Good" (students have mastered most of the competencies) while the controls group's mean score is 33.40 described as "Good" (students have mastered at the average competencies). This means that the experimental group manifested a higher mean score in the posttest than the control group, implying the experimental group's better performance in Meteorology and Oceanography 1 after the experiment.

Table 3

Posttest Score Performance in Meteorology and Oceanography 1 of the Experimental and Control Groups

Compared Group	N	M	Descriptive Rating	SD
Experimental	15	40.47	Very Good	3.04
Control	15	33.40	Good	3.66

Difference in the Pretest Score Performance in Meteorology and Oceanography 1 between the Experimental and Control Groups

Table 4 shows that there is no significant difference in the pretest score performance between the experimental and control groups, U=73, p=.100. This means that the result is good since the baseline data prior to the use of blended learning suggest that the students have similar intellectual capabilities which will be very vital for trying out the experimental group in the teaching approach. The data suggest that the groups are very ideal for the experiment since they possess cognitive similarities prior to the experiment.

Table 4

Mann-Whitney Test Result for the Significant Difference in the Pretest Score Performance in Meteorology and Oceanography 1 between the Experimental and Control Groups

Compared Group	U	W	Z	Asymp. Sig. (2-tailed)
Experimental Control	73^{ns}	193	-1.649	.100

Note. ns means not significant at .05 level of probability.

Difference in the Posttest Score Performance in Meteorology and Oceanography 1 between the Experimental and Control Groups

Table 5 shows that there is a significant difference in the posttest score performance between the experimental and control groups, U=14.50, p=.000. This means that the difference in scores in the posttest favor the experimental group which was taught using the blended learning approach. Hence, it is safe to say that blended learning is an effective intervention.

Table 5

Mann-Whitney Test Result for the Significant Difference in the Posttest Score Performance in Meteorology and Oceanography 1 between the Experimental and Control Groups

Compared Group	U	W	Z	Asymp. Sig. (2-tailed)
Experimental Control	14.50*	134.50	-4.084	.000

Note. Asterisk (*) means significant at .05 level of probability.

Difference in the Pretest and Posttest Score Performance in Meteorology and Oceanography 1 of the Experimental Group

Table 6 shows that there is a significant difference in the pretest and posttest score performance of the experimental group, Z=-3.413, p=.001. This means that the use of blended learning approach had increased the students' learning capability significantly.

Table 6

Wilcoxon-Signed Ranks Test Result for the Significant Difference in the Pretest and Posttest Score Performance in Meteorology and Oceanography 1 of the Experimental Group

Compared Test	Z	Asymp. Sig. (2-tailed)
Pretest Posttest	-3.413*	.001

Note. Asterisk (*) means significant at .05 level of probability.

Difference in the Pretest and Posttest Score Performance in Meteorology and Oceanography 1 of the Control Group

Table 7 shows that there is a significant difference in the pretest and posttest score performance of the control group, Z=-3.316, p=.001. This means that the control group's posttest performance is significantly better than their pretest performance. Hence, it is safe to say that the control group also learned from the traditional method which is lecture-class discussion.

Table 7

Wilcoxon-Signed Ranks Test Result for the Significant Difference in the Pretest and Posttest Score Performance in Meteorology and Oceanography 1 of the Control Group

Compared Test	Z	Asymp. Sig. (2-tailed)
Pretest Posttest	-3.316*	.001

Note. Asterisk (*) means significant at .05 level of probability.

Mean Gains of the Experimental and Control Groups

Table 8 shows the mean gains of the experimental and control groups. It shows that the mean gain in their scores in Meteorology and Oceanography 1 of the control group is lower than the experimental group.

This study supports the study of Hameed et al. (2008) wherein the efficacy of combined e-learning and traditional learning enhanced the students' performance in their course. They concluded that the blended learning approach provides the most flexible method of e-learning.

Table 8

Mean Gains of the Experimental and Control Groups

Compared Group	Pretest	Posttest	Mean Gain
Experimental	29.07	40.47	11.40
Control	26.87	33.40	6.53

Difference in the Mean Gains of the Experimental and Control Groups

Table 9 shows that there is a significant difference in the mean gains of the experimental and control groups, U=41, p=.003. This means that blended learning approach is better as compared to lecture-class discussion because students gain more understanding in Meteorology and Oceanography 1.

Table 9

Mann-Whitney Test for the Significant Difference in the Mean Gains of the Experimental and Control Groups

Compared Group	U	W	Z	Asymp. Sig. (2-tailed)
Experimental Control	41*	161	-2.983	.003

Note. Asterisk (*) means significant at .05 level of probability.

The Cohen's *d* effect size was 2.22 or greater than 1.0 which has a very large effect size (Cohen, 1988; Rosenthal, 1996) indicating that 98% of the control group (lecture-class discussion method) who are below the average person in experimental group (blended-learning approach) according to Coe (2002).

Conclusions

Blended learning is an effective intervention to improve the students' academic performance in Meteorology and Oceanography 1 over the traditional method which is the lecture-class discussion. This is evident in students' posttest performance, mean gain, and effect size. This simply means that students perform better in Meteorology and Oceanography 1 when exposed to blended learning approach.

Blended learning when compared to the virtual learning environment, blended learning offers a more successful learning experience since it contains some aspects of traditional classes.

Furthermore, examined students' view on blended learning environment and discovered that students enjoyed participating in a blended learning environment through which face-to-face classes supplemented with online classes. Moreover, the significance of communication and interaction for successful learning in online education was emphasized.

Recommendations

In assessing the findings and conclusions, the following recommendations were made:

1. The teaching instruction may not rely on the traditional method of giving instructions in relation to teach certain course. Other methods of teaching such as blended learning mode need to be introduced, where the presence of an instructor is supported by the use of modern technology, it can be accessible even at the convenient time and place of the learners or outside the four walls of the classroom.

2. Blended learning may be utilized to complement other methods of teaching and learning as well as for individual learning, particularly because students may struggle to explore the opportunities offered by blended learning and e-Learning.

3. Trainings and seminars may be conducted for instructors from time-to-time to bring up-to-date and get acquainted with latest technological innovations like blended learning. This will enable them to develop, modify and maintain the latest online learning technologies, such as blended learning and e-learning within the university system.

4. Maritime schools may embrace e-learning platforms as they may enhance students' academic performance.

Acknowledgment

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Towards improving SAR search patterns by time-minimal paths

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Abstract

In this paper, we consider improving the standard search patterns under the effect of drift with application to the maritime and aeronautical search and rescue operations, basing on time-minimal paths being the solutions to the aircraft navigation problem.

Keywords: maritime Search and Rescue (SAR), search patterns, IAMSAR Manual, time-minimal trajectory, aircraft navigation problem.

1 Introduction

The standard search patterns are included and repeated in the subsequent editions of the International Aeronautical and Maritime Search and Rescue (IAMSAR) Manual, Vol. III "Mobile facilities", e.g. an expanding square, a sector search [1]. This publication is required to be up-to-date and carried onboard the ships worldwide by the International Convention for the Safety of Life at Sea (SOLAS) [2]. Each edition (the latest in 2019) is published jointly by the International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO). The search patterns are also applied in the softwares of the modern Electronic Chart Display and Information Systems (ECDIS) installed onboard the vessels and in the professional navigational simulators; for more details see, e.g., [3]. The simulations create a significant part of Maritime Education and Training (MET), which is emphasized by the International Association of Maritime Universities (IAMU).

It can be noticed that the effect of drift caused by the water currents or winds are sometimes neglected or oversimplified. This may increase a total time of Search and Rescue (SAR) operations, if the standard patterns are used routinely, especially with a ship's trajectory referred only to a fixed ground and carelessly in the problem under consideration. According to [1], on one hand, it is advisible for vessels to use dead reckoning navigation rather than more accurate navigational methods. On the other hand, accurate navigation is required. In particular, the first leg of a search model is usually oriented directly into the wind to minimize navigational errors. Furthermore, precise search patterns navigation using high-precision methods such as global satellite navigation systems will produce good patterns relative to the ocean bottom, but not relative to the drifting search object. Roughly speaking, the common search patterns have been selected for simplicity and effectiveness. The corresponding search plan includes estimating the most probable position of a distressed craft or survivors and taking drift effect into consideration. Today, the traditional methods and approaches including the human factors and convenience, straightforward procedures, and good seamanship are confronted the artificial intelligence, machine learning and sophisticated computational algorithms that create the base for the future autonomous ships. We recall that IMO wants to ensure that the regulatory framework for Maritime Autonomous Surface Ships (MASS) keeps pace with technological developments that are rapidly evolving [4]. Furthermore, supporting search and rescue missions with Unmanned Aerial Vehicles (UAVs) is considered for various applications; see, for instance, [5, 6] in this regards.

Having in mind all the above factors, we ask whether the standard search models used in the SAR operations can be refined in order to decrease time of search, which matters decidedly. In our concept we aim at making use of the time-minimal paths, taking into account the acting perturbations (currents, streams, winds) *in situ* in addition. Such optimal paths are the solutions of the planar aircraft (Zermelo's) navigation problem. The problem is to find an optimal steering in the presence of perturbing vector fields so that the travel time from one position to another is minimal [7, 8]. Furthermore, another question which arises here is: in which types of scenarios, i.e. currents, are the standard search patterns based on the straight line legs optimal in the sense of time (at least locally)? In general, the currents depend on position and/or time as well as the effect of drift may vary on both the searching and searched objects. By this paper our objective is also to present some remarks on the IAMSAR Manual (Vol. III) in order to stimulate a discussion about its recommendations during the IAMU AGA 21 Conference, and to pay attention of the audience to somehow neglected impact of drift on the standard patterns used in some SAR missions at sea. As a consequence, this covers automated search pattern implementation in electronic navigation systems as well as a debate on efficient application of the improved and new search patterns in the future.

2 Standard search patterns applied in maritime and aeronautical SAR operations

First, we recall the specific search patterns which are applied in Search and Rescue operations and described in the IAMSAR Manual. The Manual provides guidelines for a common aviation and maritime approach to organizing and providing search and rescue services. The essential criterion in the SAR operations is time. The standard patterns

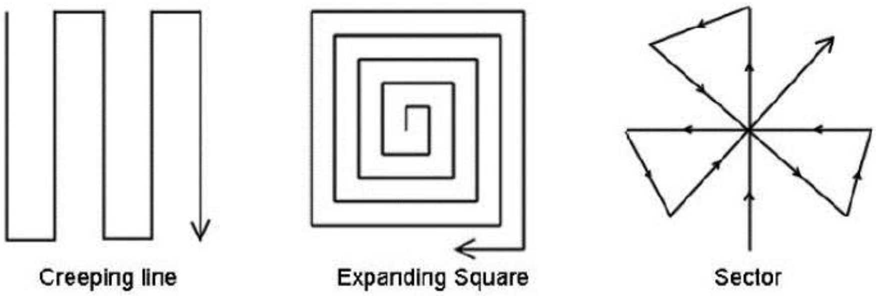

Figure 1: The standard search patterns as per the IAMSAR Manual: creeping line, expanding square and sector search [1].

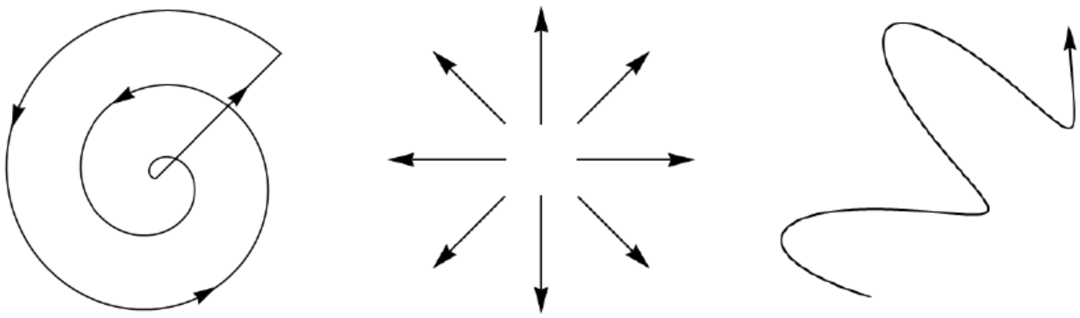

Figure 2: Other possible search methods: spiral, radial, random.

are applied when the accurate position of a searched object is unknown. The objective is to search the area efficiently (area coverage) and in the shortest time possible (time optimization). Therefore, a point of the highest probability (datum) which represents the centre point of a search space is determined first. In general, the common models are reliable and give the best result in particular circumstances. However, there is a need for an alternative approach in some cases. We remark that this is also the appropriate field for applying the theory of reliability and probability including notion of concentration ellipse as in the study of uncertainties and error analysis. In our investigation we focus on the paths of least time which could also be applied by searching crafts in order to optimize the operation, for instance, with support of the unmanned aerial vehicles.

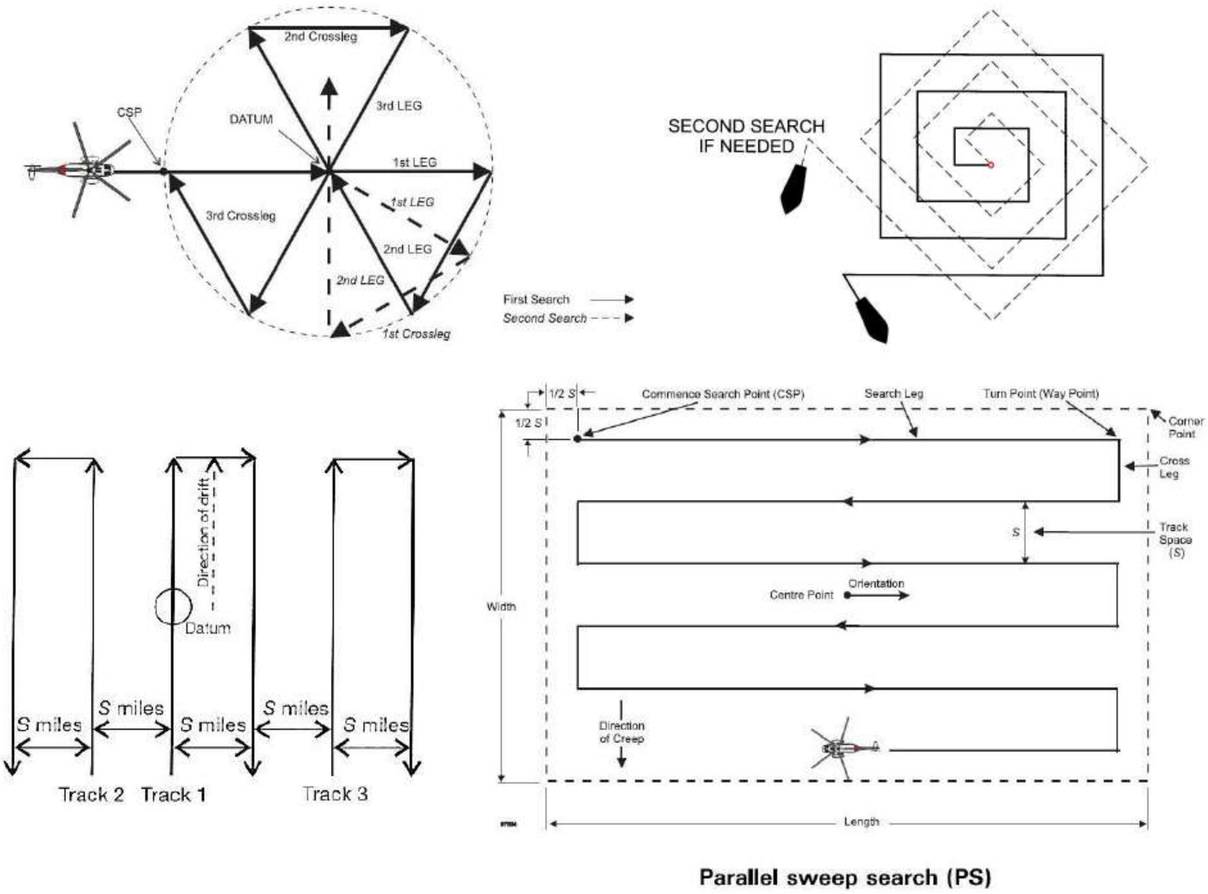

Figure 3: The SAR patterns in the aeronautical applications: sector search (top left), expanding square (top right), parallel track search - 3 ships (bottom left), creeping line (coordinate vessel-aircraft pattern; bottom right) [1].

It can be observed that the search models are created and required to be used routinely, somehow neglecting the influence of acting wind/current field in the meaning of optimization. The standard methods of search are based on the following patterns: expanding square, creeping line (coordinate vessel-aircraft pattern), sector and parallel search. They are presented in Figure 1 and Figure 3. Other possible methods are added in Figure 2. Planning the search operations, the standard paths are followed in the air and marine applications what self-explanatory Figure 3 shows. In fact, a search path can be flown/sailed in an active or passive way. The former means that we correct the route to execute search pattern over a fixed ground. In turn, we let the craft to be drifted continuously by an acting perturbation in the latter, so we follow the search pattern just in relation to air/water. With all of the above in mind we ask whether the search paths (entire or their segments) could be based on time-minimal paths in order to fulfill the time criterion more efficiently.

3 Simulations including action of constant currents

In this part of our investigation we used several softwares included in the professional navigational simulators at the Faculty of Navigation of the Gdynia Maritime University, i.e. K-Bridge ECDIS (software version 7.1.5.78) and Planning Station of the K-Bridge Navigation Software and Polaris from Kongsberg Maritime AS, the navigation information system Navi-Sailor 4000 ECDIS integrated to the navigational simulator Navi-Trainer Professional 5000 by Transas Technologies Ltd. (currently, Wärtsilä) as well as NACOS Platinum by L3 Marine Systems (currently, Wärtsilä). These are the ones of the worldwide leaders in developing a wide range of IT solutions for the marine industry and promote their own concepts of e-Navigation. Now we consider some examples referring to real world applications. To begin with, we activate the search paths with the scenario without perturbation (a calm sea model). The generated routes based on expanding square, sector search and parallel tracks in case of one searching ship are presented in Figure 4. We assume a constant speed of the craft sailing (or flying at constant altitude) in a two-dimensional area. In practice, a search speed means a maximum speed of a ship which is possible to be kept in the real conditions. Note that for $n \geq 2$ searching ships this means the highest speed of the slowest ship in a group. The simulated trajectories correspond to the standard patterns.

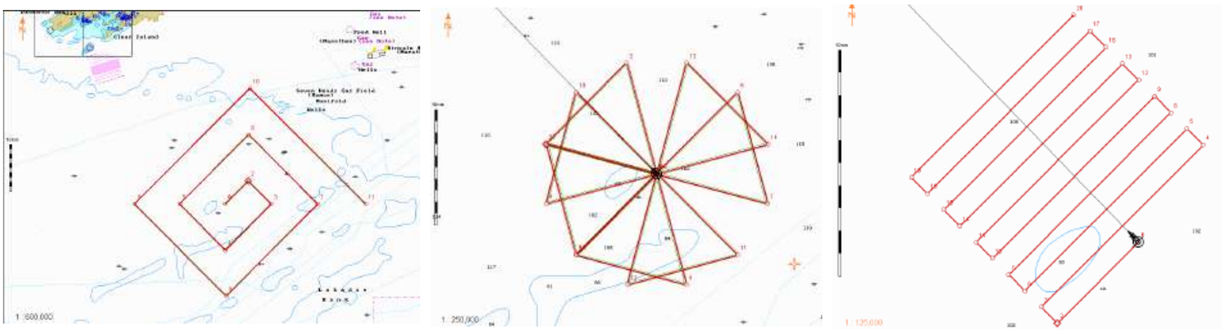

Figure 4: The simulated search paths based on expanding square (left), sector search (middle) and parallel tracks (right) in the absence of current (wind) field. The initial position of search (datum) is (50°50.0'N, 008°50.0'W) and the search speed is $|u| = 10$ kn.

Next, we introduce some perturbations with the same datum in the way it is possible to be set up in the system (ECDIS). In fact, this is not technically feasible to take into consideration any drift in the K-Bridge and NACOS Platinum simulators. Therefore, the attached figures including the modified search models with constant perturbation come from the second simulator, i.e. Navi-Sailor 4000. The current/wind is defined by two parameters, i.e. "drift" and "set" stand for direction and speed, respectively. We set the following conditions in the simulations. In the expanding square model presented in Figure 5 the speed of the ship equals 10 kn, the perturbation is determined by the pairs of drift and set as follows: (135°, 2.0 kn), (270°, 2.0 kn), (180°, 1.0 kn). The commence search point is given by the geographical coordinates (50°50.0'N, 008°50.0'W), the number of legs equals 10, the starting leg length is 7 Nm, and the search pattern heading equals 315°. Similarly, we generate the pattern for the sector search. The solutions obtained in the navigational simulator are given in Figure 6. The number of sectors is 7, the search radius equals 10 Nm and the turn angle equals 30°. For comparison, the analogous results are also presented for the model of parallel tracks under the action of the same perturbations, with track spacing 1 Nm (Figure 7).

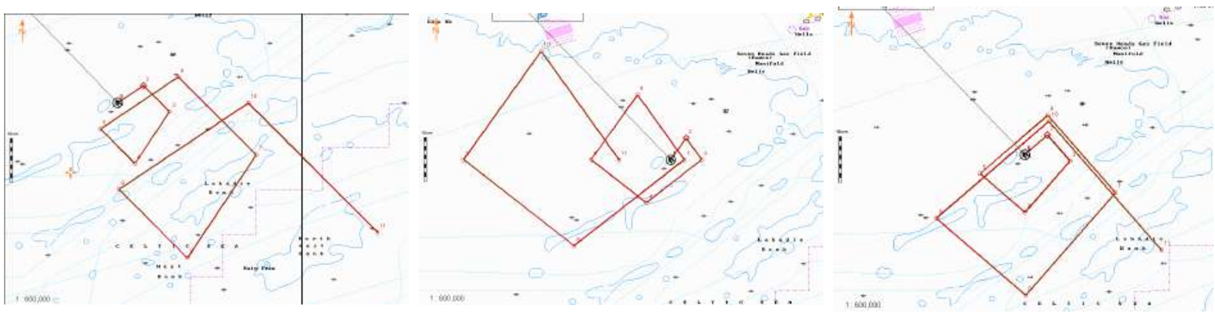

Figure 5: The simulated search paths in the model of expanding square, under acting current (wind) field with set of 2.0 kn and drift: 135° (left), 270° (middle) as well as 1.0 kn and 180° (right); the search speed is $|u| = 10$ kn.

Accordingly, the Euclidean plane with just steady current is used in order to generate the search paths. We note that, in fact, only constant currents (if any) are applied in the professional simulators as well as the corresponding devices onboard marine ships (aircrafts), since the same software is implemented. Moreover, the drift effect is assumed here to be always the same for the searching and searched objects. Clearly, in each of the simulated scenarios, if we subtract the drift vector given as a linear function of time, then we obtain the standard search patterns as illustrated initially in Figure 4. Hence, in reference to a flowing medium (water, air) the standard model is followed continuously. However, the search paths over fixed ground are then modified by the vectors of drift as presented in the subsequent figures. Nevertheless, it can be observed that many students of marine navigation and practitioners (mates) follow only the search routes generated in ECDIS (with respect to a ground) during the simulations of SAR exercises, and irrespectively of the acting currents. Such approach may increase time of entire operation considerably.

Due to some practical reasons the simplified approach is followed routinely in reality. However, taking into consideration the state-of-art in positioning, modelling, tracking and optimal control technology in the context of robotic sailing or drone (UAV) piloting, such approach becomes oversimplified nowadays because the models can be improved. This remark plays a relevant role, if the perturbations are varying in space and/or time, so like the real ones are in fact.

4 Improved navigation formula for computing time-optimal paths in flow fields of an arbitrary force

In [7] the aircraft navigation problem was emphasized in optimal control theory and approximate solutions, considering in many different contexts, i.e. controllability, simplest

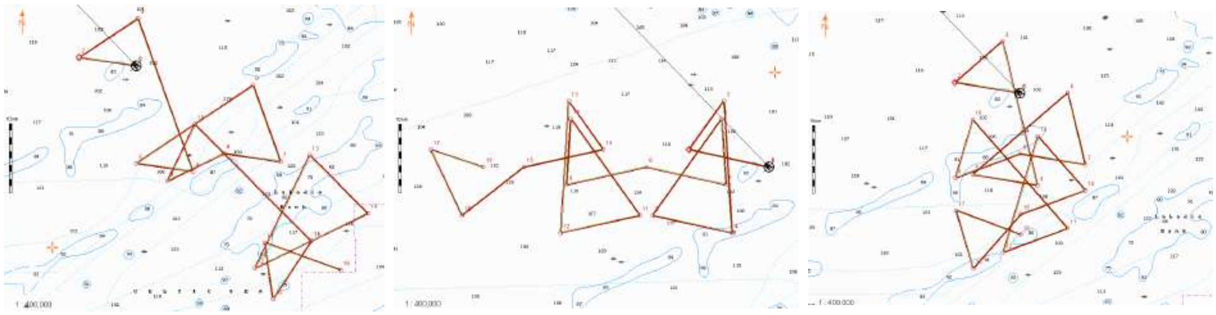

Figure 6: The simulated search paths in the model of sector search, under acting current (wind) field with set of 2.0 kn and drift: 135° (left), 270° (middle) as well as 1.0 kn and 180° (right); the search speed is $|u| = 10$ kn.

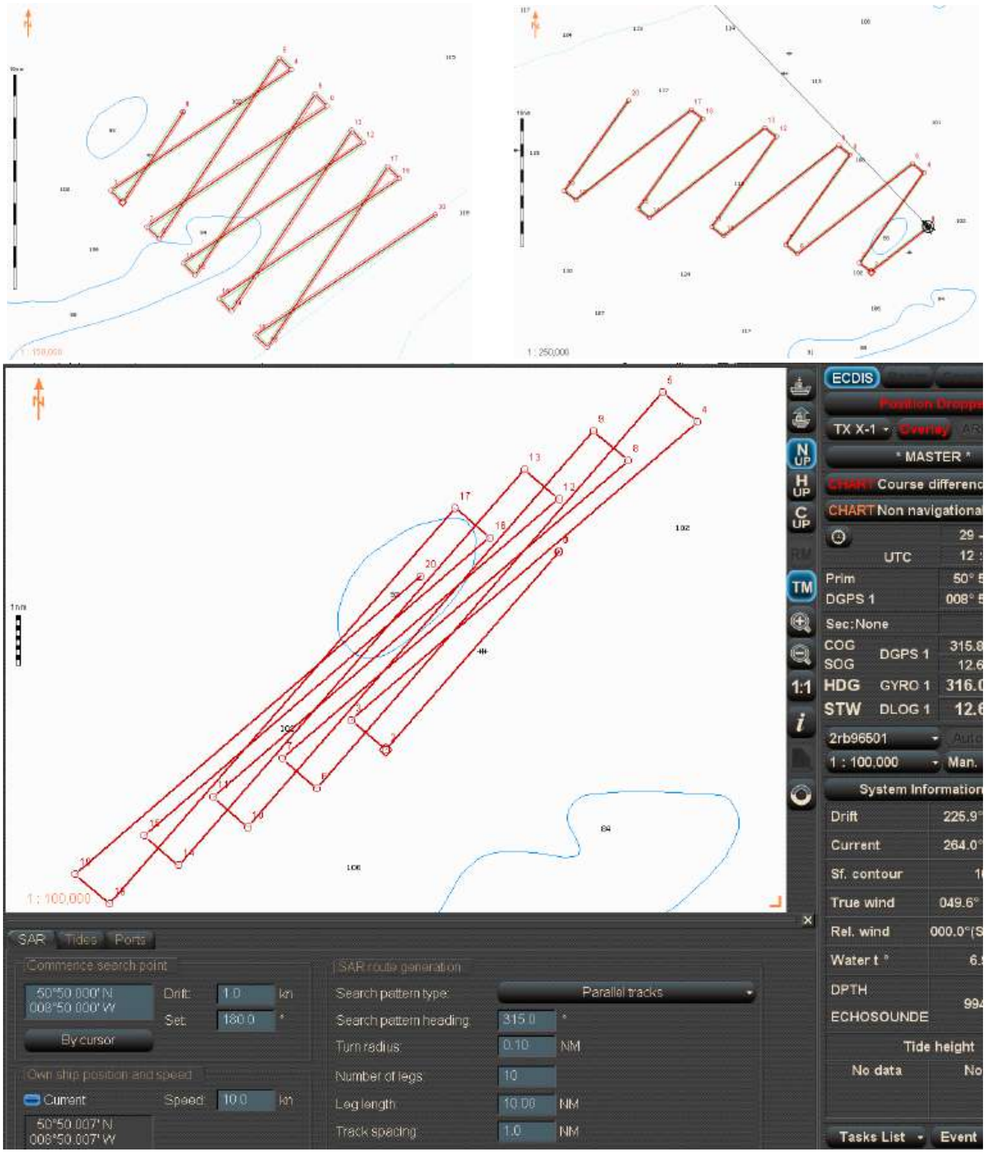

Figure 7: The simulated search paths in the model of parallel tracks, under acting current (wind) field with set of 2.0 kn and drift: 135° (top left), 270° (top right) as well as 1.0 kn and 180° (bottom); the search speed is $|u| = 10$ kn.

optimal control problems, fixed final time (first and second differentials), free final time, parameters, free initial time and states as well as approximate solutions of optimal control problems. The simplified form is stated as follows: find the control (the steering angle) of a constant speed aircraft (ship) in a crosswind flying (sailing) from one point to another that minimizes the final time. The problem can be converted into a "fixed final time" with the aim to minimize the performance index by introducing the transformation time or considering the problem that has no states. The above considerations were presented on the Euclidean plane with the use of the Hamiltonian formalism; see also [9]. With reference to the genesis of the aircraft navigation problem, we have revisited it recently. Namely, we presented some generalized and extended results regarding a backgorund space (an arbitrary surface and more generally, a conformally flat Riemannian manifold), and a varying speed in the presence of currents which depend on space and time [10, 11, 12]. In particular, these results include a condition for point-to-point time-optimal navigation in the Euclidean plane in which the craft is modelled as a particle moving at variable speed relative to the surrounding current/wind.

The aircarft (Zermelo) navigation problem in $\mathbb{R}^2$ became classical in optimal control theory and often present in various real-world applications; see [7, 13, 14, 15, 16, 17, 18, 19, 20]. When the wind is not everywhere zero, time can often be reduced by deviating from the geodesic route to take advantage of weaker headwinds or stronger tail winds (using aviation terminology), the greater length of the route being more than compensated by the increase in ground speed. Analogous scenario can be applied to marine setting with water currents or streams. More precisely, we have the following result

Theorem 4.1. *[11] Let (M,h) be a Riemannian manifold of dimension 2 with the metric given by $h_{ij}(x) = S^{-2}(x)\delta_{ij}, i,j = 1,2$ and (h,W,f) be the navigation data. The time-optimal paths in arbitrary wind on (M,h) are determined by the following ordinary differential equation*

$$\begin{aligned}\dot{\varphi}(t) = &-\frac{\partial W^1}{\partial x^2}\cos^2\varphi + \left(\frac{\partial W^1}{\partial x^1} - \frac{\partial W^2}{\partial x^2}\right)\sin\varphi\cos\varphi + \frac{\partial W^2}{\partial x^1}\sin^2\varphi \\ &+ S\frac{\partial f}{\partial x^1}\sin\varphi - S\frac{\partial f}{\partial x^2}\cos\varphi + f\frac{\partial S}{\partial x^1}\sin\varphi - f\frac{\partial S}{\partial x^2}\cos\varphi,\end{aligned} \tag{1}$$

and the equations of motion $\dot{x}^1 = W^1 + fS\cos\varphi$, $\dot{x}^2 = W^2 + fS\sin\varphi$, if $S(fS + W^1\cos\varphi + W^2\sin\varphi) \neq 0$ and $\varphi \in [0, 360°)$ is a heading angle.

The notation applied above is: $W^i(x,t)$ - wind (current) components, $f(x,t)$ - a self-speed of a ship, $S(x)$ - a conformal factor and δ_{ij} is the Kronecker delta; for more details, see [11]. The condition for optimal steering (1) can be expressed in a slightly different form using the definition of a heading in navigation which is taken as positive clockwise from north (φ_{nav}), not as positive running anticlockwise from east (φ) which is usual convention in mathematics. This then yields

$$\begin{aligned}\dot{\varphi}_{nav}(t) = &\frac{\partial W^1}{\partial x^2}\sin^2\varphi_{nav} + \left(\frac{\partial W^2}{\partial x^2} - \frac{\partial W^1}{\partial x^1}\right)\sin\varphi_{nav}\cos\varphi_{nav} - \frac{\partial W^2}{\partial x^1}\cos^2\varphi_{nav} \\ &- \left(S\frac{\partial f}{\partial x^1} + f\frac{\partial S}{\partial x^1}\right)\cos\varphi_{nav} + \left(S\frac{\partial f}{\partial x^2} + f\frac{\partial S}{\partial x^2}\right)\sin\varphi_{nav}.\end{aligned} \tag{2}$$

It is observed that if $f = f(x)$ or $W = W(x)$, then the optimality condition has still the same form. Namely, time-dependence does not change the resulting formula.

For the convenience of the reader and simplicity, we refer to the planar (Euclidean) setting. Remark that the optimality condition for the plane was applied in various investigations concerning optimal aircraft routing in general wind fields [21] or path planning for unmanned aerial vehicles in steady uniform winds [22]. If $h_{ij} = \delta_{ij}$, $i,j = 1,2$, so $S = 1$, then Eq. (1) is reduced to the condition for optimal navigation in $\mathbb{R}^2$, i.e.

$$\dot{\varphi}(t) = -\frac{\partial W^1}{\partial x^2}\cos^2\varphi + \left(\frac{\partial W^1}{\partial x^1} - \frac{\partial W^2}{\partial x^2}\right)\sin\varphi\cos\varphi + \frac{\partial W^2}{\partial x^1}\sin^2\varphi + \frac{\partial f}{\partial x^1}\sin\varphi - \frac{\partial f}{\partial x^2}\cos\varphi. \tag{3}$$

We note that Eq. (3) can be presented in a different form including the components of the resulting velocity v^i instead the components of a current W, i.e., substituting $W^1 = v^1 - f\cos\varphi$, $W^2 = v^2 - f\sin\varphi$, where $f = f(t, x^1, x^2)$. We thus have

$$\dot{\varphi}(t) = -\frac{\partial v^1}{\partial x^2}\cos^2\varphi + \left(\frac{\partial v^1}{\partial x^1} - \frac{\partial v^2}{\partial x^2}\right)\sin\varphi\cos\varphi + \frac{\partial v^2}{\partial x^1}\sin^2\varphi, \tag{4}$$

where $v^1 = \dot{x}^1$, $v^2 = \dot{x}^2$. In particular, if $S = 1$ and $f = 1$, then Eq. (1) leads to the classic navigation formula obtained initially in $\mathbb{R}^2$ [8].

The above optimality condition (3) can be expressed concisely. Namely, if at a given point of the optimal paths the rectangular coordinate system is chosen so that the x^1-axis coincides with the ship's heading, then Eq. (3) with variable self-speed reduces to $\dot{\varphi} = -\frac{\partial W^1}{\partial x^2} - \frac{\partial f}{\partial x^2}$. Equivalently, $\dot{\varphi} = -\frac{\partial v^1}{\partial x^2}$ by Eq. (4). This with $f = 1$ yields the classic navigation formula on the Euclidean plane in the shortest form $\dot{\varphi} = -\frac{\partial W^1}{\partial x^2}$[1]. Summarizing, the concise form of the condition for optimal navigation (1), with the local coordinate system referred to a ship, reads

$$\dot{\varphi} = -\frac{\partial(W^1 + fS)}{\partial x^2} \quad \text{or} \quad \dot{\varphi} = -\frac{\partial W^1}{\partial x^2} - S\frac{\partial f}{\partial x^2} - f\frac{\partial S}{\partial x^2}. \tag{5}$$

Using the condition for optimality, the time-minimal paths joining the waypoints that characterize the standard search patterns can be found. It is shown that they differ from the straight line paths [24]. Thus, some local modifications to the standard search patterns are introduced in such a way that a search pattern similar to the original one is followed in minimal time by a particle that represents the ship/ aircraft, and the coverage of the search area is ensured.

5 Exemplary modifications of search models based on time-minimal paths

The time fronts ($t = 1$, dashed colors) of the straight line and least time motions are first compared during the passage in windy conditions so that the whole area is fully covered (searched). The time-minimal paths (solid red) simulating the trajectories in a unit disc starting from the origin, with the heading increments $\triangle\varphi_0 = 10°$, under the linear wind field $W = (y, 0)$ in the Cartesian coordinates system $x0y$ are illustrated in Figure 8. It is clear that in the absence of current the optimal paths are described by straight rays (black arrows) coming from the centre, if the search speeds are constant. In the presence of wind field the space can be fully covered alternatively by curved time-optimal paths after suitable adjusting the initial headings φ_0, which determine uniquely the corresponding minimizing paths. Moreover, the travel time is saved in this case.

In contrast to the search paths created in the software of the navigational simulator we continue with the model including the perturbation W which depends on position. The standard patterns are combined with the time-optimal paths which are represented

[1] "The helm has always to be turned to that side in which the wind component acting against the steering direction increases" [23, p. 116]

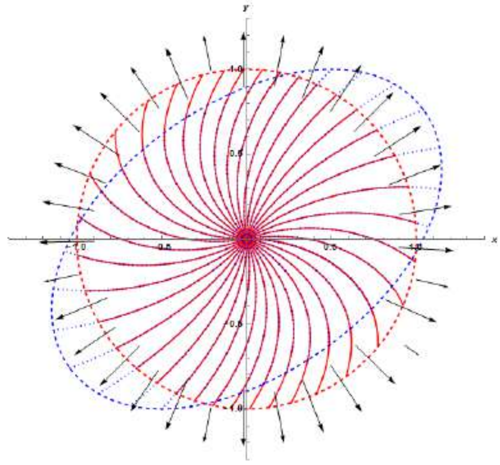

Figure 8: The time-minimal paths (solid red) in a unit disc starting from the origin, with the increments $\triangle\varphi_0 = 10°$ and the time front ($t = 1$, dashed blue), under the linear (shear) wind (or current) $W = (y, 0)$ [24, 25].

by the local solutions to the aircraft navigation problem. Regarding computations we apply the system consisting of the corresponding equations of motion and the optimality condition presented in Section 4. For simplicity, let W be given by the river-type flow, i.e. $W = (f(y), 0)$. We now consider the piecewise time-minimal paths connecting the fixed waypoints of the route defined in the standard models, where the directions of the straight search paths change at right angles. Thus, the concept is to make use of the current in order to increase the resulting speed, and not to follow the fixed standard pattern without regard for the type and properties of acting currents. Roughly speaking, if possible, we aim at avoiding to sail against perturbation routinely.

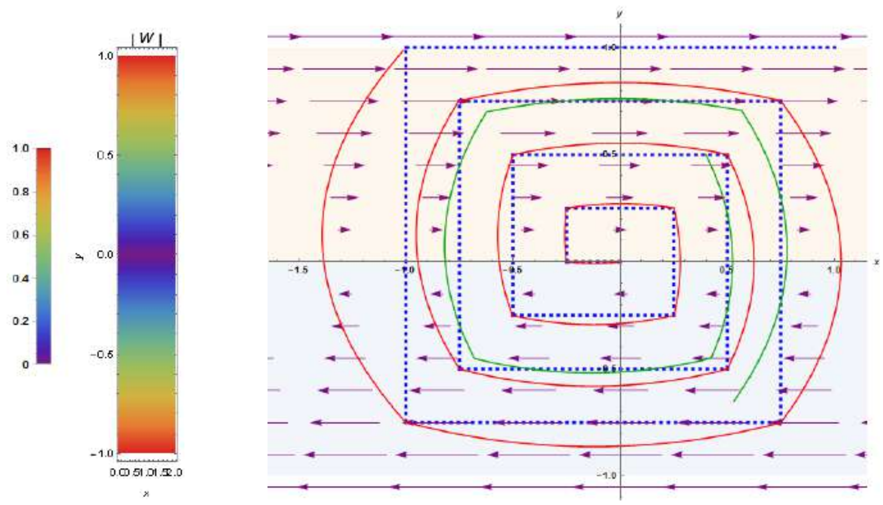

Figure 9: The expanding square model (dotted blue) modified by the piecewise-time-optimal legs (red and green) under the shear (linear) current field $W = (y, 0)$. Middle: the current speed (to scale) [24, 25].

We proceed by considering expanding square and, for simplicity but without loss of the general concept, the weak linear vector field $W = (y, 0)$. In Figure 9 we show the standard expanding square of given starting leg length which determines track spacing ε^* in the entire model and oriented so that the horizontal legs are parallel to the flow. Thus, the fixed waypoints are determined and represent the consecutive startpoints/endpoints connected by the time-minimal paths (solid red). Since time of passage is shorter in each

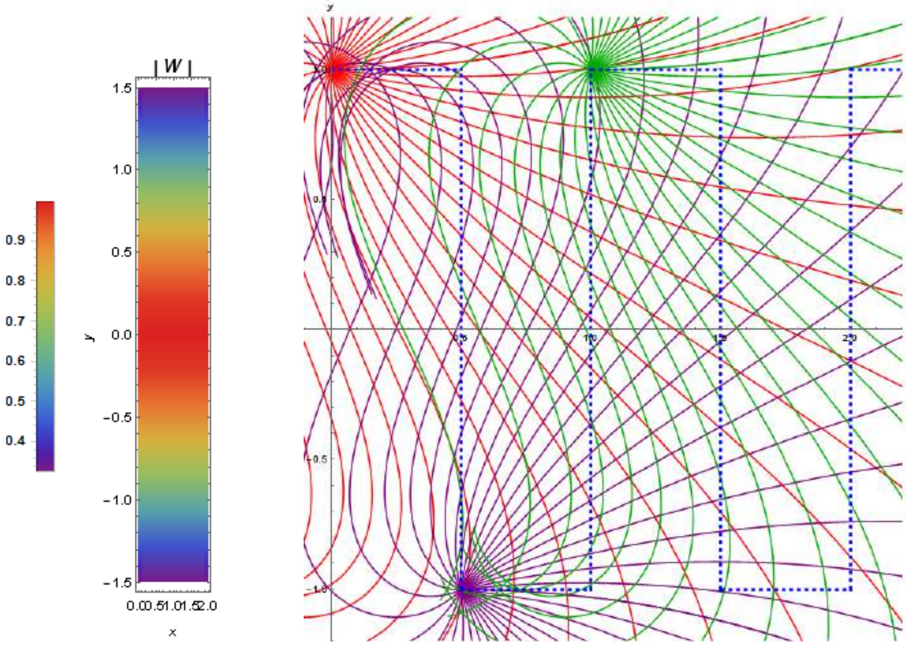

Figure 10: The creeping line search modified by the time-minimal legs starting from the fixed waypoints determined by the standard pattern, under the Gaussian wind field $W = (\frac{5}{2}\frac{1}{\sqrt{2\pi}}e^{-\frac{1}{2}y^2}, 0)$; $\triangle\varphi_0 = 10°$. Middle: the current (wind) speed (to scale) [24, 25].

leg in comparison to the corresponding straight legs of the standard pattern, the total time along the new modified paths is expected to be decreased. Obviously, we require that the search is efficient, that is, the maximum distance ε between the points of the searched space and the search path also needs to be taken into consideration. Namely, we require that the search is *complete*, i.e.

$$\forall \ \ A \in \mathcal{D} \ \ \exists \ \ \tilde{A} \in \Gamma : \ d(A, \tilde{A}) \leq \varepsilon, \tag{6}$$

where a sub-area $\mathcal{D} \subset M$ of a metric space (M, d) is a search space, $\Gamma = \bigcup_i \gamma_i$ is a search path, γ_i represents a time-optimal leg and $\varepsilon \geq 0$ is a fixed parameter. The condition implies that there are no omitted zones if the time is free and a ship follows the time-minimal legs in a complete search. Namely, the points of searched area should be close enough to at least one path. Hence, the solutions to the navigation problem in compliance with the condition (6) can be applied to the problem of search. The particular application depends on the initial conditions, type of perturbation and preset parameter ε. Each leg γ_i guarantees local optimality in the connections between the intermediate waypoints. However, we recall that the key goal is to minimize the total time t_c of a complete search. Otherwise, the models based on the piecewise time-optimal search path Γ which can be represented by the suitable solutions to the navigation problem might not state for the final time-optimal solution of the search problem. So far, we aimed at showing the potential application of (piecewise) time-optimal paths, where it is reasonable in order to minimize the total time of search without exceeding required value of ε. For that reason previously fixed waypoints are now translated such that the obtained new least time connections (solid green in Figure 9) fulfill the condition for the maximum distance between the points of searched space and search paths.

Next, we consider the creeping line search in the presence of the specific Gaussian flow $W = (\frac{5}{2}\frac{1}{\sqrt{2\pi}}e^{-\frac{1}{2}y^2}, 0)$. This is shown in Figure 10. In analogous way the standard paths (dotted blue) are modified with the use of time-minimal legs starting from the fixed waypoints obtained by the common pattern. The charts of the color-coded paths are created and they cover the area in the presence of acting current under consideration. The curves start from determined fixed points and represent the quickest connections. However, in the search problem the additional conditions are included, e.g., ε or restricted domain, in the context of free or fixed final time problems which are therefore of interest of optimal control. In each scenario the conditions modify the final search model. Thus, the situation-dependent approach is required. The objective is to make use of the minimum time legs to decrease the total time of searching the whole area or to maximize the area which can be searched in the limited fixed time. Beside combining the solutions to the navigation problem with the standard models it could be reasonable in the presence of some perturbations to omit the common paths completely. This means to follow non-standard search models configured with the time-optimal legs and rearranged wypoints without any references to the standard patterns.

To our knowledge, there are no effective solutions (including optimality and feasibility) dedicated to the search patterns in a two-dimensional area, taking into conideration a drift effect which minimize the total time of a complete search (full coverage). Thus, we can formulate the challenging task for the future study as follows: to create a feasible algorithm so that the total time of a complete search is minimized, under the action of wind field varying in space and time in case of

1. one ship (UAV) searching alone; and

2. $n \geq 2$ ships (UAVs) searching simultaneously and in coordination.

The practical interest in the above open problems refers to the current need for efficiencies in performance of maritime and aerospace vehicles (drones) as well as systems of vehicles to meet advanced operations of great importance. Furthermore, it should be emphasized that improving the search models requires that the search is efficient (both the global time minimum and area coverage), not just "optimal" in the meaning of following time-optimal legs locally.

6 Discussion and conclusions

We focused on refinement of the standard SAR patterns under the effect of drift by time-optimal paths. Such legs connecting the consecutive waypoints of a search route are not necessarily straight lines, however they minimize travel time locally between the positions in the search area. The formally recommended search patterns have been selected for simplicity and effectiveness, but they may not be efficient in various situations with action of the perturbing flow fields. The standard patterns are reliable and give good result in particular circumstances. However, there is a need for an alternative approach in some cases and examining different methods of shortening search duration. The behaviour of the trajectories of least time depend on the acting currents or winds significantly. The advantage of the proposed approach is more visible when the ratio of current speed to ship's speed increases, and the varying currents depend on position or the effect of drift is different for a searching ship and a searched object. Taking into account information on current direction and speed in situ which are more and more reliable and available today, the new patterns can save time and effort that are wasted for searching low probability areas as well as make use of the acting flows.

The idea was to make use of time-minimal paths in the problem of search when this is reasonable, i.e. reduces the total (global) time of a search. With the condition for a complete search in mind we aimed at decreasing time of search in this preliminary modelling in comparison to the existing methods, where the standard patterns are followed. They are routinely used without considering the types of current (wind) fields and initial conditions. Only the standard models are required formally to be used in real-world aeronautical applications; see [1]. This motivated us to revisit these patterns and focus on the reasons which enforce them to be followed in the scenarios under the action of a flow field. In particular, the study shows that it is not necessarily efficient to orient the search model so that a starting leg is parallel to current (wind) as it is routinely assumed. Since main criterion is time under complete search condition, combining the standard models with time-minimal paths or creating the new models based solely on such trajectories in the presence of perturbation can lead to higher efficiency. This calls for further study in order to adapt to the practical capabilities and requirements. Note that the current technology enables to implement the models based on time-minimal paths, for instance, in route planning and monitoring referring to the drone aerial survey and patrolling fixed zone, robotic sailing, weather routing combined with the numerical weather prediction models. Concerning implementations the applied simplifications admitting only constant perturbation as in the modern navigational software can be improved by considering stationary currents with the use of time-optimal solutions similarly to the presented examples. The standard search patterns may become inefficient with respect to the criterion of time. This fact gives meaningful opportunity to apply more advanced models due to the essential time reduction in the scenarios with a (relatively stronger) drift effect.

Regarding Maritime Education and Training it is recommended that more attention should be paid to the generated and followed search patterns with reference to the fixed ground in ECDIS, e.g. using GPS during simulations of SAR operations in the areas, where the drift effect is observed. In particular, following the standard patterns plotted only over ground and not with respect to the flowing water may cause increasing time of search and rescue mission instead of decreasing. Furthermore, a more general formulation of the problem should be considered in the further study in which the important aspect is to ensure the coverage of the zone to be explored and the pattern followed in the search is not fixed in advance and is determined by solving the problem. For instance, the coverage constraints could be enforced using waypoints which, depending on the current/wind field, are reached in a different order and at different time instants. Another aspect to be considered is the fact that in aeronautical search and rescue operations minimization (or at least estimation) of the fuel consumption is an important aspect. This means that more realistic models of current/ wind and ships should be applied.

Acknowledgments

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Towards Introducing Knowledge Management Concept to Maritime Education & Training

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Abstract

Knowledge Management (KM) concept had been introduced to the world through the industrial domain, where it generated following a necessity to maintain knowledge and information within a certain border, driven from strong and fierce competition. The concept itself had evolved in a way that allowed the technology to affect the process of maintaining the knowledge to transform it to more sophisticated processes of information analysis, thus producing much more useful data, which lead to further usage of KM concept, such as categorization, gap analysis, and areas of which companies need to invest more in.

However, the KM concept in the educational domain was not properly used until the early 90s, not until the problem was raised by certain fields of education, where they found that their knowledge was not less vital than that in the industrial domain. But the technological solutions faced the problem of the type of knowledge used in the educational domain, which consists partly of an implicit nature, which raised the need to develop certain administrative and Technological solutions to tackle this challenge.

In the maritime education domain, the KM Concept had had an even later start and far weaker approach than other types of education, mainly because of its vocational nature, and several other reasons that will be discussed thoroughly in this paper.

This paper is a part of ongoing research by the authors on the history of KM and how it should properly be introduced to the maritime education domain. The research includes a case study and customization of a prototype KM software to fit the nature of Knowledge normally found in the maritime domain. The paper also displays the importance of KM to the Maritime

education and training entities, and how it affects its performance and helps with its sustainable development in general.

Keywords

Maritime Education and Training – Knowledge Management – Educational policies – Communities of Practice – Maritime Knowledge

1 Introduction

Knowledge is the backbone of any civilization. It affects, directly and indirectly, the building, development, and sustainability of the community in general. Nowadays, obtaining knowledge is an easy task, considering globalization and the availability/accessibility of information. The challenge is to sustain such knowledge to use it through various applications, in other words; manage your knowledge.

Knowledge Management (KM) concept had been a hot topic in the last few decades, it was found essential, especially in knowledge-intensive organizations. No doubt, knowledge is the main asset in any organization, which forces any management to start planning how to sustain such asset represented in the knowledge of their employees, and how to find a way to utilize and maintain such knowledge. KM concept is important to enhance the understanding of how an organization becomes skilled at creating, acquiring, and transferring knowledge to support sustainable development.

1.1 Aim

To Highlight the importance of Applying the KM Concept into MET and Suggesting a roadmap enabling the swift entry of KM into policies and Quality Standard Systems of MET.

1.2 Method

Analytical/Critical review of the current level of KM application in the MET domain. Data was collected Using Qualitative methods.

2 Background Studies & Literature Review

2.1 Knowledge Management

Abundance in the literature concerning KM concepts applied incorporates is clear, produced as early as the 1990s (Gupta & Govindarajan, 1991, Hedlund, 1994 & Wiig, 1997). With the beginning of this century, the interest in applying KM concepts into education had been focused upon; it started with a trial to implement corporate-KM in education as did Kidwell et.al in 2000 & Bernbom in 2001. Then there was a huge studiousness surge into the matter when the Institute for the Study of Knowledge Management in Education (ISKME) was established in 2002. Since then, there has been serious literature on applying KM in education, like what (Sallis & Jones) & (Serban & Luan) wrote in 2002, followed by Petrides & Nodine in 2003 and Metcalfe in 2006. It is fair to say that KM in education literature surged after the establishment of ISKME.

Although education may be the same when it comes to philosophies and theories, the application may differ when it faces a special nature of education, like maritime education. Maritime education is a vocational education, derived largely from vocational knowledge and experience, which is reflected greatly in the scarcity of experienced maritime teachers.

The literature of applying KM in the maritime domain was greatly addressing the shipping industry either in running shipping companies like in articles and books of Fei in 2011 and 2013 or shipping logistics as written by Lee & Song in 2010 & 2015 and by Radhika in 2014.

On the other hand, a modest approach was made to the application of KM in MET institutes were found in a few paragraphs on an article by Raicu & Niţă in 2008 in addition to a research done by Kitada, et al (2015) about the application of KM techniques to improve online MET.

The absence of literature describing a seriously long time testing of the application of KM concepts and techniques in MET institutes will be the derive and contribution of this research, trying to find an appropriate tool to be implemented in a case study on the employees of an existing Maritime Education and Training Facility in the Middle East.

3 Types of Knowledge

Literature divides knowledge into three main types:

3.1 Personal knowledge (conceptual knowledge)

Also, called conceptual knowledge (Walsh & Rastegari, 2015). It is the first phase of knowledge, where an individual collects information to be familiar with something., it does not necessarily transfer into behavioral changes. It is the base for the next level of knowledge. “Personal knowledge relates to firsthand experience, idiosyncratic preferences, and autobiographical facts" (Henriques, 2013).

3.2 Procedural Knowledge (structural knowledge)

The next phase of knowledge is procedural knowledge when we learn the know-how of things. It is the process of gaining information to do something in particular. When an individual gain the skill of actually doing something is said that he/she had the procedural knowledge of this thing.

3.3 Propositional Knowledge

Propositional knowledge is the primary concern of epistemology (Theory of Knowledge, 2017). It is simply the type of knowledge that affects your judgment positively, that makes an individual wiser and more competent at his/her profession. One can claim that this type of knowledge is the most challenging type, either in obtaining it or transferring it to others.

4 Types of Knowledge in the Maritime Education & Training domain

Knowledge in METs is always being utilized by Educators (teachers/instructors) and learners (students/trainees). Cross (2013) once said, that finding a marine teacher is a very hard job, because of the non-ending claim that it takes a good seafarer to become a good teacher, and it takes a good teacher to become a good seafarer, so on and so forth.

The International Maritime Organization (IMO) regulated the maritime educational process in a convention named "International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers" (STCW). in the convention, there are specific requirements for maritime teachers, every administration (country) should have its Quality Management System (QMS) defining the qualifications of their maritime teachers. The only thing that the STCW mandated in this matter, was that the maritime teacher should at least carry the same level of the certificate that he/she teaches (IMO, 2017).

The maritime student on the other hand, as an undergraduate, undertakes the first type of knowledge (personal knowledge) which he/she need to pass the first level of assessment. This level requires teachers to have enough personal knowledge to go around. But because of the special nature of maritime education, there is a lot of procedural knowledge involved as well, especially after the transformation of the STCW from being knowledge-based to a competency-based educational system (Cross, 2012). In the STCW there are a lot of competencies where it clearly says that the student should have the ability to perform certain tasks. To perform these tasks, he/she should be educated to do it. To do that, his/her teacher should have this type of knowledge (procedural knowledge).

Going on, the MET does not stop at the college level, it is a continuous educational process as long as the seafarer is in service, and as long as his/her license is valid. There are certain courses needed to be undertaken to revalidate the sea-going license of the seafarer. These mandatory courses are typically transferring new techniques in several matters, as mentioned in the STCW.

For management-level education and training, it is all about decision-making. In the tense nature of sea life, decision-making requires a lot of training and special capabilities, again the transfer of these abilities must be done through an experienced teacher who accommodates a certain level of propositional knowledge.

Lastly, to conclude, according to STCW, the level of the teacher is dependent on the level of education required for the trainee, undergraduate, operational level, management level, and mandatory revalidation courses. Where a mix of personal knowledge and procedural knowledge are needed at the undergraduate level and to obtain the operational level certificate, and a mixture of procedural and propositional knowledge is required in the latent two levels of education, managerial level certificate and the revalidation mandatory courses.

5 Implicit and Explicit Knowledge

As discussed, KM is all about sharing knowledge with others sharing the same interest, based on interactive and transmission processes between producers and consumers of knowledge. This knowledge is either implicit or explicit.

Schacter (1987) defines implicit memory as the limited control of conscious or intentional recollection of data. Reber (1993) on the other hand, defines implicit learning as “the acquisition of knowledge that takes place largely independently of conscious attempts to learn and largely in the absence of explicit knowledge about what was acquired”.

The difference between implicit and explicit was expressed by Dienes & Perner (1999) in an illustrative example "They didn't say so explicitly; it was left implicit". Furthermore, a formal differentiation between implicit and explicit knowledge is introduced by Polanyi (1966):

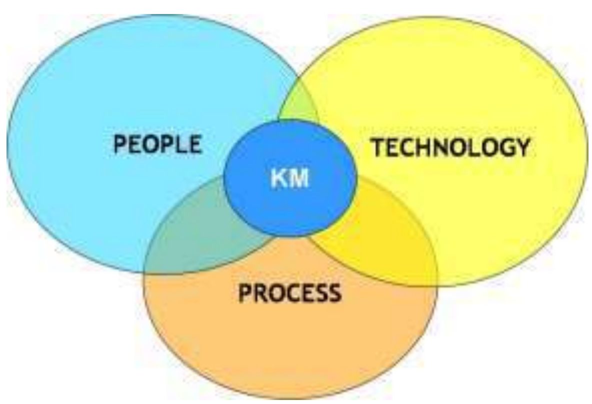
> *"Explicit knowledge is that which is stated in detail and leaves nothing merely implied. It is termed "codified" or "formal" knowledge because it can be recorded. Implicit knowledge is that which is understood, implied, and exists without being stated. It is informal, experiential, and difficult to capture or share. It is knowledge that cannot be expressed"*

Because of that contradiction, Fei (2011) claims that different KM methods should be used to deal with different types of knowledge. IT, for example, has limited outcomes when implicit knowledge is transferred when a face-to-face approach should be facilitated for better results.

6 Knowledge Management Software

Searching for the history of KM tools, it was found that the need for an IT solution was evident following the boom in the application of KM in the industrial domain. The first few KM programs were introduced in the mid-90s, the first introduction of the same to Academia was in the 2000s. The actual booming into Academia took place when major universities started teaching KM in their majors, and several KM PhDs thesis were introduced (Dalkir & Liebowitz, 2011).

Fig. (1): The Three Pillars of KM. Lyke-Ho-Gland (2016) Want Better Process Management? Think Knowledge Management



6.1 Features Required for the Intended Software

To achieve the purpose of this research, the following features should be available in the KM software chosen to be used in the research process

1. Method to retain both implicit and explicit knowledge.

Able to handle all types of data; such as word, audio, and video in such a way that it can be easily stored and reached upon request.

2. Statistical output

Where the system can provide statistical data on the usage of the system for every user, time spent, and contribution. Also, the system needs to provide data regarding the availability of certain content and the number of users that holds such content, for example, if the user is looking for how many staff holds the knowledge of "ship stability", the system should provide the percentage and information about these knowledge holders.

3. Content Management

The system should have the ability to categorize and catalog data in a certain retheme either designed by the higher management or customized by the user himself. This would lead to a quick search for information and easier access to required data. Also, searching capabilities should be available.

4. Personal accounts

Every user should have his/her account where he/she can contribute to the system, and at the same time, access the contribution of other users.

5. Sends Notification to Users

When any user updates the system with any kind of knowledge, other users should receive a notification. The notification may be set up according to "persons of choice" or "the subject of interest".

6. Accessible from management

The hierarchy of staff members should be taken into consideration in the system, meaning that a department head should have access to the activities of his/her subordinates, either by full access to their accounts or by the availability of statistical reports of his/her activities. Using a master key-like password. This would ease the usage of the "rewards and punishment" principle.

7. Mobile Phone application

Nowadays, ease of access is a must, knowledge must be available at the tip of your fingers using mobile smartphones. The mobile application does not need to have all the features of the system, but at least the major features should be available.

8. Designed for educational purposes

The utilizing of a KM system initially designed for educational institutes well far more effective than being originally designed for industrial or customer service usage. albite the data, information, and knowledge as concepts are still the same, but the utilizing capability is different.

9. Helps and support the establishment of communities of practice (COPs)

COPs had been identified as the heart and soul of any successful KM system, people of common interest share their experiences, one of the methods is through KM-Software. This should allow both official and un-official networking between colleagues, through chats, file sharing, commenting …. etc.

10. Repository of knowledge availability

Any kind of knowledge uploaded on the system should be stored and reached upon request. The entity may have its servers in case of the sensitivity of such information, or it could use web-based programs or cloud storage to build its repository.

11. Work with the organization's existing KM Technology

Most of the educational institutes have some level of KM in place, even if it is not up to the required level. Whatever the level of KM available, the nominated software should be able to absorb, work with, and upgrade it to a satisfactory level of KM implementation and build Capabilities over time.

12. Open-source

If the software is of an open-source nature, this will allow management to continually improve the software features. The necessity of change may surface over time, driven by the continuous development of the entity itself. In addition to customizing the software to meet the constantly changing needs of users.

13. Server Based

In the case of a Maritime Education Institute, the importance and the price of its knowledge will lead to the importance of having its private servers and storage facilities.

6.2 Market search for the intended software

The number of available KM programs on the market is huge, to understand the nature of such software, a thorough study was made on a limited number of programs, looking for their suitability to the intentions of this research.

To make the study more applicable and fruitful, a recommendation from "Captera" (2018), a virtual company that aims to help entities find suitable software for the nature of their work, where they recommended top 20 programs for the year 2018. The research will choose only the top 10 of the lists for this review, of which all will be examined to their suitability to the AASTMT in precise.

Table (1): the chosen KM programs compared to the availability of the research intended features

Feature	Availability											Feature Available
	Confluence	Inmagic presto	Zoho connec	Freshdesk	Bitrix24	eXo Platform	Mango Apps	iMeet Central	PHPKB	Auros	AASTMT Communi	
Retain implicit & explicit Kn.	Y	N	Y	N	Y	Y	Y	Y	N	Y	Y	**73 %**
Statistical output	N	N	Y	N	N	Y	N	N	Y	N	N	**27 %**
Content management	N	Y	N	N	Y	Y	Y	Y	Y	Y	N	**64 %**
Personal accounts	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	**100 %**
Notifications to Users	Y	N	N	N	N	N	Y	N	N	N	N	**18 %**
Accessible from management	N	N	Y	N	N	Y	Y	N	N	N	N	**27 %**
Mobile application	Y	Y	N	N	Y	Y	Y	N	Y	N	N	**55 %**
Designed for educational use	N	N	N	N	N	N	N	N	N	N	Y	**9 %**
Communities of practice	Y	Y	Y	N	Y	Y	N	N	Y	Y	Y	**73 %**

Knowledge Repository	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	**100 %**
Work with Org. existing KM	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y	**82 %**
Open-source	N	N	N	N	N	Y	N	N	N	N	Y	**18 %**
Server-based	N	N	N	Y	Y	N	N	N	N	N	Y	**27 %**
Total Wight of Software	**54 %**	**31 %**	**54 %**	**31 %**	**62 %**	**77 %**	**54 %**	**31 %**	**54 %**	**45 %**	**62 %**	

From table (1), the sample programs were inspected for the availability of the features that serve the purpose of this study. Giving that All features were given the same weight for their equal importance and their strong correlation, the following remarks were found:

- The most suitable programs are *EXO Platform – AASTMT Community – Britrix24.*
- The least suitable programs are *Inmagic Presto – FreshDesk – iMeetCentral.*
- The three features that are almost available in all programs are *Personal accounts – knowledge raspatory -Work with the organization's Existing KM.*
- The features that are less available in most programs are *Notifications to Users - Designed for educational use - Open source.*
- The only software that is designed for educational purposes is the *AASTMT Community*.

From the above findings, this research will use the *AASTMT community* software for the following reasons:

- The program came second from eleven programs analyzed by the researcher.
- The software is the only program on the list that is designed specifically to serve the purpose of an educational institute.
- The research will be conducted on some of the AASTMT educational departments, and the AASTMT is the maker and the owner of the software, this will overcome a lot of logistical and security problems that may arise.
- Staff members that will participate in this research already have personal accounts on the program.

- The software is of an open-source nature and can be developed to add all missing features with the aid of its maker.

7 Interviews

To legitimize the research, gain credibility, validate the research problem, and know how deep the problem has reached into the Maritime educational system. Also, to conciliate the practicality/suitability of the proposed solution and obtain an overview of the expectation of its outputs.

Several interviews had been carried out over a long period, some of the interviews were made in a highly scientific/professional method, and some were less formal, and some were carried in a non-formal manner, depending on the time available and the circumstances of the interview.

The names and the identities of the interviewers will not be reviled because of privacy disclosures, but the researcher is free to declare that the professional positions of the staff members interviewed can reflect on the overall subject, either to identify the problem or to evaluate the solution. (detailed information is available for authentication upon request).

The pool of interviewers is from different sectors of Academia, policymakers, educational deans, heads of departments, research and development, researchers, quality assurance personnel, undergraduate studies administrators, postgraduate studies executives, student affairs, senior and junior lecturers.

7.1 Interview discussion points and feedback

- **What is KM and how well it is embedded in our Maritime educational system**

All of the Higher managerial positions interviewed had a very clear understanding of KM as a concept, the same understanding of the concept was not available at the majority of the non-managerial and junior staff members. After the concept had been introduced to those who were not familiar, they all appreciated the vital role that KM plays in delivering maritime education.

On the other hand, when asked about whether the KM is implemented in the current educational system or not, they all agreed that they cannot admit that there is any official KM tool being used to apply the concept, except few shy personal initiatives from individuals that will soon demolish eventually, as a result of an absence of a fathering policy.

- **How would you suggest an action plan to apply/improve KM in your department/deanery?**

The researcher received some suggestions in this debate, varying from using computer software, data collection portal, content management system, to human-centered systems, like the communities of practice, scheduled meetings, non-formal gatherings, shadowing, etc.

some may not have used the scientific name of the tool but at least they describe it well enough to reflect that they have a fair understanding of the concept and the deep will to contribute in case of adopting.

- **Do you think that KM as a practice should be a self-driven initiative from employees or an institute policy-driven from higher management?**

This was the single discussion item that all participants agreed upon. For the KM to flourish it must be a policy-driven concept, following the "rights and liabilities" code. Personal initiatives will not live long in the absence of strong commitment from higher management. Of course, this does not relieve the employees from their responsibility towards the KM system, but in the presence of rules and regulations, the application could be formally supervised and monitored through legitimate channels.

- **Do you believe that the roadmap proposed by the researcher will help resolve the problem (if any), and how well do you think the proposed solution will perform?**

Optimist interviewers saw that the road map proposed by the researcher as a solution to the lack of proper KM absence will most probably succeed, but will need great support from policymakers and some training on the software. Some had doubts about the ability of software engineers to achieve the level of required results, given the complicated nature of the scientific content of the maritime education

The pessimistic participants, on the other hand, didn't have much to say on the platform but had very strong doubts about the ability of personnel to adapt to the system and take a role in its application, even in the presence of strong compulsory requirements from the administration. in their point of view, people have always ways to override the system.

Finally, all agreed that if we could overcome the technical challenge and were able to find a way to ensure people docility, the system will achieve its goal and KM will positively affect the quality of Maritime Education and Training

8 Findings

- General Lack of defining KM.
- Lack of identifying the importance of KM, and naturally, failed to anticipate its effect.
- Strong wellness of policymakers and employees to contribute to the process of adding KM systems to the MET Domain. After being convinced of its essentiality.
- The practicality of the roadmap of implementation introduced by the research.

9 Conclusion

In conclusion, knowledge management systems are an essential managerial tool used in any knowledge-intensive organization. Believing that the knowledge of its employees is the most important asset in any successful competitive organization; top management should always utilize its resources most beneficially. To do that, this paper had illustrated different aspects of knowledge management and its subsidiary theories. Also, discussed Nonaka & Takeuchi's theory on the flow of organizational knowledge and how this theory would successfully be integrated throughout the educational system backed by strong formal and non-formal Communities of Practice (COPs) and a powerful functional Content Management System (CMS).

Therefore, this research recommends that all Maritime Education and Training Institutes shall construct/develop a Knowledge management model/system and implant it in its quality standard system where all employees would obligatorily contribute in. In this way, knowledge will be retained within the institution, and the overall performance of the Institute would surely magnify.

For further research, the complete design of a knowledge management platform will need to take place and be introduced to a sample of participants. On that ground, quantitative methods shall be used to measure the effectiveness of the tool concerning the quality of Maritime Education and Training.

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Proceedings

New Trends in Maritime Transport and Job Opportunities

Automation of FRAMO Cargo Pump purging with IoT

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Abstract. Liquid cargo tankers of variable size can preferably choose FRAMO system for their cargo transfer requirements. FRAMO [1] system has been proved as a reliable technology with maker recommended human supervision. The reliability of the pump is mainly depending upon the seals fitted on both cargo and hydraulic oil sides. The major damage of these seals makes the pump completely in- operatable or minor damage leads to the maintenance requirement to bring the pump back to normal. To determine the condition of seals, FRAMO recommends to perform purging operations of cargo pumps whenever the tanker is loaded with cargo on daily basis. This procedure will help us to decide the choice of the particular pump for cargo discharging operations. On today's onboard practices the complete purging procedure is performed manually. The pressurized air supply through the cofferdam forcefully removes the content in that space and it helps the crew member to identify any failure of seals and the extent to which the failure is. This paper discusses about automating the purging process under unmanned environment and communicating the test results to the control center for the decision making on the use of the particular pump. In this paper details of electronic control circuit to automate the purging procedure is described. Added with the above, the detailed testing methods to determine the cofferdam space content and the data transmission of collected test results to control center also explained.

Keywords: FRAMO, Autonomous Ship, IoT, Automation

1. Introduction

Today's big issue is autonomous and remote-controlled vessels. It's no surprise that people believe this is the next stage in the evolution of marine technology in an era where artificial intelligence is closer to reality than it has ever been. Unmanned aerial vehicles and self-driving automobiles are now available, but there are no unmanned vessels in use till date.

The future of maritime technology may be autonomous technology [2], but in what form remains to be seen. There is still need of crew on some cases, no matter how interesting or cool new developments are. New technology must not only substitute but also build upon what came before, and this is also true in the case of autonomy. There are a variety of ways to operate an autonomous vessel, one among them is without any on-board computing system and all command and control from shore [3]. Because of more cargo space available due to replacing the crew (at least some of them), with autonomous or remote-controlled technology could reduce operating expenses and save money. The creators of this technology claims that it would create safe environment with less or nil incidents. Human error is the leading cause of maritime incidents [4] today, so reducing this element could help the industry.

Autonomy can be applied in tiny chunks to make it simpler for a ship's crew, for example, assisting them with docking the vessel. While both autonomous and remote-controlled vessels are unmanned, there is a distinction. Remotely operated vessels [5] are piloted from a control station on shore, while autonomous vessels use computers, algorithms, and sensors to navigate and operate. These two types of unmanned vessels are often discussed in the same breath as a potential solution for sea voyages, implying that they are not mutually exclusive. Both would almost certainly be present in vessels that employ these technologies. There have already been a few real-world examples of autonomy and remote control [6], and more are on the way.

1.1.Various degree of autonomy

A seaborn vessel that navigates the seas without human intervention is described as an autonomous vessel [7], but as previously mentioned, this is not always the case. When it comes to MASS [8], there are various levels of autonomy. Companies, organizations, and individuals all have their own definitions of autonomy and degrees of autonomy, which may lead to some misunderstanding. In order for MASS to be implemented on a global scale, clear definitions of the various levels of autonomy are needed. MSC had their 100th meeting in December 2018, and they made progress on the regulatory scoping exercise for MASS. The current set of MASS rules and regulations must be differentiated based on the degree of autonomy of a vessel.

Degree 1: The crew is present and running the vessel with the help of automated systems: In some conditions, certain tasks can be automated and unmonitored. If required, the crew is prepared to take command.

Degree 2: Ship with seafarers on board that is controlled remotely: The vessel is controlled remotely. The crew stay on board and is prepared to take command if necessary.

Degree 3: Remotely controlled ship with no onboard seafarers: The vessel is controlled from shore.

Degree 4: The vessel is totally self-contained and runs on its own. In all cases, the vessel will decide the best approach and make the necessary decision.

1.2.Maritime autonomy vs Industry 4.0

In Industry 4.0, data and machine learning will be used to construct smart and autonomous systems. As the use of cyber-physical systems, cloud technology and the Internet of Things (IoT) rises in manufacturing, so does the demand for cyber security. Autonomous automobiles have already been deployed. Ships, without a doubt, have different challenges than autos, and the maritime industry [9] is known for its slow adaptability to change.

Number of autonomous functions in maritime vessels on specific applications are growing for example, Automated fire safety systems and Automated energy optimization technics. Still, it is lagging behind the trajectory of other industry including aviation. Even though same basic elements such as motors, pumps, and fans are used in the ships too, they are not connected with Information Technology, communication, or data. New evolution in this area needs, a range of networked gadgets and ICT systems.

Cyber vulnerabilities [10] have also been discovered in planes and Automated avionic vessels are in use. There’s no reason to expect that ships will not be more secure, which are one among our vital infrastructure in the maritime industry.

2. Review of Existing Maritime autonomy

MUNIN [11] is a cooperative research venture financed by the European Commission. Maritime Unmanned Navigation with Network Intelligence is what it stands for. This was the first study to investigate whether and how autonomous applications in big commercial ships might reach the same levels of safety as conventional ships [11,12]. The goal is that a ship constructed in this project will deliver goods to its destination autonomously, safely, and independently. The world’s first remotely operated commercial vessel has been developed by Rolls-Royce Commercial Marine [6] and global towage operator Svitzer. A demonstration was held in Copenhagen port in Denmark in early 2017 [13], and the development is part of the SISU project. The tug Svitzer Hermod successfully completed a number of remotely controlled manoeuvres.

Kongsberg Maritime [14], or KM for short, is developing a new self-driving ship. AutoBarge is the name of the vessel they're working on, and it's a collaboration with Asko. The project will conclude in two autonomous, electric, and zero-emission vessels crossing the Oslo fjord. AutoBarge will suit 16 semitrailers and replace 150 truck journeys between Moss in Stfold and Holmestrand in Vestfold [15] every day. It will reduce CO2 emissions while also improving traffic congestion and safety. Each of the ships is equipped with a standard bridge, however they will be supervised from a shore control centre, just like Yara Birkeland [16]. The idea is to have Kalmar's autonomous and electric tractors drive semitrailers on and off the ships. Asko wants to be able to drive the trailers from the ports to his storage facility using electricity. The goal is to begin testing in 2021 and to be self-driving, electric, and emission-free by 2024.

Autonomous ships must function at least as safely and reliably as modern ships operated by on-board people in order for their development to be beneficial [17-20]. While algorithm-based decision making can eliminate certain human errors [20], new risks and concerns, such as cybersecurity for autonomous ships, will undoubtedly develop. The simplest remote operation of a ship necessitates a reliable means of monitoring its health and precisely observing the ship's environment without substantial delays. Adopting and further development on existing sensor technology and computer vision to work precisely in the maritime environment, where climatic conditions might be vastly different from those on land. This is one of the first stage in achieving this reality. The findings of vision-based tracking of marine traffic ships [18] and collision avoidance have proven promising in recent investigations. As a result, successful sensory data interpretation is critical for autonomous ships to perform the appropriate action at the right time. As a result, smart decision algorithms must be thoroughly created and validated.

3. FRAMO submerged cargo pumps

FRAMO Cargo pumps as shown in the Fig.1 are vertical, single-stage centrifugal pumps that operate safely and efficiently with hydraulic motors. FRAMO cargo pumps are composed of stainless steel and restricted number of flanges to improve its efficiency to pump any liquid. These pumps are widely used in product carriers and on the introductory phase in large crude carriers.

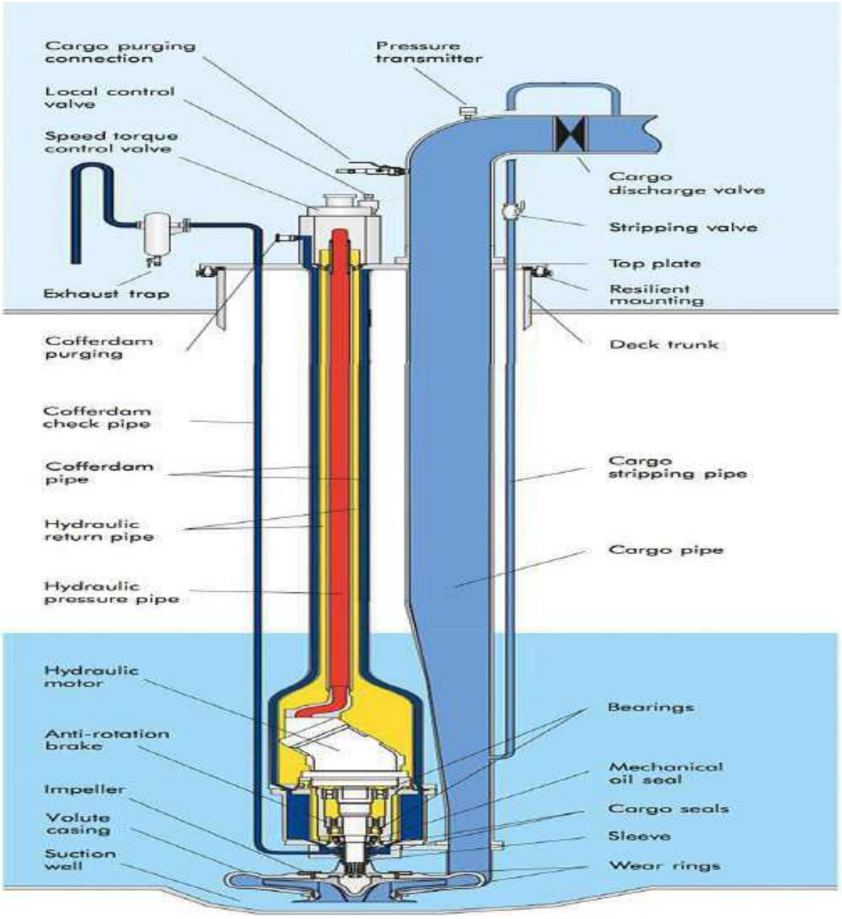


Fig.1.FRAMO PUMP [1]

3.1.FRAMO Pump Operation

Hydraulic motor drives the FRAMO pump [21], which receives pressurized hydraulic oil from the power packs. The high-pressure hydraulic oil goes into the hydraulic motor in the red area as in the Fig.2a, and the hydraulic oil returns in the yellow area. Both of these pipes are in a circle around each other.

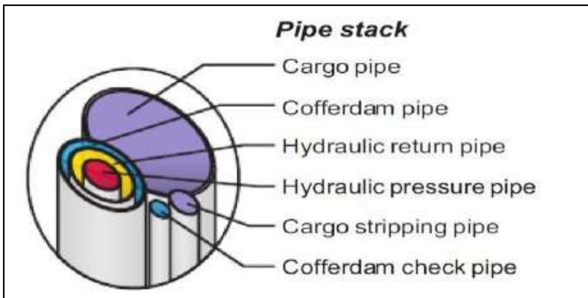


Fig.2.a	Fig.2.b

As this pump is located within the cargo tank, two liquids (hydraulic oil and cargo) must not come into contact. The cargo may be contaminated if hydraulic oil leaks into tank. The hydraulic system will be contaminated if cargo gets into the hydraulic system. The FRAMO pump has a feature that prevents this, Hydraulic oil leaking to the cargo side is prevented with a hydraulic seal. There's also a cargo seal as shown in Fig.2.b to keep cargo from seeping into the hydraulic side. As a steel cup with a cargo seal at the bottom, a cofferdam will collect any hydraulic oil or cargo leaks.

3.2.Onboard Condition based Maintenance

Monitoring the condition of seals regularly ensure the trouble-free operation of cargo pumps. Seal monitoring is done by purging the cofferdam from the cargo pump top plate. On the use of FRAMO submerged Cargo pump, one of the most critical preventive maintenance routines is to purge the cofferdam. This is one kind of method to inspect the pumps' seals, and hence their condition, without having to enter the cargo tanks. Any leakage through the seals will accumulate in the cofferdam. By regularly purging the cofferdam, the leakage rates may be assessed, and action (if necessary) may be planned to ensure the cargo pump's safe and efficient functioning.

The cargo pump cofferdam must be purged on a regular basis in line with the FRAMO Purging Instruction, which may be found in Ship's Service Manual. The ship's crew bears primary responsibility for purging, logging results, and any further actions. They are familiar with the actual operating circumstances on board and are entrusted with the proper operation and maintenance of the equipment on a regular basis. If the purging findings suggest that maintenance is required, the ship's crew must take action as soon as possible.

4. Proposed Methodology

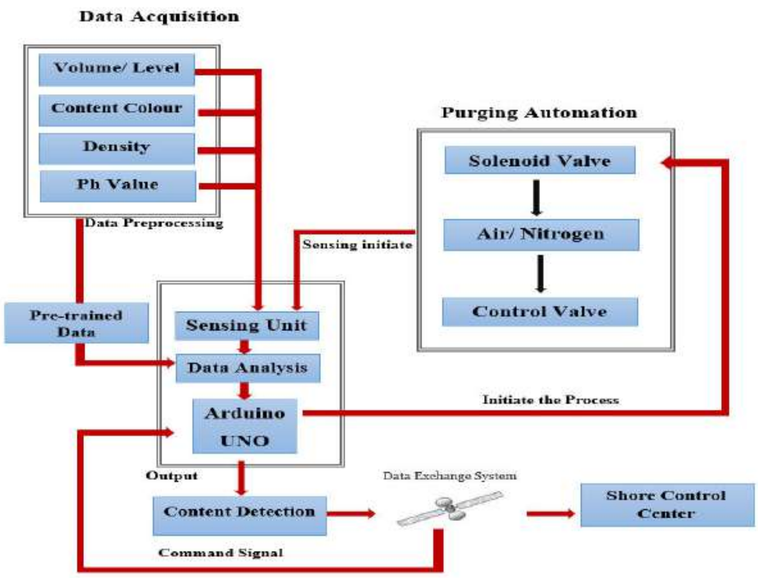


Fig.3.Proposed Methodology on Automation of Purging

To automate this purging operation, this paper describes the Proposed methodology as Fig.3 consist of the following:

1. Initiation of this purging operation triggered either by delay timer or command signal through IoT from shore control station.
2. Automating the purging process under unmanned environment [22] and collect the leakage content if any.
3. Analyze the physical properties of the leakage content with different electronic sensors.
4. Compare the physical property data measured with the sensors and pre-defined database stored to identify the leakage content.
5. Identified result will be notified to the shore control centre using IoT communication [23].

4.1.Purging Automation

When the pump is idle at sea, the purging procedure is started by a delay timer or a command signal from the control station. The cofferdam pipe (Dark blue in colour as depicted in the Fig.1) is pressurized by air or nitrogen depending on the cargo type carried, by opening the cofferdam purging supply control valve (Fig 4) located in the main deck.

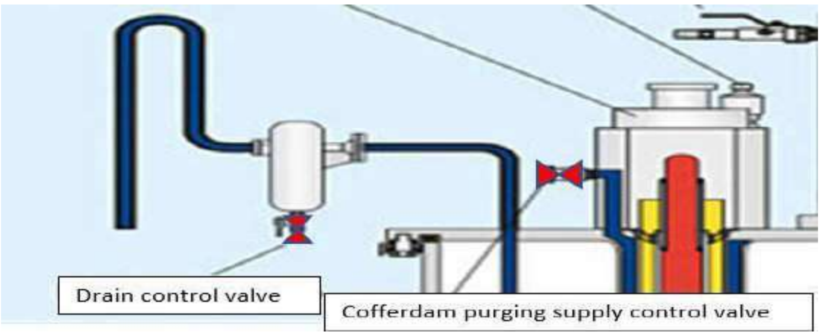


Fig. 4. Purging Automation

Through the cofferdam check pipe, pressurized air forces the content gathered in the cofferdam to the exhaust trap in the main deck (Dark blue in colour as shown in the Fig.1). The exhaust trap's drain control valve (Fig 4) opens, and the contents are emptied into the sample container. In each operations sample will be collected in a new container to ensure that the test sample is clean. This complete sequence of operation is accomplished by Automation using Arduino UNO system.

4.2.Data Acquisition:

Basis on the sample content following results is derived

- The cofferdam is empty if simply get air into the purging line's exit. There is no hydraulic oil or cargo leakage, and both seals are intact.
- If cargo is detected in the cofferdam, that means the FRAMO pump's cargo seal is leaking.
- If hydraulic oil is detected in the cofferdam, that means the FRAMO pump's hydraulic oil seal is leaking.

The sample content is analyzed on its physical properties to conclude weather the content is cargo or hydraulic oil.

- The ship is equipped with various sensors for short and long-range proximity measurements, as well as software for the control unit and sensors, which is run on an Arduino. The control unit runs on the on-board edge cloud, which is an Arduino in this case, and the edge device connects with other components.
- The information acquired from the ship's sensors has to be saved as attributes in Data base. We propose to use larger data sets for simple debugging and test data collection, which necessitated a more robust design.

4.3. Control Unit:

Control unit in this proposal perform the following activities,

- Initiating the cargo pump purging operation either of the two conditions.
  1. Pre-defined interval from Timer.
  2. Command signal from Shore control station
- Supervision of purging sequence and alarming if any faults in the sequence.
- Operate and monitor the Sequential flow of sample containers to different sensing devices.
- Data acquisition from different measuring sensors.
- Comparative study of both the measured value and stored database.
- Detect the sample content
- Communication exchanges info based on events.
- The shore control centre (SCC) ensures that the ship is operating safely and, if necessary, acknowledges the decision.

5. Feasibility of the Proposal:

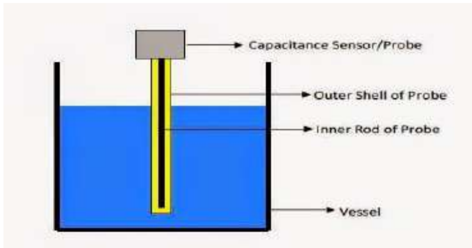
As this paper discuss about automation of Purging process on FRAMO cargo pumps, this feasibility study can be tripartite as following sub segments

5.1. Automation of Purging Operation

This is an operation in which the functions of various valves are intertwined with time intervals. All of the valves can be hydraulically powered and controlled by an electronic signal to OPEN/CLOSE. The hydraulic power required can be obtained from the same FRAMO system. The ARDUINO board could be used to programme the signal that controls the sequence.

5.2. Analysis of Purged Content

Analysis of the content is based on their physical properties which are measured using different sensors.

A. Volume of leakage • Leakage volume estimated using measured liquid level and known container cross sectional area. Capacitive level sensors are used for level measuring. • This sensor is inserted into the sample container as indicated in the image to measure the liquid level.	 Fig 5. Level sensor
B. PH value of the content • The PH value is used to distinguish cargo, particularly if it is chemicals and hydraulic oil. In the sample container, prob type PH metres are used to determine this value.	 Fig 6. PH meter
C. Density of the leakage fluid • Because some of the oil cargo and hydraulic oil are generated from the same crude oil source, density is a key criterion for distinguishing the two. Density metres with forks are a good choice for this application	 Fig 7. Fork type Density meter
D. Appearance of the liquid • The colour of the liquid is another useful physical parameter for determining the content. The identification of content liquid can be sped up by colour comparision. Using a high-definition camera to capture the image of sample content and comparing it to a database helps to attain this task.	 Fig 8.Different coloured cargo

5.3. Data Transmission

As ship is always floats distance away from the shore, the communication system gets much more priority in the maritime industry. With today's developments in the efficient satellite communication and real time data transfers [24] between ship and shore ensures un- interrupted service in the proposed automated process.

The existing available data communication used for the vessel operation eliminates the vessel identification (Address) during the data communication with multiple vessels [25]. we'll use Arduino UNO because the setup needs to be easily scalable and cloud-integrable. Also, Arduino is the right choice due to its size is ideal and it has adequate computational capacity to handle the data processed on the edge cloud under Shore control centre.

Integrated sensors eliminate the need for external components, which speeds up and simplifies the automation of this process. The data exchange system as a bridge between the real-world environment and the control unit embedded with Arduino UNO system. To ensure low latency and consequently proper control unit operation, sensor data is transmitted directly to the control unit via the edge device. The control unit receives raw sensor data, which it can pre-process when the type of data it receives requires to Analysis the content of the sample.

6. Barriers

With the current study of the proposal, few of the following barriers were identified. By performing additional number of experiments these barriers can be removed.

i. **Accuracy of sensors:** Accurate results of measurements were expected if the volume of sample is considerable in size. If the leakage of the seal is less and the sample volume also less, it affects the accuracy of sensor's result.

ii. **Mixed liquids:** At one scenario, if both cargo and hydraulic seals were leaking, the properties sensed on the sample collected in the container does not match with the properties of either cargo or hydraulic oil. To conclude this situation, additional data such as sensor accuracy and properties related to mixer of both liquid need to be considered.

iii. **Different cargo in different Tanks:** Parcel Tankers loaded with different cargo in different tanks. To identify the leakage content, system required to predefine that what cargo loaded in which tank. By including additional parameters sensing such as vapour pressure, can eliminate this limitation. This can be achievable after adding other suitable parameters also in the database.

iv. **Cyber security:** In order to maintain safe marine operations, cyber security [10] is a crucial factor to consider. Because of the increased information and communication technology (ICT) onboard, different attackers may attempt to exploit the system remotely, causing serious damage or disruption. As a result, illegally manipulating or exploiting the system be possible under any circumstances. To be protected from cyber threats, vulnerabilities in the ICT infrastructure must be addressed. Outsiders should not be able to interfere with communication between a ship and the SCC.

7. Conclusion:

Autonomous ships are very near to reality. The first step toward autonomous ships is for the ships to be unmanned and operated from a shore control centre [26]. This necessitates a comprehensive ability to remotely monitor the ship's condition in real time, which creates a slew of new issues. To enable correct decision-making, the data gathered from the ship's state must be precise and conveniently available to the operator.

Each and every small operation performed by crewmembers out at sea, which are essential for the operation of the vessel or pre-preparation of vessel for its cargo operation required to be automated. This paper chooses one such an operation. This proposal identified how FRAMO cargo pump purging operation can be automated and can produce the accurate result. This study analyzed the feasibility of the proposal along with current hurdles to achieve the same. Overall, the detailed study produced in this paper shows the much confidence on the proposal.

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Big Data Management in the Shipping Industry: Examining Strengths Vs Weaknesses and Highlighting Relevant Business Opportunities

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Abstract

History testifies that there is a dialectic relationship between humans and technology. Especially during the last couple of decades, the shipping industry has benefitted from a very extended number of advanced technology innovations. Today, all systems supporting the conduct of navigation and the various information technology (IT) applications related to ship management activities are heavily reliant upon (almost) real-time information to safely/effectively fulfil their allocated tasks. As a result, truly vast quantities of data -which are often described as "Big Data" in the wider literature- are created and the issue of how to effectively manage all the associated information is clearly standing out. Furthermore, topics such as optimising the conduct of all relevant activities on-board the vessel at sea, identifying the right opportunities in order to further promote business and boost profits, or even contributing to the numerous elements of sustainability by achieving reductions in energy consumption and/or a better environmental footprint for shipping, should all be researched further.
Considering the quite limited capacity of the human brain to process really enormous quantities of data in comparison to modern computers, the trend to use advanced software tools for extracting and processing the "right" information that is often hidden in the vast pool of Big Data, as well as relying on advanced techniques and algorithms to perform the relevant statistical analysis becomes quite obvious. The purpose of this paper, which follows a qualitative approach working in unison with a "Strengths, Weaknesses, Opportunities, and Threats" (SWOT) analysis, is to identify and briefly discuss the most relevant tools and techniques that are associated with Big Data Management. It will also clearly highlight the various benefits that are opening up and will try to explain the notion behind this transition to a new era, characterized by the term "smart shipping". A very important conclusion is that the exploitation of Big Data and the role of certain software applications in accessing and managing this large volume of information are key factors for improving/optimising the conduct of ship operations and management; establishment of a "Data Driven Culture" within a shipping company can clearly improve the current business model and at the same time promote sustainability.

Keywords: *Big Data Analytics, SWOT Analysis, Data Driven Culture, Optimisation, Shipping Industry.*

1. Introduction

The modern business environment is characterized by continuous changes and fierce competition. This situation is creating a pressing need for companies to identify and quickly adopt the right "means" for ensuring their survival, as well as promoting their further development and consolidation within the markets they operate. Informatics, from the very beginning of their inception, have proven to be a powerful tool at the disposal of companies that want to improve their business model, as they can be used as the main strategic enabler for integrating changes in the company's internal structure, functions and processes. Especially in the maritime sector, a large volume of data is produced from a very extended pool of relevant sources (i.e. systems supporting the conduct of navigation and/or ship's machinery, as well as related marine fleet management systems etc.), on a daily basis. The domain of

“Big Data Analytics” examines large amounts of data to uncover hidden patterns, correlations and other insights (i.e. market trends and customer preferences) that can help organizations make informed business decisions; it can be categorized as a special branch of the wider information technology (IT) domain and its main aim is to discover correlations and interactions between different measurable or non-measurable parameters, in order to identify non-clearly defined standards and patterns (Goyal et al., 2020). This research effort aims to clearly highlight that Big Data Analytics have the potential to create a very positive impact upon the shipping industry. To achieve this, a qualitative approach is deployed, working in unison with a “Strengths, Weaknesses, Opportunities, and Threats” (SWOT) analysis. This combinatory methodology will allow to identify and briefly discuss the most relevant tools and techniques that are associated with effective Big Data Management. Furthermore, the various benefits in terms of improving the current prevailing business model will be explained, indicating that the transition to a new era, characterized by the term “smart shipping”, has already started.

2. Background

2.1 Big Data in the Maritime Sector

The contemporary era is frequently referred to as “the information age”; it is therefore not a coincidence that modern economic activities are very highly dependent on data. It is quite obvious that the volume of (stored and processed) data has grown exponentially over the course of time and this trend is recorded in literally all economic sectors and related activities. In order to provide a relevant definition, the McKinsey Global Institute, is approaching “Big Data” as those data-sets with a size that exceeds the ability of traditional database software tools to collect, store, manage and analyze these data (Manyika et al., 2011; Saxena, 2016; Al-Sai et al., 2019). This very significant growth in accessibility of data, storage capacity, and computational power has impacted businesses throughout the world. This change involves not only very popular and well known businesses like Yahoo or Facebook that were “*were born and function solely online”*, but also early adopters in more conventional industries such as banking, retail and transport. In the near future, a really impressive data growth is expected because of the related developments in remote sensors, as well as functions like communications, computations and processing activities of an “interconnected world” that will involve very large data collections/handling (Davenport and Harris, 2007; Goyal et al., 2020). It is also true that there are various definitions of Big Data. The prevailing version is usually different from one industry to another, and clearly depending on the type of available software tools and the sizes of datasets that are in common use within that specific industry (Al-Sai et al., 2019).

In simple terms, the notion of Big Data translates into a dataset that continues to grow till it becomes very difficult to effectively manage it by using the prevailing (standard) resources of database management. Data collection, processing, search, sharing, analytics, and visualization can all be viewed as the possible reason of this complexity and ineffective management (Manyika et al., 2011). The META Group analyst Doug Laney (now Gartner) defined data growth challenges and opportunities as being three-dimensional (volume, velocity, and variety) in 2001 (Esteves and Curto, 2013). After just two years, this definition was updated by Gartner: "*high-volume, high velocity and/or high variety information assets that demand cost-effective innovative forms of information processing for enhanced insight, decision making, and process optimization*" (Zainal et al., 2017). SAS also defined Big Data as "*Popular term used to describe the exponential growth, availability, and use of information, both structured and unstructured*"; IBM added more input towards the Big Data concept: "*Data, coming from everywhere; sensors used to gather climate information, posts to social media sites, digital pictures and videos, purchase transaction record, and cell phone GPS signal to name a few*", "*Big Data is defined as large set of data that is very unstructured and disorganized*", "*Big Data is a form of data that exceeds the processing capabilities of traditional database infrastructure or engines*" (Al Nuaimi et al., 2015; Quintero, 2015; Al-Sai et al., 2019).

A very large number of researchers and associated practitioners approach Big Data as a term that describes large volumes of high velocity, complex/variable data that require advanced techniques and technologies to enable the capture, storage, distribution, management, and analysis of the information. This domain is characterized as a new generation of technologies and architectures, designed to economically extract value from massive volumes of a wide variety of data, by enabling high-velocity capturing, discovery, and analysis (Esteves and Curto, 2013). Several studies, such as those by Manyika et al., (2011), Widyaningrum (2016), Bronk and Khan (2017), as well as Drus and Hassan (2017), have characterized Big Data by a multi-V (4Vs) model (volume, variety, velocity and value). At the same time, other approaches emphasize the so-called 5Vs model (Fig. 1). Specifically, the Five Vs (volume, velocity, variety, veracity, and value) exhibit certain differentiating characteristics that have been formulated by the difference between using traditional data and effectively exploiting Big Data (Saxena, 2016).

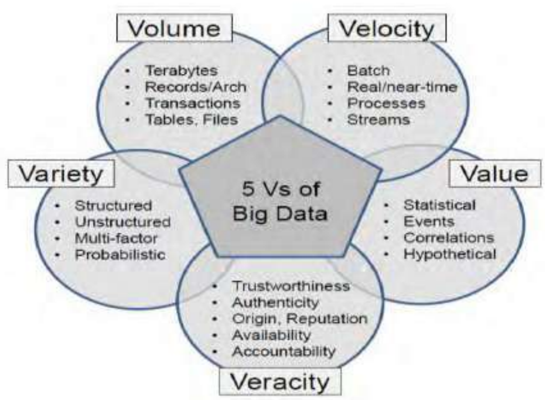

Fig. 1. Big Data – 5Vs definition model (Ishwarappa, & Anuradha, 2015)

The 5Vs model is summarizing the basics of all those characteristics that clearly define Big Data. Volume-Velocity-Variety are standing out first, with Veracity-Value coming next (Chen and Zhang, 2014; Ishwarappa and Anuradha, 2015). A short description of the above mentioned term is described with the help of Fig.1, along with some additional clarifications that follow: a) *Volume:* Big Data volume refers to the data storage space. Storage space for such data imposes Terabyte or Petabyte requirements; b) *Velocity:* It refers to the rate at which data is generated or processed and stored and further analyzed in real time; c) *Variety:* Data can be stored in various formats such as databases, excel (or csv) files, or even as simple text files. Sometimes the data under discussion does not follow a traditionally tabular format; basic types of this data are divided into structured, semi-structured and unstructured. The greatest challenge for shipping companies is to handle properly these large volumes of unstructured or semi-structured data and manage to convert them into a structure format; d) *Veracity:* It makes sense that among all this data there is "*dirty data"*, which should either be corrected or excluded from the analysis process. The quality of the data stored is important, as the analysis of erroneous data can lead to invalid or unreliable results. The main factor that affects the veracity of the data is their source; e) *Value:* this characteristic was added later on the features of Big Data definition, but it is still very important. The potential value of Big Data is truly huge and it is associated with the fact that it can help companies to identify new opportunities.

Big Data analysis is performed where advanced data techniques and technologies work in large sets of data, as defined above, in order to deconstruct complex information and semi-structured or non-structured data into structured information (Goyal et al., 2020). Specifically, Big Data Analytics (BDA) is a process for examining the variety of data with the aim to improve (or even optimize) relevant decision-making. Indicative benefits of BDA are: a) Reduction of costs. Big data technologies such as Hadoop and cloud-based analytics offer substantial cost savings when it comes to processing large amounts of data; b) Really effective, better decision-making. By combining Hadoop's speed and in-memory analysis the ability to evaluate new data sources is provided; companies can then quickly analyze knowledge and make "better" decisions based on what they have found; c) Improving provision of goods and services. Through the use of analytics, the designated analysts can measure and better define the needs of the customers; improved, or completely new products can be created to effectively meet the needs of consumers.

2.2 Big Data Applications

The volume of data coming from vessels is truly huge. It is indicative for someone to just think the large amounts of data from the Marine Traffic portal that indicate the exact locations of all vessels, at the worldwide level. Also, effective implementation of existing maritime regulations requires continuous data from vessels, which must be collected, stored in a format that allows monitoring of the vessel, such as position/location, speed, course, the weather at the respective location or even data generated each time in real time and collected by sensors such as main engine telemetry data and many more. Data recording must be continuous and maintained on vessel's applications, offering detailed information that will contribute into "easier" decision making. An additional feature of Big Data is its wide variety, as it is stored in many different formats. Data coming from vessels can be collected from dozens of different devices and with different formats. Accuracy and validity in shipping systems may have evolved considerably, but the risk of some data errors remains. An incorrect measurement, or an incorrect entry, can lead to erroneous results and consequently to the wrong decision (Rodseth et al., 2016; Zaman et al. 2017). Sources of Big Data on board a vessel are (Rodseth et al., 2016): Bridge data network; Conventional ship's automation; New cyber-physical systems; Ship performance monitoring systems; Ship voyage monitoring and reporting systems; External ship monitoring (AIS and VTS);

Weather data, among others. Data associated with ship operations can be collected from various sources. However, in order to extract the “right” information and be able to make meaningful decisions, the stage of analysis is essential; a rigorous (Big Data) analysis is crucial. The Big Data value chain also consists, in the case of shipping data, of collecting, processing and storing data, analyzing it with innovative and cost effective technologies and techniques, and formatting it in such a way as to either create a better understanding, or improve insight and decision making (Rodseth et al., 2016).

The adoption of Big Data Analytics is facilitated by the willingness of the shipping industry to move from a traditional culture to its operational management into a new Data Driven culture, as it is moving forward towards digitalization. According to various sources (IMO 2014; ISO 2015a, 2015b; IEC, 2015; Rodseth et al., 2016), indicative areas of interest include (but, are not limited to): a) *Vessel Performance Monitoring.* The vessel's energy efficiency management plan requires vessels to collect information on the vessel's performance and conduct of navigation from various on-board systems and associated Data Acquisition Systems. These systems are designed to collect, store and communicate large amounts of data relating to vessel performance and navigation data through complex processes. Data obtained from analytics allows a better understanding of the vessel's performance. Data on, for example, fuel consumption may show that in extreme weather conditions a significant reduction in speed can lead to disproportionate fuel reduction, leading the vessel to consume more fuel to move and indicate a change in speed at the point of optimal consumption. Data analytics in relation to a specific vessel might also “predict” a repair or a possible malfunction; b) *Navigation Data.* In 2000, the International Maritime Organization (IMO) defined the need for an Automatic Identification System (AIS), capable of automatically providing information about the vessel to other (nearby) vessels as well as to relevant authorities ashore. Since then, that data have been created and turned into a common object of research in the field of marine studies. This data mainly consists of the ship's identity, location, speed and direction. Big data analytics could provide a better understanding of the vessels’ movements, indicating, for example, the most popular points of trade or helping them to avoid collisions and ensure a better level of safety at sea; c) *Green Shipping.* IMO has introduced several regulations regarding the reduction of emissions and improvement of energy efficiency. Big Data analytics can provide important information and lead to optimizations in relation to vessels’ emissions, allowing a deeper understanding of the problem; d) *Safety.* Another area of interest for the world of Big Data analytics is that of safety in the operational management of the vessel. The information generated clearly creates new perspectives on maritime risk management and accident prediction; e) *Autonomous or Remote Controlled Ships.* BDA could provide a better decision-making for people performing remote control and allow for a smoother integration of these types of vessels.

3. Methodology and Findings

A SWOT analysis was used as the research tool. SWOT Analysis can be used both for strategic planning and strategic management; it can be used to build organizational strategy and competitive strategy (Gurel and Tat, 2017; Sammut-Bonnici and Galea, 2014). Thompson et al. (2007) point out that “*SWOT Analysis is a simple but powerful tool for sizing up an organization’s resource capabilities* *and deficiencies, its market opportunities, and the external threats to its future*". The acronym SWOT stands for "strengths, weakness, opportunities and threats". The SWOT Analysis, also referred to as "SWOT Matrix", can also be formulated as "TOWS Analysis" or "TOWS Matrix" (Gurel and Tat, 2017). Specifically, this internal analysis can be used to identify resources, capabilities, core competencies, and competitive advantages inherent to an organization. Similarly, the external analysis identifies market opportunities and threats by looking at competitors' resources, the industry environment, and the general environment. The objective of a SWOT analysis is to use the knowledge an organization or area or field has about its internal and external environments and to formulate its strategy accordingly (Sammut-Bonnici and Galea, 2014). As internal and external sources of the SWOT analysis, input of relevant papers from google scholar and science direct databases was used. Maritime environment related keywords were used to search articles for a period of the last ten (10) years, to ensure the relevance of the identified academic papers. The term "maritime" was always included in the search, along with the key terms "Big Data" and "Big Data Analytics". Certain abbreviations and/or combinations were also used, such as BDA in shipping, AIS and big data etc. Fig. 2 demonstrates the methodology approach; a summary of the findings is provided via Tab. 1:

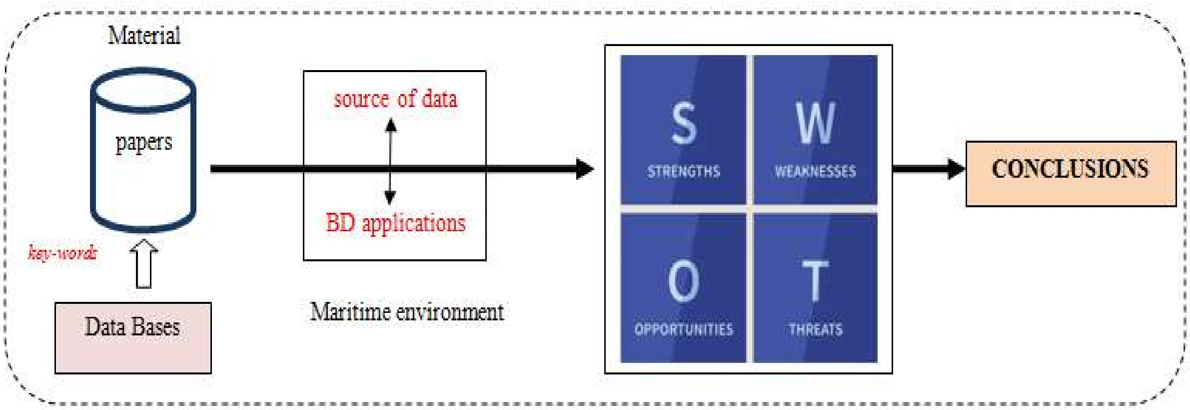

Fig. 2. Methodology Framework

Tab. 1. Final Results

INTERNAL ENVIRONMENT	EXTERNAL ENVIRONMENT
Strengths Data Quality Consistency Data Reliability Data Availability Data Confidentially Data Set Scalability	***Opportunities*** Data protection Business Model Human Factors and Practice AI using (machine & deep learning) IoT application Energy Management Environmental legislation monitoring Performance management Autonomous ship

Weakness	***Threats***
Data management	Hackers / cybersecurity
Data transfer	Data ownership
Accidents (from IT errors)	Ethics issues (decision making from autonomous shipping or smart shipping)

4. Conclusion

It is a self-explanatory fact that the volume of data is increasing over the course of time and at the same time there is also an increase in the related speed of transfer (upload and download) and its diversity. The value that is “hidden” in these huge volumes of data, when properly discovered and verified, can provide access to improved knowledge in relation to the business environment and even lead to the notorious “competitive advantage” over other competitors. Shipping companies can no longer rely their business decision-making processes in anachronistic ways (old mode of “paper and pen”)", but on the contrary, it seems quite important to invest in new technologies and techniques that will ensure the optimization of their processes and associated results. Big Data is impacting our daily lives for good with applications like Facebook and various Google services; huge volumes of data (from various sources) are being processed and analyzed in relation to topics like operations of vessels at sea, loading/unloading their cargo, as well as to serve the needs of fleet management. Shipping, despite its peculiarities in relation to companies in other sectors, should view as a priority the best possible utilization of this type of data. It is more than clear that truly vast volumes of data are obtained from both in-vessel systems such as bridge data or on-board automated systems. Additional examples include vessel performance monitoring data from sensors on the vessel or relevant daily reports, as well as external sources like AIS and/or weather data. That data can be collected, processed, analyzed and stored in such a way as to provide the “right” information.

All the above can be facilitates by big data analytics. Following this approach, shipping companies can extract, with a relatively low cost of implementation, meaningful information and improve their decision-making in areas like reduction in fuel consumption and improving the vessels’ environmental footprint. In addition, the use of spatial-temporal data (i.e. vessel identity, location, speed, direction, etc.) can provide opportunities for a better risk management and even contribute into accident prediction. The exploitation of Big Data and the role of certain software applications in accessing and managing this large volume of information are key factors for improving/optimizing the conduct of ship operations and management; establishment of a “Data Driven Culture” within a shipping company can clearly improve the current business model and at the same time promote sustainability. Big Data analytics can be deployed as a powerful tool and facilitate the transition towards “smart shipping” and at the same time help the shipping companies that perform the investment and effort to enjoy the benefits of a more “safe” and more “green” operating environment. In any case, topics such as optimizing the conduct of all relevant activities on-board the vessel at sea, or contributing to the numerous elements of sustainability by achieving reductions in energy consumption and/or a better environmental footprint for shipping, should all be researched further.

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CYBER SECURITY ANALYSIS OF MARITIME SURVEILLANCE SYSTEMS

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Abstract
The authors present in the paper the main technical features of the AIS system as most popular marine traffic surveillance system. In the framework of the made cyber vulnerability analysis they shape the main cyber vulnerabilities of the system. The explanation of the vulnerabilities is connected with the possible way of their exploitation, together with the motivation of the actors. The research is conducted by applying the technical assumptions and simulations in the operational environment. The methodology allows to replay various scenarios and to outline the most typical, the most usual, the most unusual, etc. The four most typical scenarios are described and assessed based on the two factors risk assessment methodology. Groups of technicians and AIS system operators were involved in the assessment filling in a questionnaire. After the answers processing the authors define the level of cyber risk for the AIS systems for each scenario. The experts indicated controls to deal with the risk.
The last part of the paper is dedicated to the ways to cover the cyber vulnerabilities of the AIS system during the real work of the system in favor of the effective and safety marine traffic control. The operators are given the awareness of how real is the situation they monitor and how to recognize possible inadequacy of the actions. The results of AIS cyber vulnerabilities analyses help the operators to have clear understanding how much the generated operational picture on the screens represents the reality. The most important outcomes are included in the cadets' educational program.

Keywords: **AIS, cyber threats, cyber vulnerabilities, risk assessment, marine surveillance, traffic control**

1. Introduction

Modern Vessel Traffic Management and Information Systems (VTMIS) are hi-tech facilities, including the latest achievements in the field of information and communication technologies along with classical radio communication systems, radar surveillance systems and sources of hydro- and meteorological information. The majority of them are connected to external computer networks to provide information of different types and purposes to different external users by means of the so called "cloud" technologies (see Fig. 1).
Among the most important issues to be addressed in these cases are those related to the security of these systems in terms of unauthorized access and external impact, both on specific sensors and on integrated system information.

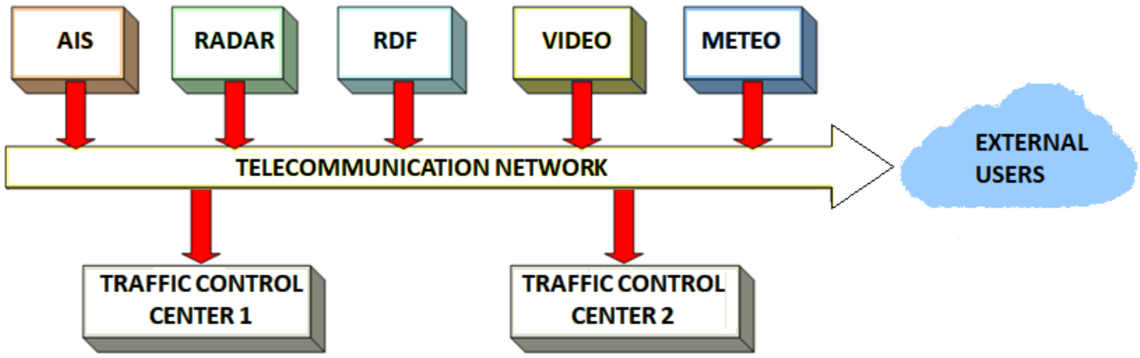

Figure 1. Typical VTMIS Architecture

In this paper, authors attempt to evaluate the degree / the level of threats of a different nature on specific subsystems and sensors, included in the complex VTMIS systems and propose solutions to increase protection against cyberattacks. The scenario based risk assessment methodology is applied using qualitative assessment by experts in area of operational use and technical support of the VTMIS system. The main contribution of the paper is the answer of the question – how to cover the cyber vulnerabilities of the AIS (Automatic Identification System) system and to create as realistic as possible maritime operational picture.

2. Technical aspects of maritime surveillance systems cyber security

The VTMIS structure integrates the following subsystems:

- Universal Automatic Identification System (AIS)
- Radar Observation and Tracking System (RADAR)
- Closed-circuit television system for video monitoring of ports areas (VIDEO)
- Radio Direction Finders System (RDF)
- Hydro- and Meteorological Sensors (METEO)
- Radio Communication System in VHF and MF/HF frequency bands
- Telecommunication Network, the backbone of the VTMIS
- Data processing system
- System for monitoring and control of the above components

AIS is the newest and most powerful system in terms of information capabilities. It is a vessel information and vessel location reporting system, providing information about vessels identity, position, speed, course, and other information to coastal states and to another ships in the vicinity on a common VHF channel, named VHF Data Link, VDL (ITU VHF Channels 87B and 88B). Information provided to another ships can be used mostly for collision avoidance, while when integrated with VTMIS, the AIS information can be used for monitoring and managing the traffic in coastal waters and port areas.

Despite AIS being the most powerful source of information for VTMIS, some of its serious limitations must be taken into account. First of all, there are conventional limitations, arising from IMO requirements that this system is mandatory to be used only by so-called SOLAS vessels. Non SOLAS vessels, i.e. vessels under 300gt may have no AIS equipment installed onboard and as such may remain “invisible” for the coastal surveillance systems and for VTMIS. Another limitation is relatively small coverage area, related to the way of propagation of VHF radio waves – up to the line-of-sight or to about 40nm from the coast. And last but not least, the transmission of correct AIS information depends on the status of onboard equipment and qualification of people, responsible for proper operation. In [1], three main types of incorrect AIS data were identified: errors, falsifications and spoofing.

The errors, having an impact mostly on the static data (ship's ID, size and antenna position, type of ship), dynamic data (co-ordinates of the ship, COG and SOG), or voyage related data (the ship's draught, hazardous cargo type, destination and ETA), can be caused by transponder deficiency, an incorrect data entered manually, erroneous pieces of information that come from external sensors, etc. In [2], more than 20% of AIS data is incorrect due to these errors.

The falsifications is the modification of a correct value of any parameter by a false value, or by stopping the broadcast of messages, made in order to mislead the ships sailing nearby and the coastal authorities, responsible for the management of the traffic, i.e. VTS authorities, port authorities, etc. Unlike the errors, in falsifications the wrong data is broadcasted intentionally. According to [3], about 1% of the vessels broadcast falsified data, including theft of identity, broadcast of false coordinates or disappearances, statements of a wrong activities, etc.

The spoofing activities include broadcasting of externally generated and / or modified AIS data by an outsider. In order to mislead the ships sailing nearby and the coastal authorities, the outsider creates ghost vessels or aids to navigation, or broadcasts false emergency messages intentionally, similar to falsifications.

Based on the world wide published research results for the AIS operation in different type of environment [3,5,6,7,8] the authors conducted cyber security risk analysis of Bulgarian AIS as part of VTMIS operated by Port Infrastructure company.

3. Cyber security risk assessment methodology and its application

The purpose of risk identification[1] is to identify what may occur or which situations may exist, influencing the achievement of the set objectives. Given the cyber security of AIS systems, for the purpose of the research the objective is *to keep the situational awareness of the operator as real as possible in order to achieve the safety of navigation and security of the infrastructure*. In order to identify all the possible risks for the AIS cyber security a risk description was developed, that contains the following main elements:

- Sources of risk: elements of the scenario that, isolated or combined, have the potential to affect the expected results (signal attenuation or interference, etc.)
- Event: a specific set of circumstances (overloading the air, placement /scattering of real objects radiating signals for unreal objects, etc.)
- Reason: the initial state that triggers the event (illegal activities that has to be covered, hacking curiosity, etc.)
- Consequence: the result of the event affecting the target (loss of data, invalid objects, etc. affecting the correct situational awareness of the operators)

Using a risk identification methodology increases the chances of identifying all these elements, either by gathering verifiable evidence, by using expertise, or in another structured way. For this purpose, the following risk identification methodologies are applied:

[1] According to ISO 31010: 2012 - "Risk Management - Risk Assessment Techniques" [10]

- Brainstorming: it was useful for risks identification because the situation requires a rapid response and few official data is available.
- Interview: Two groups consisting of IT experts and operators from Bulgarian Port Infrastructure Company were interviewed. A questionnaire was developed in order to collect the expert's opinion on the predefined questions / statements relevant to the AIS cyber security area;
- Scenario analysis: 4 scenarios were developed, that according to the expert's opinion are most balanced and cover the possible spectrum of source-event–reason-consequence chain of AIS cyber security risk relevance, taking into account the possible outcomes, strategies and actions leading to the outcomes. They are as follows:

S1: Attenuation or interference of signals emitted by AIS (ship and shore) stations - the system works by digital transmission of VHF data, as frequencies are known and can be simulated or attenuated.

S2: Overloading of the air with false signals - submission of data for invalid objects, which are accepted by the system along with the real ones.

S3: Placement (scattering) of real emitting objects in the area, which, in addition to AIS signal should also generate marks from the ships' own sensors or the coastal services.

S4: Sabotage of the work of the AIS by blocking or controlling the management (hacking) of key components of the system such as base stations, network devices, power supply, etc. via the Internet or other electronic connectivity.

As the main AIS cyber security risks are described in scenarios the risk assessment is conducted in the process of playing the scenarios (by the same experts) and answering specific questions composed in a short interview. Answering the questions, both groups of experts had to take into account the source-event–reason-consequence logical construction and to assess the two factors of the cyber security risk: scenario occurrence likelihood (rating is ranged from 1 - most unlikely to 5 - most likely) and impact / severity of the consequences (rating is ranged from 1 – negligible to 5 - severe). This method was chosen because of difficulties in determining the likelihood of occurrence, as there is lack of statistical information for defined types incidents in past. The results are presented in the table 1.

During the scenario playing the experts express and take into account the following considerations:

- S1 is an easily feasible scenario from an organizational point of view, associated with a relatively easy unnoticed deployment and power supply of jamming equipment, but requires availability and activation of specific equipment, as well as trained professionals to handle it. The AIS malfunctioning is an easy-to-identify problem, and the safety of navigation is ensured by other options such as visual surveillance, own sensors, radio and other communications between the various participants of shipping.
- S2 - Each AIS transceiver looks for free time slots and can be set to fill them with false information - invalid virtual objects. A standard transmitter can transmit data for only one object, but a base station can transmit a number of objects such type. It is relatively easy to implement from a technical point of view, but it is necessary to mobilize a specialized technical resource as well as trained specialists to handle it.

It is relatively difficulty to identify the problem. It will also take time and the involvement of well-trained professionals while filtering out invalid from real objects, during which period of time it may be necessary to take action to divert vessels or traffic in general, leading to financial losses. It is not clear to what extent ship crews will be able to identify and deal with the problem and whether this will not lead to immediate safety threats.

Table 1. Results of the scenarios assessment

Scenario description	**Consequences**	**Occurrence likelihood**	**Impact**	**Risk level**
S1. Attenuation or interference of signals emitted by AIS (ship and shore) stations - the system works by digital transmission of VHF data, as frequencies are known and can be simulated or attenuated.	Inability of AIS to receive data from other receivers (ship and shore) and the inability to digitally identify the targets.	3	1-2	low
S2. Overloading of the air with false signals - submission of data for invalid objects, which are accepted by the system along with the real ones.	AIS works normally or close to normally but the visualization does not reflect the real situation at sea. A lot of objects with no idea which is valid/invalid	3	3	Mode-rate
S3. Placement (scattering) of real emitting objects in the area, which, in addition to a signal to the AIS, should also generate marks from the ships' own sensors or the coastal services.	AIS works normally but the visualization does not reflect the real situation at sea. The operator cannot recognize which object is valid/invalid.	1	5	Mode-rate
S4. Sabotage of the work of the AIS by blocking or controlling the management (hacking) of key components of the system such as base stations, network devices, power supply, etc. via the Internet or other electronic connectivity.	AIS works normally but the visualization does not reflect the real situation at sea. The operator cannot recognize the intrusion and which object is valid/invalid.	5	3-4	High

- S3 - The hidden circulation in the area by vessels to locate physical objects would be associated with a large technical and financial resource and a very complex organization at various levels to overcome the monitoring and control of the vessels movement. Vessels with low detection probability can be used, research of the possibilities of the monitoring systems has to be done in advance, specialists and / or insiders have to be engaged, etc.

The presence in the navigation waters of physical objects that have unclear origin and destination would require adoption of the resolute measures such as reorganization and redirection of all traffic, measures for inspection and deactivation of objects deployed in the in the water area. This generates a waste of time and money and can pose a real threat to the safety of vessels and the safety of facilities.

- S4 - It can be applied remotely by accessing the system via the Internet. There are many levels at which the system can be manipulated this way - from malfunctioning (a lighter option in terms of consequences) to taking the control (option with many possible consequences - false targets, navigation errors when submitting false information for real objects, etc.)

There are many different formulas for risk, but perhaps the most widely accepted formula for quantifying risk is: Risk = likelihood of scenario occurrence *x* severity of consequences, so the risk matrix (fig. 2) is used to calculate the risk level of every one of the scenarios and the results are presented in the last column of Table 1.

Impact

Likelihood

	Negligible	Minor	Moderate	Significant	Severe
Very Likely	Low	Moderate	High	High	High
Likely	Low	Moderate	Moderate	High	High
Possible	Low	Low	Moderate	Moderate	High
Unlikely	Low	Low	Moderate	Moderate	Moderate
Very Unlikely	Low	Low	Low	Moderate	Moderate

Figure.2 Risk matrix [11] used

At the final step of the assessment the experts team was requested to address the deficiencies identified in order to reduce the significance of the likelihood and impact as risky factors. Summary risk management measures described by the team include but are not limited to:

- Training of navigational staff for ships identification (generally – objects) without using AIS - through behavior analysis, communications etc.;
- Increased surveillance and tracking to control the activities of small vessels, that can be used for placement (scattering) of real emitting objects in the area;
- Establishment of protection and appropriate architecture of the Internet environment where AIS operates, training of cybersecurity specialists and counteraction to hacker actions;
- Establishment of the maritime operational picture using different sources, data fusion.

4. Possible implementation of the AIS cyber security risk mitigation measures

Integration of information from many sensors included in the VTMIS, or data fusion is a way to deal with the disadvantages of AIS mentioned above by using technical approach. According to the IMO Resolution A.917 (22) AIS should become a useful source of supplementary information to that derived from navigational systems. The data fusion aims to confirm the existence of a real target and its location by using another sources of information and thus to verify the reliability of AIS information. The appropriate parameter such as ship's position, speed over ground (SOG), course over ground (COG), track history, etc., and an appropriate threshold corresponding to the accuracy requirements should be defined. To confirm the existence of a real target, the difference between the measured parameters should comply with the inequality (1):

$$|C(Sensor) - C(AIS)| \leq \delta, \quad (1)$$

where *C(Sensor)* is the parameter (coordinates, COG, SOG etc.), provided by any other sensor, such as radar observation and tracking system, RDF, etc., and δ is the threshold value of the criterion [4, 5].

Integration of information provided by the radar observation and tracking system with AIS data is the main tool in this process [6, 7]. In Bulgarian VTMIS the algorithm for integration of radar data with AIS has been built into the software of operator's workplace or Operator Display Unit (ODU). Software visualizes both radar and AIS data on the ODU, as shown on fig. 3, where radar echoes (yellow and green colored), provided by two coastal surveillance radars are displayed together with AIS information, which includes the name of the vessel, her size and velocity vector. The essential information for traffic control however is based on radar data processing.

Figure 3. Integration of RADAR picture with data provided by AIS

Radio Direction Finders (RDF) can be used to confirm the existence of real targets as well. Having a network of coastal RDF installations in the composition of a coastal VTS, the position of a transmitting object can be determined by using radio-triangulation scheme. The locating accuracy of this technology is poor, but it is very useful for the purposes of Search and Rescue operations at sea to detect small objects such as life boats or life rafts equipped with only portable VHF radios, transmitting on Ch. 16 and/or 406MHz satellite EPIRBs. Direction finders installed in Bulgarian VTMIS have also options to receive signals transmitted on VHF channels 87B and 88B and therefore to determine directions to AIS transponders.

Synthetic Aperture Radar images, or SAR images, provided by satellites may also be used to verify the reliability of AIS information. The most significant advantage of this technology is its global coverage and the main disadvantage is the relatively long time interval between two consecutive flights of the platform or the so called "revisit period". For medium latitudes for example, the revisit period is about 48 to 72 hours using the acquisitions of one of the Sentinel-1 A/B satellites only, and 24 to 36 hours using the acquisitions of both satellites. The SAR imaging in this case is also affected by the Doppler effect, as a result of which the location of the target of observation changes depending on its radial velocity. If it is assumed that area of observation is relatively small and within this area the Earth surface is flat, the azimuth offset or displacement, δ_x, e.g., the difference between the actual moving target location and its location on the SAR image, can be determined by using Eq. (2):

$$\delta_x = \frac{u_r . R}{V}, \tag{2}$$

where u_r is the radial velocity of the target, R is the slant range to the target and V is the platform velocity [6Graziano, …] On fig.4 SAR images of a target at anchor (on the left), a target moving to the west (in the middle) and a target moving to the southeast (on the right, see the arrows) can be seen with their displacement due to radial velocity. SAR image of the target, moving to the west is shifted north of the position, provided by AIS (AIS position is visualized by using yellow pins), while the image of the other moving target - southeast of the AIS position. Images are provided by Sentinel-1 A/B satellites during their ascending passes and are verified by using AIS data from Bulgarian VTMIS [9].

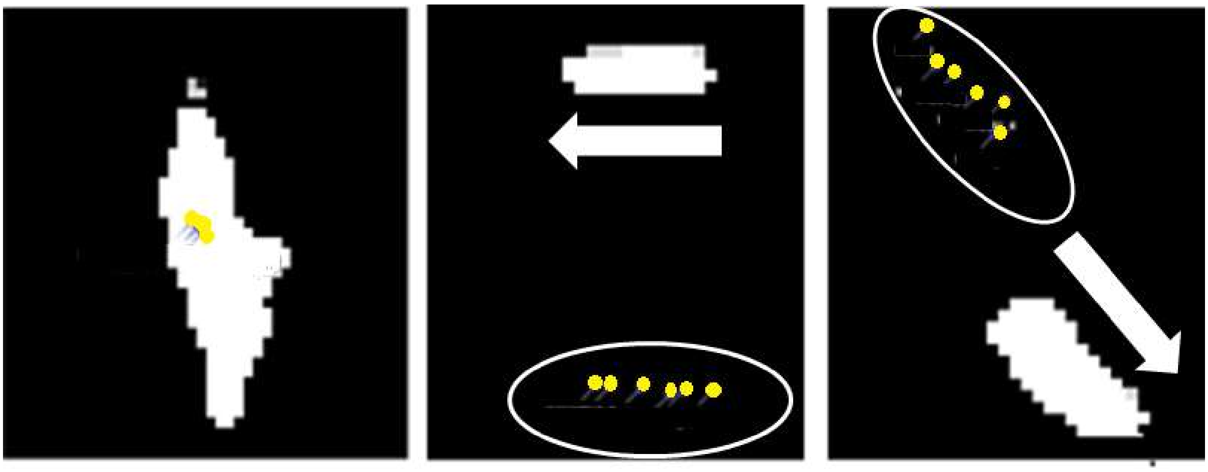

Figure 4. SAR Images of targets with displacement depending on radial velocity

5. Conclusion

In this paper the main technical features, advantages and weaknesses of the AIS system as most powerful component of marine traffic surveillance systems were discussed. Authors shaped the main cyber vulnerabilities of the system within the framework of the conducted cyber vulnerability analysis. The research was conducted by applying the technical assumptions and studying in the operational environment. A number of scenarios were created in order to outline the most typical cases of cyber vulnerabilities utilization. The cyber security of AIS system is determined when the scenarios risk assessment is conducted. At the end of the paper different measures for mitigation of cyber security risk were discussed. Integration of information provided by different sensor such as the radar observation and tracking system and the radio direction finder system, both included in Bulgarian VTMIS, as well as SAR images provided by Sentinel-1 satellites, was presented as the main means to compensate the vulnerabilities of AIS and thus reduce cyber security risk of coastal surveillance systems.

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LEADERSHIP CAPABILITIES FOR A MARITIME UNIVERSITY IN THE 21ST CENTURY

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Abstract

Faced with a rapid evolution in technology, maritime universities are under increasing pressure to recognize, anticipate and respond to the complex needs of the maritime industry. This depends on organizational leadership and the capabilities of its leaders. Our study proposes a set of 16 capabilities for the leadership in maritime universities, allocated to four groups: Self-Mastery; Interpersonal Mastery; Process Mastery; Systems Mastery. We present results from an online survey to explore these leadership capabilities, seeking to test the relevance of the proposed leadership capabilities using Bootstrap statistical analysis. It also defines and confirms the gap between the required level, at which a capability should operate, and the actual level experienced and practiced within the organization. Our study also examines the findings for both academic and professional staff to discern any statistically significant variances in the responses of the two groups, which could be seen as being culturally distinct. These results are compared to a control sample from a non-maritime university to identify if there were capabilities unique to a maritime university. As future research, we can validate these leadership capabilities across all maritime universities and then, on a more critical basis, compare these capabilities to those considered most important by the maritime industry.

Keywords: leadership mastery, demographical features, Bootstrapping, skills and attributes, online survey, statistical analysis

1. Background and developments in higher education leadership capabilities

After researching universities in Australia and New Zealand, Langford (2013) positions leadership among senior managers as a key factor of success. Given the link between the quality of higher education and national GDP, it might be expected that leadership would be an area of vital interest to universities. However, recent research shows that university leadership is very sparsely researched [Scott et al., 2008] and often criticized [Hall, 2017]. The situation is similar regardless of the profile of the higher education institution (HEI) and includes maritime education and training (MET) institutions as well. Different models to restructure the university sector have been proposed [Dempster, 2009; Townsend, MacBeath, 2011]. There is also the expectation to properly identify the leadership capabilities in universities [Ghasemy, Hussin, Daud, 2016], although the studies mostly concentrate on the skills amongst senior university roles, i.e. vice-chancellors, deans and heads of school and their academic credentials [Bolden et al., 2012]. There is an evident need to construct an overarching approach to leadership based on proper understanding of leadership capabilities in universities using a well-structured model.

The changes faced by leaders of universities might be driven by external or internal factors. Analyses show that universities are rather partial to adapting their understanding of a successful educational model to changing external realities [Boxall, 2015] even though there are developments of forward-looking operating models [Bokor et al., 2012; Cawood, 2018]. These are driven by the knowledge economy concept inspired by the concept of providing education for all students aiming for social justice [Taylor et al., 1997], and the strong connection between educational levels and a country's GDP [Valero, 2016]. A key driver of internal change is the popular concept of adaptive leadership and its adequacy to turbulent environments [Heifetz, 1994; Dweck, 2008]. Another factor of internal change stems from the need to challenge the traditional teaching and learning concepts. For example, [Bowles, 2016] focused on educational changes following the future needs of the workforce through the identification and development of capabilities.

University leadership is identified as understudied [Scott et al., 2008], with the suggestion that leadership skills are not explored beyond individual performance measures [Burgoyne, 2009]. The increased significance of institutional leaders in a university leading change and maintaining organizational identity [Bolden, 2012] and the translation of purpose into staff engagement and strategic response to disruptive change remain nascent in the university sector [Mukerjee, 2014]. Dempster's model of Leadership for Learning (L4L) [Dempster, 2012] is one of the highly ranked leadership models with specific application to education institutions. A proper model of leadership requires a better understanding of leadership capabilities, i.e. the set of behaviours, attributes and traits that are essential to the recruitment and development of staff in an organisation. Leadership requires a suite of capabilities to recognise turbulence, its impact on individuals, the organisation, and strategic direction and identify the actions required to change the organisation to anticipate and respond in ways which allow the organisation to adapt, survive and achieve its strategic goals [McCann, Selsky, 2012]. The early work [Bowles, 2007] and later [Scott et al., 2008] worked on identifying leadership capabilities, which were later confirmed in [Bowles, 2015; Bowles, 2016]. We shall adopt and explore those capabilities in this paper as a foundation of our analysis.

In this paper, we explore a set of capabilities of university leadership and their impact, focusing more specifically on MET institutions. We shall explore the assumption that the leadership framework of L4L may be a basis for a potential model for university leadership. We shall adopt a modified version of the L4L framework with sixteen leadership capabilities from a previous study and explore the extent to which those factors are acknowledged and measured. To test the suitability of this framework, we shall utilize the results of an online study across academic and professional staff at two universities in Australia and South Africa. Participants rated the capabilities both in terms of theoretical importance and practical demonstration using a Likert scale. We shall use both quantitative and simulation-based approaches to analyze the survey data, utilizing techniques developed in earlier study around simulation based statistical tests (which helps us improve the quality of statistical findings). We shall show that the analysis fo survey data demonstrated (with minor exceptions) that in the view of respondents the selected capabilities are important for university leadership. We shall also aim to explore the respondents' views of how well developed the capabilities are in practice to explore a gap between importance and development of those capabilities, and whether these findings can be validated in terms of importance. Our research may lay the foundations for the development of university leadership model (with more focus on MET institutions) which can be further refined through larger survey, more participating universities and through comparison against the leadership models being developed in industry.

2. Setup of the survey

Our focus of study is to explore leadership skills and how those apply to the reality of two universities, one of which a leading MET institution. We selected capabilities that stem from the modified L4L framework in [Bowles, 2015]. Initially those were presented in [Bowles, 2007] as a framework of 4 domains of leadership with 3 capabilities each (12 in total). Later on, reflecting on works of [Swaffield, McBeath, 2009; Kotter, 2012], those were developed into the Institute for Working Futures' Leadership and Management for the Digital Age (LaMDA) capability framework [Bowles, 2015] to specifically deal with the core capabilities required in the future workforce. The final framework has 4 domains of leadership with 4 capabilities each (16 in total), given in **Table 1**.

Table 1. Framework of leadership capabilities adopted in the analysis

Self Mastery	**Interpersonal Mastery**
1. Develops self.	5. Connects with stakeholders & builds collaborative relationships.
2. Communicates with clarity.	6. Leads and empowers others.
3. Acts in a professional and ethical manner.	7. Displays emotional judgment.
4. Displays personal resilience.	8. Embraces individual and cultural differences.
Process Mastery	**Systems Mastery**
9. Builds positive conditions for learning.	13. Develops a shared moral purpose and vision.
10. Plans/coordinates quality curriculum, learning & teaching.	14. Fosters a learning culture.
11. Instils focus on priority actions & educational outcomes.	15. Thinks and acts strategically.
12. Leads change.	16. Fosters innovation and creativity.

We constructed a survey in two universities in South Africa (SA) and Australia (AU), where the data sought was comprised of two parts:

a) demographic features of respondents (gender, country of residence, and type of position in the organization) each with two sublevels (male/female; SA/AU; academic/professional);

b) Likert responses [Bishop, Herron, 2015] on five-level scale of each of the 16 capabilities (using the scheme: "Completely Disagree", "Disagree", "Mildly Agree", "Agree", "Strongly Agree" coded as 0, 1, 2, 3, and 4) in terms of their *importance* and their *level of development* (making a total of 32 assessments from respondents).

This would test all capabilities for relevance to higher education and assess the relative levels of development and therefore the developmental variance for each capability. The results are expected to shed light on whether there are leadership capabilities needed for the effective leadership of universities. The results would also provide further evidence as to how well the capabilities are demonstrated in practice.

The survey was distributed to academic and to professional staff of the University of KwaZulu Natal, South Africa (UKZN) and the University of Tasmania's Australian Maritime College (AMC). The international nature of the survey population was to test that the capabilities were valid between countries. The survey was conducted using the *QuestionPro* platform and was conducted over three weeks in February of 2016. The survey and the collection methodology were conducted under ethics approval H15432 from the University of Tasmania Ethics Committee. A total of 66 respondents took part in the survey from both organizations.

3. Data analysis on leadership capabilities

3.1. Methodology of analysis

In the survey, we sought information on importance/development of capabilities based on a five-level Likert scale. Hence, the answers of each respondent can be presented as a random variate of the discrete random variable X with T=5 discretes $d_1=0<d_2=1<d_3=2<d_4=3<d_5=4$. In our previous work [Nikolova et al., 2020], we have presented approaches to compare two samples of a discrete parameter using Bootstrap simulations [Efron, Tibshirani, 1993]. We formalized a generic statistical test that determines whether the evidence in the two samples is enough to claim that the distributions of X in the two populations are different. We developed a Bootstrap procedure based on the Pearson test statistic pn_{re} [Ghasemi, Zahediasl, 2012] calculated from a contingency table. The test p-value was estimated using the simulated conditional distribution of the test statistics under null hypothesis for equality of population distributions. We aim to demonstrate the higher precision of our procedure compared to analytical approaches and also to show how our methods decrease uncertainty in small and large samples.

For the sake of experimentation, we applied our techniques over the results about the level of development of *capability 11: Instils focus on priority actions & educational outcomes* (see Table 1) from the leadership survey. In this paper, we shall adopt the statistical Bootstrap based techniques from [Nikolova et al., 2020] to conduct a full-scale analysis of the survey results. All our statistical results are obtained from simulations with N=10000 pseudo-realities. Let us adopt the 5 populations denoted as in [Nikolova et al., 2020]:

Q_1– all male university staff members from SA and AU;
Q_2– all female university staff members from SA and AU;
Q_3– all university academic staff members from SA and AU;
Q_4– all university professional staff members from SA and AU;

Q_5– all university staff members from SA;
Q_6– all university staff members from AU.

Those form six samples $\chi^{(i)}$ of response results, with their variates sampled from Q_i for i=1,2,…,6. Initially, we shall explore the significance of demographic categories over the assessment of mastery groups. Then we shall explore if there are significant differences on each of the leadership capabilities caused by the different demographic categories. In other words, we explore a series of claims regarding an existent statistical difference of responses across the mastery categories or across individual leadership capabilities that might be caused by the different gender, different country of residence, and different type of position in the organization.

3.2. Comparison by groups of leadership capabilities

Based on the setup in section 3.1, the statistical results for importance and level of development of each of the four mastery categories (given in Table 1) are given in **Table 2**. In that table, we presented the sample size, Pearson test statistic and p-value across the four mastery groups based on the three demographic features (gender, country of residence, and type of position in the organization). There are only two p-values (bolded) that indicate statistical significance of responses, as follows (all other results showing no statistically significant differences):

1) the claim that "the position in the organization affects the distribution of answers regarding the importance of systems mastery among all university staff members from SA and AU" is considered statistically significant based on the data in $\chi^{(3)}$ and $\chi^{(4)}$ with estimated p-value=0.0246;

2) the claim that "the country of residence affects the distribution of answers on the level of development of the interpersonal mastery among all university staff members from SA and AU" is considered with borderline statistical significance based on the data in $\chi^{(5)}$ and $\chi^{(6)}$ with estimated p-value=0.0476.

Table 2. Statistical results by group of leadership mastery across gender, position and country (significant p-values are bolded)

	Gender				Position				Country			
Mastery	$\chi^{(1)}$ n_1	$\chi^{(2)}$ n_2	pn_{re}	p-value	$\chi^{(3)}$ n_1	$\chi^{(4)}$ n_2	pn_{re}	p-value	$\chi^{(5)}$ n_1	$\chi^{(6)}$ n_2	pn_{re}	p-value
Importance												
Self	187	75	2.255	0.2908	181	79	3.778	0.1808	35	225	6.609	0.0859
Interpersonal	184	76	5.891	0.0648	180	80	5.266	0.0852	36	224	2.094	0.3214
Process	186	74	5.055	0.1546	182	78	4.295	0.2238	36	224	1.819	0.5941
Systems	184	76	6.493	0.0990	181	79	9.579	**0.0246**	35	225	4.911	0.1816
Development												
Self	184	75	3.452	0.4898	180	79	4.171	0.3815	36	223	7.678	0.1004
Interpersonal	183	76	2.917	0.5820	180	79	7.664	0.1053	36	223	9.740	**0.0476**
Process	182	74	8.229	0.0745	178	78	6.864	0.1366	36	220	4.246	0.3586
Systems	181	71	6.763	0.1275	178	74	5.908	0.1783	35	217	4.041	0.3403

3.3. Analysis by individual leadership capabilities

The statistical results for importance of each of the 16 leadership capabilities is given in **Table 3**, where we present the sample size, Pearson test statistic and p-value based on the three demographic features. There is only one p-value (bolded) that indicates statistically significant responses. It shows statistical significance for the claim that "position affects the distribution of answers regarding the importance of capability 16 among all university staff members from SA and AU" based on the data in $\chi^{(3)}$ and $\chi^{(4)}$ with estimated p-value=0.0354. All other answers do not give substantial grounds to claim statistically significant differences of opinion.

Table 3. Statistical results for importance of leadership capabilities (numbering based on Table 1) across gender, position and country (significant p-values are bolded)

Capability	Gender				Position				Country			
	$\chi^{(1)}$ n_1	$\chi^{(2)}$ n_2	pn_{re}	p-value	$\chi^{(3)}$ n_1	$\chi^{(4)}$ n_2	pn_{re}	p-value	$\chi^{(5)}$ n_1	$\chi^{(6)}$ n_2	pn_{re}	p-value
1	47	19	1.721	0.2167	46	20	0.0567	0.8319	9	57	0.6723	0.4668
2	47	19	0.4105	0.5962	46	20	0.4415	0.5162	9	57	0.1603	0.6361
3	45	19	0.8717	0.3775	44	20	0.9384	0.3810	8	56	2.654	0.1173
4	46	18	0.04224	0.8728	45	19	1.329	0.2840	9	55	0.9672	0.2419
5	46	19	0.8523	0.3998	45	20	0.3582	0.7163	9	56	0.3316	0.6101
6	46	19	0.4195	0.5977	45	20	0.4514	0.5188	9	56	0.1632	0.6266
7	46	19	0.02559	0.9482	45	20	1.398	0.2847	9	56	0.5055	0.5254
8	46	19	0.6656	0.5135	45	20	4.529	0.0556	9	56	1.062	0.3381
9	46	18	0.4887	0.5174	44	20	0.9384	0.3839	9	55	0.3378	0.6213
10	47	18	1.205	0.2976	46	19	1.299	0.2915	9	56	0.5055	0.5250
11	46	19	0.2231	0.7259	46	19	0.2231	0.7330	9	56	0.8705	0.4145
12	47	19	1.732	0.4230	46	20	0.06748	0.9167	9	57	1.584	0.3327
13	44	19	4.072	0.1085	44	19	2.173	0.3448	9	54	1.527	0.4130
14	47	19	0.4477	0.5838	46	20	4.06	0.0733	9	57	0.8542	0.3937
15	46	19	1.768	0.4166	45	20	3.595	0.1353	8	57	1.101	0.5081
16	47	19	0.4527	0.5285	46	20	4.744	**0.0354**	9	57	0.3257	0.6091

The statistical results for the level of development of each of the 16 leadership capabilities is given in **Table 4**, where we present the sample size, Pearson test statistic and p-value based on the three demographic features. There are four p-values (bolded) that indicate statistically significant responses:

1) the claim that "position affects the distribution of answers regarding level of development of capability 8 among all university staff members from SA and AU" is considered statistically significant based on the data in $\chi^{(3)}$ and $\chi^{(4)}$ with estimated p-value=0.0367;

2) the claim that "country affects the distribution of answers regarding level of development of capability 9 among all university staff members from SA and AU" is considered statistically significant based on the data in $\chi^{(5)}$ and $\chi^{(6)}$ with estimated p-value=0.0249;

3) the claim that "position affects the distribution of answers regarding level of development of capability 11 among all university staff members from SA and AU" is considered with borderline statistical significance based on the data in $\chi^{(3)}$ and $\chi^{(4)}$ with estimated p-value=0.0452;

4) the claim that "gender affects the distribution of answers regarding level of development of capability 12 among all university staff members from SA and AU" is considered statistically significant based on the data in $\chi^{(1)}$ and $\chi^{(2)}$ with estimated p-value=0.0311. All other answers do not give substantial grounds to claim statistically significant differences of opinion.

Table 4. Statistical results for level of development of leadership capabilities (numbering based on Table 1) across gender, position and country (significant p-values are bolded)

	Gender				Position				Country			
Capability	$\chi^{(1)}$ n_1	$\chi^{(2)}$ n_2	pn_{re}	**p-value**	$\chi^{(3)}$ n_1	$\chi^{(4)}$ n_2	pn_{re}	**p-value**	$\chi^{(5)}$ n_1	$\chi^{(6)}$ n_2	pn_{re}	**p-value**
1	47	19	1.759	0.6831	46	20	1.356	0.7338	9	57	5.146	0.2184
2	45	19	4.703	0.1847	45	19	2.786	0.4189	9	55	0.8723	0.8177
3	47	18	6.437	0.1384	45	20	3.611	0.4133	9	56	5.066	0.2300
4	46	19	2.436	0.4272	44	20	5.116	0.1644	9	55	7.499	0.0838
5	45	19	3.18	0.3873	45	19	0.5418	0.9159	9	55	4.106	0.2442
6	47	19	3.125	0.3954	46	20	0.7863	0.8693	9	57	1.913	0.6098
7	44	19	1.558	0.6877	43	20	1.415	0.7165	9	54	7.101	0.0681
8	47	19	3.622	0.4087	46	20	9.369	**0.0367**	9	57	2.965	0.4542
9	46	18	1.57	0.4699	44	20	2.931	0.3394	9	55	10.51	**0.0249**
10	46	19	2.23	0.5455	45	20	3.067	0.3899	9	56	5.049	0.1601
11	44	19	6.736	0.0876	44	19	8.051	**0.0452**	9	54	4.476	0.2156
12	46	18	9.869	**0.0311**	45	19	6.226	0.1550	9	55	2.499	0.5568
13	42	17	4.536	0.2156	42	17	3.795	0.2900	9	50	0.8789	0.8665
14	47	19	3.088	0.4783	46	20	2.735	0.5383	9	57	2.566	0.5151
15	45	16	3.705	0.3049	44	17	0.4003	0.9473	8	53	4.834	0.1771
16	47	19	1.152	0.7822	46	20	3.069	0.3988	9	57	2.83	0.4264

4. Discussion

We can generalize based on the information from **Table 3** and **Table 4** that:

a) responses from males were very dominant in number compared to responses from females (which might be attributed to gender balances in participating universities);

b) more academic and professional staff members responded to the survey (which might be due to the difference between academic and professional roles and the level of understanding and interest in institutional leadership);

c) the responses from AU were substantially more than those from SA, which might distort some of the conclusions based on country of origin.

5. Conclusion

In this paper, we outlined the importance and level of development of a framework of 16 identifiable leadership capabilities needed for the effective leadership of universities. Those were based on the LaMDA capability framework. The capabilities were structured into four groups, with four capabilities in each group. We explored both their importance and their level of development. To explore those capabilities, we utilized the results of an online survey on university leadership capabilities conducted in 2016. The survey data included 66 respondents from AU and SA. Using the survey results, we performed analysis firstly on the four groups of leadership masteries and then on each individual capability. For each of the groups and for each of the capabilities, we analysed the significance of difference in the responses depending on country, gender, and capacity of the respondents. In the analysis over groups of mastery, we identified statistically significant responses based on the Pearson test on the importance of systems mastery depending on position and a borderline significance of country on the level of development of the interpersonal mastery. In the analysis of the individual capabilities, we identified statistical significance depending on position for capability 8 (and borderline for capability 11), depending on country for capability 9, and depending on gender for capability 12.

The lack of prior research into university leadership capabilities is some form of a limitation of our study. This is a field which is rapidly evolving outside academia which makes reliable data difficult to source. The impact of this on the findings cannot entirely mitigated. The survey structure accounted for the potential impact of social desirability bias (SDB) which arises when respondents answer test questions in such a way as to present themselves in a socially acceptable way. Amongst the most critical factor in minimising SDB is ensuring a high level of respondent anonymity, which we have factored into the design of the survey and data collection. The capacity for the responses to be impacted by SDB was assumed to be limited mostly to those respondents who saw themselves as being the leadership being evaluated. This can only be evaluated retrospectively as part of the input into future surveys and the continuing research. Overall ensuring the complete anonymity of respondents was seen as the most effective method of minimising any SDB by removing social exposure.

We can outline several directions for future research of our research:

a) Conducting further data collection to refine the survey for a global population. This would require testing one or more of the concepts that the capabilities would need a central guiding purpose and may also reflect the different types of university.

b) Analyse the results from the current survey to refine and test the capabilities with cross comparisons.

c) Extend the research into the variances between the importance and the level of development of each capability to develop evidence-based leadership training programs for universities

d) Expand the survey with input from other universities (incl. MET institutions) from other countries to explore the development of leadership across various education systems and cultural settings.

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Navigational Alarms and Warnings to Support VTS Operation

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Abstract

In this paper, the authors discuss the current development of IMO and IALA regulatory framework and future technological developments to look at the present state of VTS operation. Taking into account the importance of situational awareness and any dangerous situations that could potentially be overseen, collision avoidance warnings to support the operation onboard and ashore are highlighted. Research is ongoing by participating observations, online surveys and interviews of VTS operators around the world. The selected results emphasized that although technology is rapidly developing, heading to digitalization and autonomous operation, the basis of alarms and warnings functions are still the same. In the future different mixed traffic situations, reliable technology and adaptive training would be very much suggested to achieve the harmonization of VTS operation by competent VTS operators.

Keywords: Vessel Traffic Services, IALA, Alarms and Warnings, Harmonization of Maritime Safety, Competent VTS Operators

1 Introduction

Vessel Traffic Services (VTS) has been originally developed from radar and voice radio assistance [1], [2] that over the years turned into multi-sensor shore-based surveillance, integrated marine radar chains integrated with AIS and ECDIS systems, along the coastal waters and ports worldwide to have a real-time information exchange. Regulated by the International Maritime Organization (IMO), VTS plays an essential role in ensuring and increasing the safety and efficiency of maritime traffic flow and protection of the marine environment by its capability to interact and respond to the traffic developing in the monitored area. The services are to pro-actively respond to developing risks. Besides IMO, the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) provides fundamental guidelines on the implementation and operation of VTS in a harmonized manner to effectively achieve its purpose to ensure the safe and efficient traffic flow of vessels from and to ports and to protect the marine environment. This is basically done through provision of information, warning, advice and instructions to support mariners' decision making onboard and consequently avoid accidents.

In maritime traffic, *collision*, *contact* and *grounding/stranding* have represented 44% of all casualty events within the period of 2014-2019 [3]. VTS operators are using a wide spectrum of technologies in order to enhance and improve assessment of developing risks, detect violations of predefined limits and provide decision support for vessels to take appropriate actions [4]. However, although sophisticated technology is available to combine shore-based and onboard data collection from the traffic and environment, the number of accidents is still high and, as seen from the grounding of "Ever Given", has far reaching consequences.

The continuous development of digitalization and automation has improved watch alarms and warnings that may help to ensure sufficient situational awareness of VTS operators when monitoring, commanding and controlling ships sailing in their VTS areas. Therefore, the installation of alarms and warnings are vital to strengthen the safety barrier and help the process of decision-making by navigators onboard and operators ashore.

2 Present State of VTS Operation: A State of Change

2.1 Legal frameworks

VTS is regulated by IMO, according to the International Convention for the Safety of Life at Sea (SOLAS) in Chapter V Regulation 12 about *Vessel Traffic* Service and guided by IALA. It takes into account the coastal states' national regulatory frameworks. The legal basics for VTS are laid down in IMO Resolution A.857(20) as *Guidelines for Vessel Traffic Service*. As it has been 24 years since the presently valid resolution was adopted in 1997, a revision of this guideline is becoming essential to adapt to various developments in the maritime domain and will come to final adoption in December 2021 [5], [6].

The new draft of the IMO resolution gives more concise guidance for VTS to provide services proportional to the volume of traffic and the degree of complexity within a VTS area [7], [8]. According to the current development in maritime transportation, IMO and IALA found that three different labellings of VTS services (Information Service (INS), Navigational Assistance Service (NAS) and Traffic Organization Service (TOS)) are not necessary any longer. They also deleted the distinction between a Port/Harbor VTS and Coastal VTS from the resolution. This would ease the scope of each Government to adapt its regulatory framework according to the needs. In preventing any confusion to ship-masters sailing around the world, the establishment of VTS is no longer just an option and more parties are recommended to take part.

The purpose of a VTS remains, it should be able to mitigate developing unsafe situations. Firstly, through the provision of information on factors that may influence the ship's movement and assist onboard decision making (former INS). Furthermore, nowadays VTS shall additionally provide the reporting formalities and ISPS code details, support and cooperate with allied services. Secondly, through the monitoring and management of ship traffic (former TOS). Regarding this, VTS has empowerment for the compliance of vessels and enforcement of the existing regulatory framework. Thirdly, through responding to developing unsafe situations (former NAS). Difficult navigation circumstances are now including some more elements, such as a ship unsure of its route or position, a ship deviating its route, a ship needing guidance for anchoring or a ship is at risk of grounding or collision.

2.2 VTS personnel

VTS personnel has to be competent and only considered competent when appropriately trained and qualified for their duties. In this case, IMO recommends VTS personnel training to the IALA model courses. The model courses are only effective if it is applied based on the prior qualification held by the personnel and based on approval from the Government, which is responsible to the training applicable in their country. Meanwhile Competent authority provides regulation, approves training and certification, the VTS provider operates VTS and ensures the appropriate training and qualification of its VTS personnel are being met. Periodic assessment should be carried out through monitoring and observation of VTS personnel performance to maintain their competencies.

In a critical situation, VTS operators immediately have to take proper measures ensuring smooth communication and interactions between navigational officers and VTS. Shifting the vessel participation from voluntary to mandatory allows for reducing inattention errors by the mariners involved and acting more proactively in traffic management. Taking into account the wide range of tasks and situations in VTS monitored areas, this requires also effective support of VTS operators' situational awareness including alarms and warnings at the VTS operators' workstations.

2.3 Technological developments

The fundamental development is currently characterized by IMO's e-Navigation initiative and the rapidly increasing digitalization and automation in the maritime domain. This development is addressed in [9] highlighting the advances in data sharing and the potential of Sea Traffic Management (STM). It is expected that STM connects and updates marine stakeholders in real-time with efficient information exchange concerning, e.g., effective arrival times, route optimization, port call synchronization and more efficient risk management. The integration of electronic data interfaces and the development of remotely and autonomously operating vessels are where the VTS interface gets going. Several studies and projections of the future maritime transportation system (i.a. [9]–[12]), assume new scenarios of mixed traffic and technical solutions regarding decision support for the VTS operators with even more sophisticated alarm and warning functions as of today. Consequently, situational awareness of VTS operators remains a key element of safe and efficient vessel traffic in coastal waters and therefore needs to be studied and to be adapted to changing legal, technical and organizational circumstances.

2.4 Onboard and shore-based Collision Avoidance

Collision avoidance is a permanent task of the officer of the watch onboard and of most of the operators in VTS centers.

The presence and response of alerts onboard vessels, in particular to the collision avoidance alarms of Radar/ARPA devices, were found to be unsatisfying [13]. One of the reasons is that the thresholds for triggering a collision warning have to be configured manually from which operators onboard and in a VTS tend to switch them off instead of continuously adjusting them based on the changing traffic circumstances. In contrast, collision alerts in air traffic have clearly defined minimal time and space standards for separating aircraft, in which the pilot cannot switch the alert off nor change the alarm thresholds.

There are numerous studies discussing collision risk assessment and proper alarming. Studies into adapting solutions from air traffic to the maritime domain [13]–[16] are ongoing with promising results. Fast-time simulation techniques for calculating rudder response times, maneuvering parameters for the actual ship status (in ballast/full laden) and environmental conditions (e.g. wind and current) are being applied, suggesting dynamic adaptation of the fixed thresholds to the prevailing circumstances of a given situation. It was demonstrated that the number of collision alerts in a shore station could be reduced by 40 per cent with the variable thresholds compared to the conventional fixed limits [14], [17], [18]. However, collision warnings are only one alarming function out of many others implemented in the workstation of VTS operators.

3 Empirical Studies into VTS Alarms and Warnings

A spotlight study is ongoing to investigate the use of alarms and warnings in VTS. The empirical studies are carried out by participating observations, online surveys and guided interviews with VTS operators. The survey is aiming to understand how the alarms and warnings support operators and benefit VTS operations. In these selected preliminary results, we have gathered worldwide responses, regarding the implementation, usefulness and limitation of alarms and warnings, for providing services in each VTS center. The study collected 43 valid data out of 47 total responses in 20 countries in Europe, Asia, Africa and South America. Respondents were VTS operators having nautical backgrounds or expertise in port and technical operations.

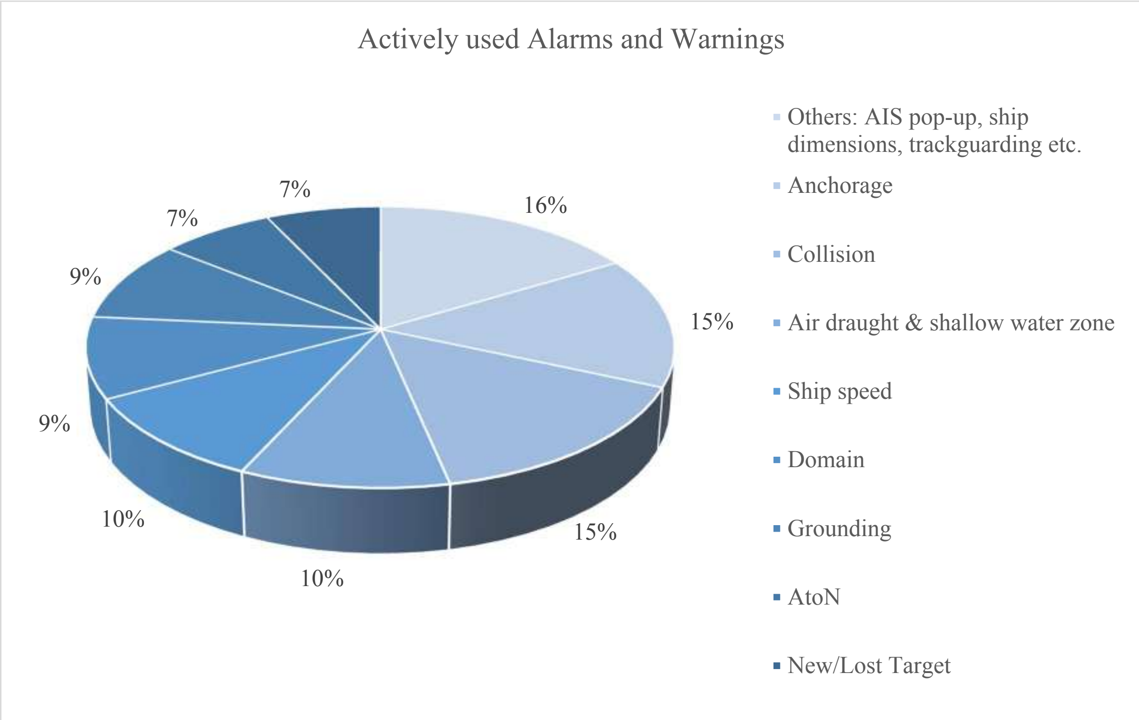

Figure 2. Actively Used Alarms and Warnings, responses to the question “Which alarms/warnings do you actively use?”

The alarm and warning functions act as decision support tools for VTS to respond and indicate potentially unsafe traffic situations. Overall, there is a wide range and number of alarms and warnings. Looking at an exemplary selected “Operator Manual” of a VTS monitoring workstation, there are 56 operational warnings mentioned, while, from the survey we gathered there were even 95 different warnings presented in participants’ VTS.

Operators being confident and satisfied with their alarms and warnings always switched on and actively used it, as shown in Figure 2, mainly mentioning its high importance for collision and grounding predictions. The alarm for ship length and breadth helps VTS monitor the passage during wind restrictions, the high-speed alarm helps VTS due to the ferry swell in port and air draught alarm triggered due to the airport safety limit. Alarms and warnings would be beneficial as well for a vessel not under command or diverging from the Traffic Separation Scheme.

Based on the study, VTS operators mostly monitored specific areas with ship routeing measures and they found the existing alarms and warnings in their VTS center had given them the benefit to be aware of dangerous encounter situations. Especially in high traffic density, these functions were very helpful as many operators had overseen more than three potential developing risks to the navigation safety in their VTS area at a time. These are the responses from participants to the question ”Have you ever experienced that collision alarm/warning has made you aware of a dangerous encounter situation that you maybe have overseen and how often?”. However, VTS operators expressed they had too many alarms which sometimes generated incorrectly or alert all the time causing distraction and confusion, especially in a narrow VTS area. Operators later would switch them off or mute the sounds for every ship that is not of concern, while the warning sensors are still working in the background. In other cases, VTS personnel considered that vessels are already relatively safe with the presence of a pilot onboard and for near the port area.

The configuration of the traffic monitoring functions in each VTS had mostly been preloaded automatically by the manufacturer and each different function correspondingly had a different effect on user performance. Since there is no one-fit model for all VTS with different areas, both open water and enclosed river, the experience of VTS operators is the superior choice to have a good interpretation of situations displayed on the electronic charts. Unfortunately, operators who had not been provided with such functions were having difficulties assessing and responding to the traffic and should rely on their visuals.

Almost all VTS centers are equipped with alarms and warnings functions, with either set alarms or individually configured alarms. Regarding the collision warnings, VTS has fixed alarm thresholds (17 responses) and sets the thresholds individually (24 responses). These configurations could be seen in Figure 3 and Figure 4. For the integrated configuration, VTS personnel has to first estimate the situation and choose suitable alarms. This includes the ship type, ship dimensions, ship speed, sea area and traffic situation, environment conditions and unknown objects in the waterways a vessel navigates in. The previous study proved that a 10 min vector for monitoring collision risk based on potential danger, such as ship dimension and dangerous goods onboard, was commonly used [4], [13]. VTS operators expressed that having 0.3 nm and 6 min for their CPA/TCPA limits would be great for their operation.

Different countries applied different functions to their VTS personnel competencies. One-fourth of operators observed had participated in refresher training during the last year, yet another one-fourth of operators had never participated in any kind of training. In general terms, authorities seem to provide training for compensating deficiencies in the initial entry qualification of their VTS operators. Those without training are considered to have a good grasp of tackling the traffic situation as they had been for quite a long time (5 to 27 years) working onboard vessels.

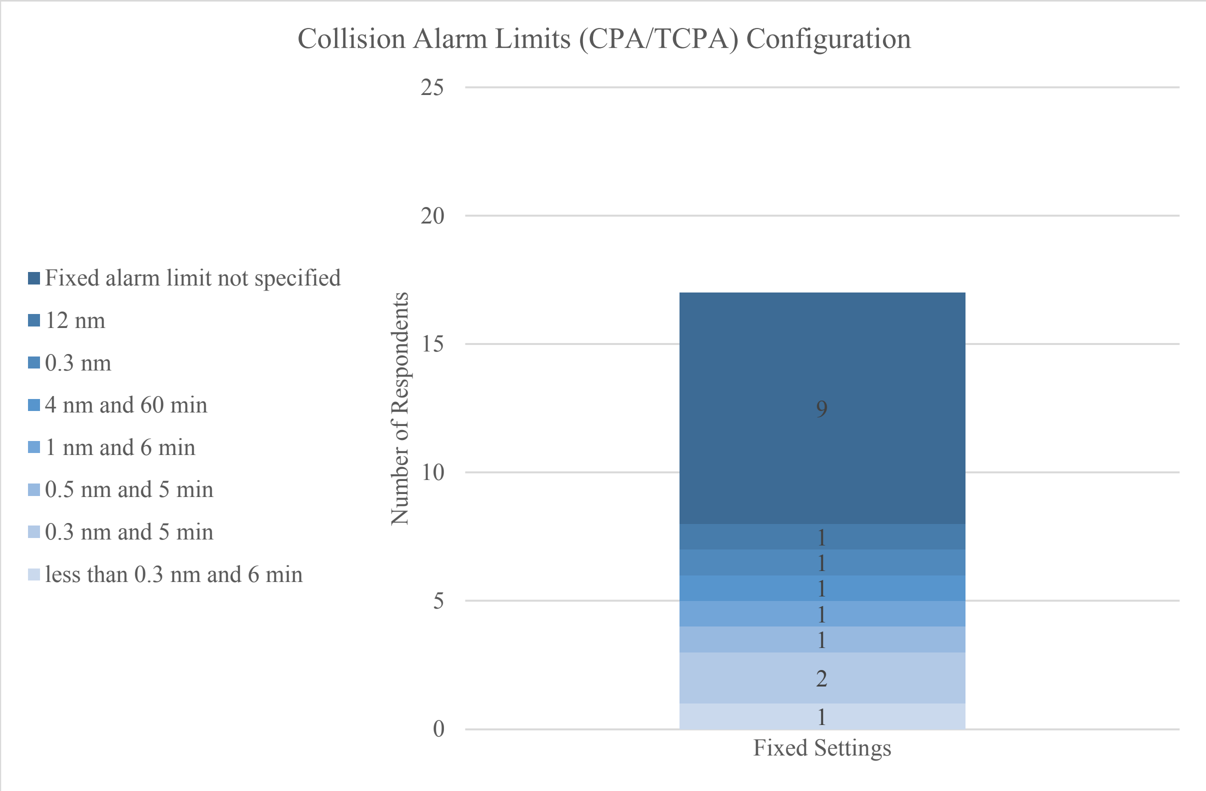

Figure 3. Configuration of Fixed CPA/TCPA Limits, responses to the question "If there are fixed settings, what are the alarm limits in your area?"

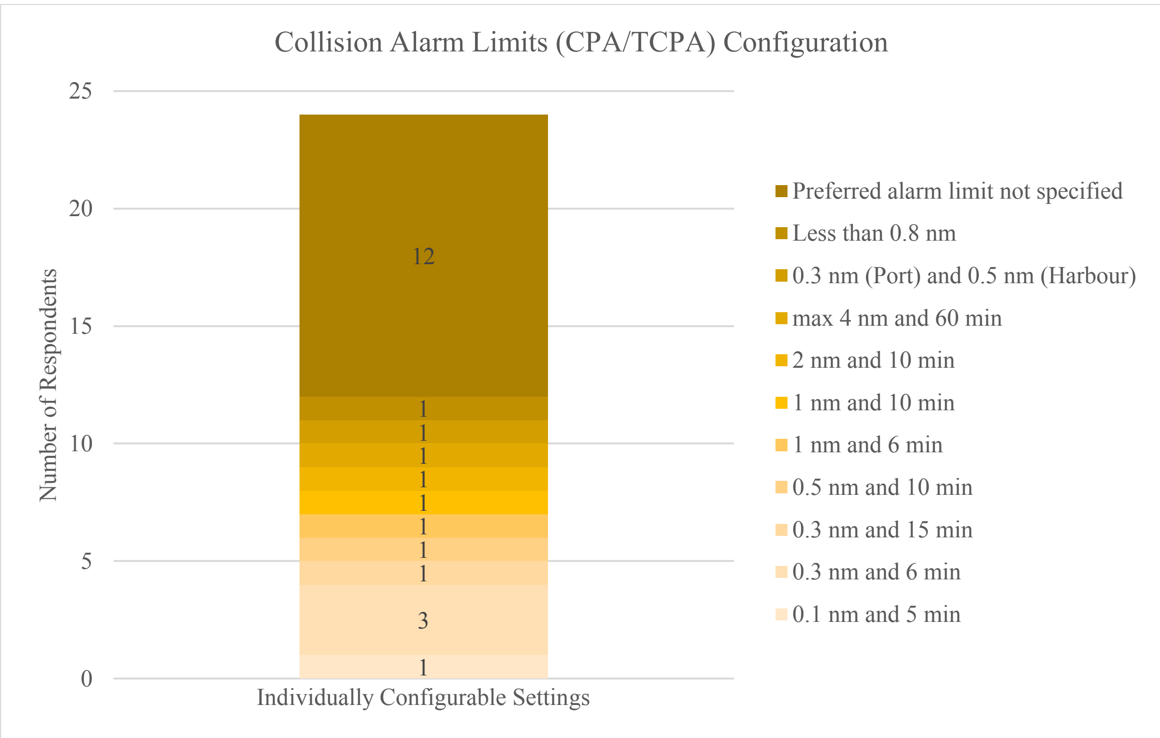

Figure 4. Configuration of Individual CPA/TCPA Limits, responses to the question "If

individually configurable, what are your preferred settings for the CPA- and for the TCPA limit for collision avoidance when you are monitoring your area?”

For this, the revised IMO resolution for final adoption at Assembly 32 urges appropriate training for VTS personnel to be considered competent [6]. This consists of generic training, On-the-Job Training (OJT) and refresher/revalidation training which shall be an output-driven measure and subsequently issue appropriate certifications for them. As such, IALA VTS Committee has recently accredited organizations in 24 countries to deliver effective training and at the moment is updating their training model courses and its modernization [19].

4 Summary and Conclusions

Maritime industry and specifically the shipping domain is undergoing substantial changes in terms of revision of existing regulatory frameworks and organizational structures, but moreover, in regard to technological developments with increasing digitalization and automation [20]–[23] and new demands in relation to training and education [24]. Shipping of the future will be characterized by vessel traffic consisting of a mixture of conventional ships and automated carriers navigating remotely controlled or autonomously and unmanned. VTS will have to ensure the safe and efficient traffic flow of such mixed traffic. Situational awareness to detect and react to situations requiring intervention by VTS remains essential for meeting the objectives. In this paper, the authors presented preliminary results of ongoing empirical studies into shore-based alarm and warning functions implemented in the workstations of VTS operators. The outcome of participating observation, online survey and interviews shows that operators are aware of the manyfold options. However, there is overall a huge number of warnings of which only a limited number is used and known and participants expressed that some of the functions are not really satisfying.

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NOVEL SHIPPING COMPETITIVENESS INDEX USING ORDERED WEIGHTED AVERAGE OPERATOR

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Abstract

There is limited research on the sustainable development of maritime economies, and on the role of maritime transport in those economies. At most, we can find some isolated case studies that fail to explore the dependencies across factors. In some of our previous works, we introduced indices assessing the national and the beneficial fleet competitiveness and their connection with several factors that influence the role of shipping for a given country. Here, we extend this research and create models only with significant variables, as well as propose a new index to rank countries based on shipping competitiveness that utilizes the ordered-weighted average operator. We demonstrate in detail our methodology. We also test our new index and compare its efficiency with previously developed indices using a data set for 84 maritime countries. We clearly demonstrate the advantages of the new ordinary weighted average operator index.

Keywords (3-5 words): linear regression; national fleet; beneficial fleet; influential factors

1. Introduction and background

The shipping industry has a long history, with the first cargoes being moved by sea more than 5,000 years ago [Stopford, 2009]. It is estimated that 80% of the international cargo is transported by ship [UNCTAD, 2017]. Internationally, shipping is the key means of supplying raw materials, consumer goods, and energy, becoming a facilitator of world business and contributing to economic evolution and employment, both at sea and on land [McKinley et al., 2019]. The top five ship-owning economies combined accounted for 52% of world fleet tonnage [UNCTAD, 2017]. The importance of national shipping has received growing attention for several reasons outlined in [Nguyen et al., 2019]. The development of the blue economy [CSIRO, 2015] has emphasized further the understanding of the connection between economic development and sustainable shipping. The amount of research on national shipping, specifically on broader maritime sector and blue economy is limited and expands to the introduction of the ocean economy [Spalding, 2016], which includes aspects of renewable energy, seabed mining, ocean restoration, blue biotechnology, etc. Another area of discussion around the importance of shipping to the global economic arena is the notion of the maritime cluster. It incorporates the large shipping, marine, and port operations industries and is a spatially bounded organisational form where co-location and geographical proximity encourage the formation of interactive networks between organizations [Doloreux 2017]. Despite the existing trend of de-globalization and regionalization [Hee-Yeon 2017], maritime clusters still hold their strategic significance in the maritime arena.

Continuing our research from three previous papers - Nguyen (2011), Nguyen & Bandara (2015), and Nguyen et al. (2019), we develop further our exploration on how we measure national shipping competitiveness and its relation to various factors (international trade, shipping history, policy, registration, oil exports, technology development, etc.). In the previous three works, we explored two measures of national shipping – national fleet and beneficial fleet over data for 84 maritime countries. Here, we aim to identify the significant variables over national competitiveness and propose a new shipping competitiveness index based on an ordered-weighted average operator. Our paper makes contributions both in terms of analyzing literature in shipping competitiveness and in terms of the computational tools adaptable to problems of how we measure shipping competitiveness. In what follows, section 2 we provide the background of our new index, and identify the variables utilized in this and the previous ranking indices. Section 3 justifies the ordinary weighted average index, and section 4 presents in detail our methodology and new indices. Section 5 gives substantial details on the ranking results with our new indices for the 84 maritime countries. Section 6 concludes the paper.

2. Models and variables for shipping competitiveness

To create a shipping competitiveness index (SCI), we need to find a connection between several factors that influence the role of shipping for each country, measured by the natural logarithms of the deadweight tonnage of national fleet (V=LnFleet) and of the deadweight tonnage of beneficial fleet (W=LnBen). The beneficial fleet is the fleet owned and operated by companies located in the country [UNCTAD, 2014]. We have identified 4 binary and 13 continuous factors, given in the column 1 of Table 1. The meaning and origin of those are described as follows: parameters from 1 to 12 are given in [Nguyen, Bandara, 2015]; parameters 13, 16 and 17 are given in [Nguyen, 2011]; parameters 14 and 15 are given in [Nguyen et al., 2019].

For simplicity, the above-described factors are short-written as the variables X_j (j=1,2,…,17), given in column 2 of Table 1. Let the values of the variables V, W, and X_j are known for N countries, denoted as v_i, w_i, and $x_{i,j}$ for the i-th country. We can construct a linear regression model of some proxy for the shipping competitiveness of a given country depending on several of the factors above and take as a criterion the predicted value minus the constant term. By doing so, we can improve the measurement process by smoothing errors and inconsistencies modeled by the residual terms in the regressions. The rank of the acquired predicted value of a given country is assumed to be the country's shipping competitiveness index. By selecting different proxies, we can obtain a family of SCIs based on linear regression models.

In [Nguyen, 2011] a NAT-SCI is proposed, where the LnFleet (national fleet) is regressed on 2 binary and 10 continuous variables (see column 3 of Table 1). In [Nguyen, Bandara, 2015], a BEN-SCI is proposed, where the LnBen (beneficial fleet) is regressed on 4 binary and 9 continuous variables (see column 4 of Table 1). A similar model is developed for LnFleet as well. To overcome the problem of aligning the two basic criteria for the national shipping (V and W), two new proxy variables were introduced in the same paper: combined SCI (C-SCI) and weighted SCI (W-SCI). The first one uses the sum of LnFleet and LnBen as a dependent variable whereas the second uses the weighted sum of LnFleet and LnBen as a proxy for shipping competitiveness. The sets of independent variables are shown respectively in columns 5 & 6 of Table 1. In [Nguyen et al., 2019] an adaptive SCI (A-SCI) is applied to solve the problem with the unknown weights of the two criteria, where LnFleet is regressed on LnBen and on the 15 variables from column 7 of Table 1. Then, the proxy variable is calculated as the predicted value of LnFleet minus the constant term and minus the LnBen term. All criteria are using full regression models with slope coefficients for any independent variable indicated in Table 1.

The objectives of this paper are on one hand to create models only with significant variables and on the other hand to propose a novel proxy for the SCI ranking based on the ordered-weighted average operator (OWA) proposed in [Yager, 1988]. The OWA-SCI will give alternative solution to the problem with the unknown weights of the LnFleet and the LnBen basic criteria. The first objective will allow full regression diagnostics of the created models although using full regression models has its own merits. All models will use the independent variables in column 8 of Table 1.

Table 1: Independent variables utilized in the various ranking indices

Independent variable	Alias	NAT-SCI	BEN-SCI	C-SCI	W-SCI	A-SCI	OWA-SCI	Independent variable	Alias	NAT-SCI	BEN-SCI	C-SCI	W-SCI	A-SCI	OWA-SCI
Dum_OilEx	X_1		*	*	*	*	*	**LnCoastline**	X_{10}	*	*	*	*	*	*
Dum_TopOilEx	X_2	*	*	*	*	*	*	**LnPolicy**	X_{11}	*	*	*	*	*	*
Dum_TopOilIm	X_3		*	*	*	*	*	**LnReg**	X_{12}	*	*	*	*	*	*
Dum_Flag	X_4	*	*	*	*	*	*	**LnGDPCap**	X_{13}		*	*	*	*	*
FinDev	X_5	*	*	*	*	*	*	**LnTour**	X_{14}					*	*
LnBuild	X_6	*	*	*	*	*	*	**LnFish**	X_{15}					*	*
LnHistory	X_7	*	*	*	*	*	*	**LnGDP**	X_{16}	*					
LnTrade	X_8	*	*	*	*	*	*	**SDUM_FOC**	X_{17}	*					
LnOil_Ex	X_9	*	*	*	*	*	*								

3. Essence of the OWA operator

The OWA operator was introduced as a possible solution of the aggregation problem where t criteria C_r (r=1,2,…,t) are used to rank the elements of a given set of alternatives Z. For any $z \in Z$, the values of the criteria belong to the unit interval: $c_r = C_r(z) \in [0,1]$,for $r =,1,2,\ldots,t$. Here, c_r is the degree to which the alternative z satisfies the r^{th} criterion C_r. So, z can be described with the t-dimensional argument tuple $(c_1, c_2, \ldots, c_t)$ or equivalently, with the t-dimensional ordered argument tuple $(d_1, d_2, \ldots, d_t)$, where d_r is the r^{th} largest element of the argument tuple. Let $\vec{K}(k_1, k_2, \ldots, k_t)$ be a t-dimensional weighting vector whose elements are non-negative real numbers which sum to one. The OWA aggregation operator is defined as

$$F(z) = F(c_1, c_2, \ldots, c_t) = OWA(d_1, d_2, \ldots, d_t) = \sum_{r=1}^{t} k_r d_r \tag{1}$$

This operator transforms the t values of criteria $(c_1, c_2, \ldots, c_t)$ into a value function $F(z)$ for the alternative z. The OWA operator generalizes the ‘or’ and the ‘and’ operators and produces results which are between these two extremes. A measure of closeness of a specific OWA operator to the ‘or’-operator is called degree of “orness” [Yager, 1988]:

$$orness(\vec{K}) = orness(k_1, k_2, \ldots, k_t) = \frac{1}{t-1} \sum_{r=1}^{t} (t-r) k_r \tag{2}$$

For a discussion about the numerous applications of the OWA aggregation operator together with an excellent bibliographical review see [Emrouznejad, Marra, 2014].

4. Formal description of methodology and new indices

For simplicity of notations, we will introduce the dependent variables Y_k (k=1,2,3,4) which will serve as proxies of the shipping competitiveness as follows: Y_1=Y_3=V, Y_2=W, and Y_4=V+aW, where

a is a known positive constant. The values of Y_k for the i^{th} country will be denoted as $y_{k,i}$. We shall attempt to construct four regression models:

$$\begin{aligned} y_{1,i} &= \text{LnFleet}_i = \beta_{1,0} + \beta_{1,1}\text{Dum\_OilEx}_i + \beta_{1,2}\text{Dum\_TopOilEx}_i + \beta_{1,3}\text{Dum\_TopOilIm}_i \\ &\quad + \beta_{1,4}\text{Dum\_Flag}_i + \beta_{1,5}\text{FinDev}_i + \beta_{1,6}\text{LnBuild}_i + \beta_{1,7}\text{LnHistory}_i + \beta_{1,8}\text{LnTrade}_i \\ &\quad + \beta_{1,9}\text{LnOilEx}_i + \beta_{1,10}\text{LnCoastline}_i + \beta_{1,11}\text{LnPolicy}_i + \beta_{1,12}\text{LnReg}_i \\ &\quad + \beta_{1,13}\text{LnGDPCap}_i + \beta_{1,14}\text{LnTour}_i + \beta_{1,15}\text{LnFish}_i + u_{1,i} = \beta_{1,0} + \sum_{j=1}^{15} \beta_{1,j} x_{i,j} + u_{1,i} \end{aligned} \tag{3}$$

$$\begin{aligned} y_{2,i} &= \text{LnBen}_i = \beta_{2,0} + \beta_{2,1}\text{Dum\_OilEx}_i + \beta_{2,2}\text{Dum\_TopOilEx}_i + \beta_{2,3}\text{Dum\_TopOilIm}_i \\ &\quad + \beta_{2,4}\text{Dum\_Flag}_i + \beta_{2,5}\text{FinDev}_i + \beta_{2,6}\text{LnBuild}_i + \beta_{2,7}\text{LnHistory}_i + \beta_{2,8}\text{LnTrade}_i \\ &\quad + \beta_{2,9}\text{LnOilEx}_i + \beta_{2,10}\text{LnCoastline}_i + \beta_{2,11}\text{LnPolicy}_i + \beta_{2,12}\text{LnReg}_i \\ &\quad + \beta_{2,13}\text{LnGDPCap}_i + \beta_{2,14}\text{LnTour}_i + \beta_{2,15}\text{LnFish}_i \beta_{2,0} + u_{2,i} = \beta_{2,0} + \sum_{j=1}^{15} \beta_{2,j} x_{i,j} + u_{2,i} \end{aligned} \tag{4}$$

$$\begin{aligned} y_{3,i} &= \text{LnFleet}_i = \beta_{3,0} + \beta_{3,1}\text{Dum\_OilEx}_i + \beta_{3,2}\text{Dum\_TopOilEx}_i + \beta_{3,3}\text{Dum\_TopOilIm}_i \\ &\quad + \beta_{3,4}\text{Dum\_Flag}_i + \beta_{3,5}\text{FinDev}_i + \beta_{3,6}\text{LnBuild}_i + \beta_{3,7}\text{LnHistory}_i + \beta_{3,8}\text{LnTrade}_i \\ &\quad + \beta_{3,9}\text{LnOilEx}_i + \beta_{3,10}\text{LnCoastline}_i + \beta_{3,11}\text{LnPolicy}_i + \beta_{3,12}\text{LnReg}_i + \beta_{3,13}\text{LnGDPCap}_i \\ &\quad + \beta_{3,14}\text{LnTour}_i + \beta_{3,15}\text{LnFish}_i + \beta_{3,16} w_i + u_{3,i} = \beta_{3,0} + \sum_{j=1}^{15} \beta_{3,j} x_{i,j} + \beta_{3,16} w_i + u_{3,i} \end{aligned} \tag{5}$$

$$\begin{aligned} y_{4,i} &= \text{LnFleet}_i + \beta_{3,16}\text{LnBen}_i = \beta_{4,0} + \beta_{4,1}\text{Dum\_OilEx}_i + \beta_{4,2}\text{Dum\_TopOilEx}_i \\ &\quad + \beta_{4,3}\text{Dum\_TopOilIm}_i + \beta_{4,4}\text{Dum\_Flag}_i + \beta_{4,5}\text{FinDev}_i + \beta_{4,6}\text{LnBuild}_i + \beta_{4,7}\text{LnHistory}_i \\ &\quad + \beta_{4,8}\text{LnTrade}_i + \beta_{4,9}\text{LnOilEx}_i + \beta_{4,10}\text{LnCoastline}_i + \beta_{4,11}\text{LnPolicy}_i + \beta_{4,12}\text{LnReg}_i \\ &\quad + \beta_{4,13}\text{LnGDPCap}_i + \beta_{4,14}\text{LnTour}_i + \beta_{4,15}\text{LnFish}_i + u_{4,i} = \beta_{4,0} + \sum_{j=1}^{15} \beta_{4,j} x_{i,j} + u_{4,i} \end{aligned} \tag{6}$$

Since the value of the positive constant, a, used in Y_4 is the slope $\beta_{3,16}$ estimated in (5), it follows that the regression model (6) can be constructed after constructing the regression model (5). The four regression models will be solved using the Ordinary Least Square (OLS) method. We will obtain a Classical Normal Linear Regression Model (CNLRM) [Gujarati, 2004, pp. 107-117] provided the assumptions of nullity, homoskedasticity, normality, independence, and multicollinearity hold [Selvanathan et al., 2021, p. 791].

The necessity to use only significant coefficients comes from a sixth assumption, called linearity, which is formulated in [Lind et al, 2012]. It boils down to identifying a model with proper structure where every coefficient contributes to the precision of the predicted values and no available regressor can improve the model precision. We will use forward stepwise regression procedure to construct the CNLRM with a correct structure. It starts with a set of regressors containing only the constant term and adds one regressor at each step. The selected regressor is that one of the significant slopes which maximally increases the adjusted coefficient of determination (R^2_{adj}). The significance of each candidate regressor slope is determined by a t-test with the heteroscedasticity-consistent HC4-estimate of the slope's standard error [Cribary-Netto, 2004] which deals with possible heteroscedasticity, non-normal errors, and existence of high-leverage points. If all available slopes are selected or when no regressor is added, then the procedure stops, and the "best" structure of the regression is determined.

Let all the significant coefficients of the k^{th} model are denoted as $\beta_{k,j}=\beta^*_{k,j}$ (where k=1,2,3,4 and j=1,2,…,15). Since the correlation between V=LnFleet and W=LnBen is close to perfect (correlation coefficient 0.9713 over data described in the next section), the model (3) will always select W as the best regressor and therefore $\beta_{3,16}=\beta^*_{3,16}$ (i.e. the value of the positive constant, a, used in Y_4 will come from a significant slope).

Knowing the significant coefficients of the linear regression models (3)-(6) we can calculate several criteria for shipping competitiveness and estimate the corresponding SCI ranks for each country.

The first criterion, NAT-Crit, is equivalent to the predicted value of Y_1=LnFleet in model (3):

$$\text{NAT-Crit}_i=\sum_{\substack{j=1\\ \beta_{1,j}=\beta^*_{1,j}}}^{15}\beta^*_{1,j}x_{i,j}\Rightarrow \text{NAT-SCI}_i=rank\left(\text{NAT-Crit}_i\right) \tag{7}$$

The second criterion, BEN-Crit, is equivalent to the predicted value of Y_2=LnBen in model (4):

$$\text{BEN-Crit}_i=\sum_{\substack{j=1\\ \beta_{2,j}=\beta^*_{2,j}}}^{15}\beta^*_{2,j}x_{i,j}\Rightarrow \text{BEN-SCI}_i=rank\left(\text{BEN-Crit}_i\right) \tag{8}$$

The third criterion, A-Crit, is equivalent to the predicted value of Y_3=LnFleet from model (5) but disregarding the influence of the "independent" variable LnBen:

$$\text{A-Crit}_i=\sum_{\substack{j=1\\ \beta_{3,j}=\beta^*_{3,j}}}^{15}\beta^*_{3,j}x_{i,j}\Rightarrow \text{A-SCI}_i=rank\left(\text{A-Crit}_i\right) \tag{9}$$

The fourth criterion, W-Crit, is equivalent to the predicted value of Y_4= LnFleet +aLnBen in model (6), and the positive constant a is defined in model (5) as $a=\beta_{3,16}=\beta^*_{3,16}$:

$$\text{W-Crit}_i=\sum_{\substack{j=1\\ \beta_{4,j}=\beta^*_{4,j}}}^{15}\beta^*_{4,j}x_{i,j}\Rightarrow \text{W-SCI}_i=rank\left(\text{W-Crit}_i\right) \tag{10}$$

The fifth criterion, C-Crit, is the sum of the first two criteria:

$$\text{C-Crit}_i=\text{NAT-Crit}_i+\text{BEN-Crit}_i\Rightarrow \text{C-SCI}_i=rank\left(\text{C-Crit}_i\right) \tag{11}$$

The novel sixth criterion, OWA-Crit, is equivalent to an ordered-weighted average of the two basic criteria (V and W) with weights respectively 0.25 and 0.75:

$$\text{OWA-Crit}_i=\frac{100}{0.25\,max\left\{\text{NAT-SCI}_i,\text{BEN-SCI}_i\right\}+0.75\,min\left\{\text{NAT-SCI}_i,\text{BEN-SCI}_i\right\}} \tag{12}$$

$$\Rightarrow \text{OWA-SCI}_i=rank\left(\text{OWA-Crit}_i\right)$$

The theoretical minimal and maximal limits of the OWA-Crit are 100/N and 100, respectively, which can be achieved by two last rank results and by two first rank results from the NAT-SCI and BEN-SCI basic criteria. The OWA-Crit is slightly modified reciprocal of the OWA aggregation operator with t=2 criteria and with weighted vector $\vec{K}\left(0.25,0.75\right)$. The first modification is that the unit interval of the two attributes are substituted with the closed interval [1,N]. The second modification is that here our preferences decrease with the decrease of the attributes unlike the original OWA operator. That is why formula (2) will measure the degree of "andness" and the degree of "orness" will be estimated as the complement to 1 of the degree of "andness":

$$orness\left(\text{OWA-Crit}\right)=1-\frac{1}{t-1}\sum_{r=1}^{t}\left(t-r\right)k_r=1-\frac{1}{2-1}\left[\left(2-1\right)0.25+\left(2-2\right)0.75\right]=0.75 \tag{13}$$

The function $rank$(.) used in formulae from (7) to (12) is calculated as:

$$rank\left(\text{Crit}_i\right)=\sum_{\substack{j=1\\ Crit_j<Crit_i}}^{N}\left(1\right)+\frac{1}{2}\sum_{\substack{j=1\\ Crit_j=Crit_i}}^{N}\left(1\right)+\frac{1}{2} \tag{14}$$

5. Analysis and results

We shall utilize numerical information that describes the shipping competitiveness of N=84 nations with at least relatively developed maritime industry. The properties of the data set are described in [Nguyen, et al, 2019]. The coefficients of all regression models are calculated with Singular Value Decomposition of the design matrix as described in [Press et al., 2007], where the singular values are classified using the PCCSV algorithm from [Nikolova et al. 2021]. By doing so, any harmful effect of possible multicollinearity is eliminated from the solution. The homoscedasticity of the models is tested with the MHTRA algorithm formulated in [Tenekedjiev et al., 2021] which uses an auxiliary regression model for the absolute predicted residual value. If the latter is not significant, then the original model is declared homoscedastic. If the auxiliary model is valid according to the ANOVA test, but its adjusted coefficient of determination is less than 0.25, then the original model will be labeled as heteroscedastic with practically negligible heteroscedasticity [Tenekedjiev, Radojnova, 2001]. The validity of the normality assumption is diagnosed with Jarque-Bera statistical test [Gujarati, 2004, pp. 148-149] with p-value calculated using a Monte-Carlo procedure proposed in [Tenekedjiev et al., 2021].

The stepwise regression procedure for model (3) converges in 6 steps into

$$\begin{aligned}\text{LnFleet}_i=&-12.21-0.6499\text{Dum\_OilEx}_i+0.7574\text{Dum\_TopOilEx}_i\\&+0.1060\text{LnBuild}_i+0.6227\text{LnTrade}_i+0.2317\text{LnReg}_i+u_{1,i}\end{aligned} \tag{15}$$

The 95%-confidence interval of the standard error of the residuals is [0.963, 1.32] with point estimate 1.11. The R^2=0.805, whereas R^2_{adj}=0.792. The model is adequate with p-value of ANOVA test of less than 10^{-14}. The coefficients of the regression model are significant (Table 2), where the last column shows the contribution $\Delta R^2_{adj,j}$ of the j-th regressor to R^2_{adj}. The HC4 correlation matrix of the coefficients is given in Table 3.

Table 2. Regression coefficients in model (3)

Variable	Mean	HC4 sigma	HC4 t_stat	HC4 Pvalue	$\Delta R^2_{adj,j}$
Constant	-1.221e+01	2.566e+00	-4.757e+00	8.847e-06	0
Dum_OilEx	-6.499e-01	2.636e-01	-2.466e+00	1.587e-02	0.010
Dum_TopOilEx	7.574e-01	2.899e-01	2.612e+00	1.078e-02	0.006
LnBuild	1.060e-01	2.720e-02	3.897e+00	2.044e-04	0.121
LnTrade	6.227e-01	1.260e-01	4.944e+00	4.299e-06	0.622
LnReg	2.317e-01	8.238e-02	2.812e+00	6.226e-03	0.033

The model is homoscedastic since the auxiliary model of the absolute predicted residual value is insignificant (ANOVA p-value of 0.11) with negligible $R^2_{adj}=0.049$. The residuals are not normally distributed since the Jarque-Bera Monte-Carlo test p-value is around 0.01. That fact justifies using the HC4 estimates for the standard deviations of the model slopes.

The stepwise regression procedure for model (4) converges in 5 steps into

$$\begin{aligned}\text{LnBen}_i=&-12.90-0.5775\text{Dum\_OilEx}_i+0.1026\text{LnBuild}_i\\&+0.6417\text{LnTrade}_i+0.2594\text{LnReg}_i+u_{2,i}\end{aligned} \tag{16}$$

The 95%-confidence interval of the standard error of the residuals is [0.902, 1.24] with point estimate 1.04. The R^2=0.826, whereas R^2_{adj}=0.817. The model is adequate with p-value of ANOVA test of less than 10^{-14}. The coefficients of the regression model are significant according to Table 4, where the last column shows the contribution $\Delta R^2_{adj,j}$ of the j-th regressor to R^2_{adj}. The HC4 correlation matrix of the coefficients is given in Table 5.

Table3.HC4-correlation matrix of the regression coefficients for model (3)

	Constant	Dum_OilEx	Dum_TopOilEx	LnBuild	LnTrade	LnReg
Constant	1.000	0.167	0.274	0.567	-0.951	0.302
Dum_OilEx	0.167	1.000	-0.191	-0.014	-0.202	0.115
Dum_TopOilEx	0.274	-0.191	1.000	0.044	-0.238	0.007
LnBuild	0.567	-0.014	0.044	1.000	-0.480	-0.141
LnTrade	-0.951	-0.202	-0.238	-0.480	1.000	-0.574
LnReg	0.302	0.115	0.007	-0.141	-0.574	1.000

The model is homoscedastic since the auxiliary model of the absolute predicted residual value is insignificant (ANOVA p-value of 0.11) with negligible $R^2_{adj} = 0.043$. The residuals are normally distributed since the Jarque-Bera Monte-Carlo test p-value is around 0.073.

Table 4. Regression coefficients in model (4)

Variable	Mean	HC4 sigma	HC4 t_stat	HC4 Pvalue	$\Delta R^2_{adj,j}$
Constant	-1.290e+01	2.371e+00	-5.442e+00	5.737e-07	0
Dum_OilEx	-5.775e-01	2.551e-01	-2.264e+00	2.634e-02	0.011
LnBuild	1.026e-01	2.855e-02	3.595e+00	5.624e-04	0.136
LnTrade	6.417e-01	1.205e-01	5.324e+00	9.277e-07	0.628
LnReg	2.594e-01	8.504e-02	3.051e+00	3.106e-03	0.042

The stepwise regression procedure for model (5) converges in 3 steps into

$$\mathrm{LnFleet}_i = 0.1506 - 0.4228\mathrm{Dum\_Flag}_i + 0.9726\mathrm{LnBen}_i + u_{3,i} \tag{17}$$

The 95%-confidence interval of the standard error of the residuals is [0.504, 0.687] with point estimate 0.582. The R^2=0.945, whereas R^2_{adj}=0.943. The model is adequate with p-value of ANOVA test of less than 10^{-14}. The coefficients of the regression model are significant according to Table 6, where the last column shows the contribution $\Delta R^2_{adj,j}$ of the j-th regressor to R^2_{adj}. The HC4 correlation matrix of the coefficients is given in Table 7.

Table 5. HC4-correlation matrix of the regression coefficients for model (4)

	Constant	Dum_OilEx	LnBuild	LnTrade	LnReg
Constant	1.000	0.175	0.593	-0.944	0.343
Dum_OilEx	0.175	1.000	0.021	-0.242	0.205
LnBuild	0.593	0.021	1.000	-0.457	-0.221
LnTrade	-0.944	-0.242	-0.457	1.000	-0.624
LnReg	0.343	0.205	-0.221	-0.624	1.000

The model is practically negligibly heteroscedastic since the auxiliary model of the absolute predicted residual value is significant (ANOVA p-value of 0.0435), but with negligible $R^2_{adj} = 0.052$. The residuals are not normally distributed since the Jarque-Bera Monte-Carlo test p-value is less than 10^{-14}. That fact justifies using the HC4 estimates for the standard deviations of the model slopes. From this model, we can find the positive parameter a=0.9726, equal to the slope in front of W=LnBen in (17).

Table 6. Regression coefficients in model (5)

Variable	Mean	HC4sigma	HC4t_stat	HC4Pvalue	$\Delta R^2_{adj,j}$
Constant	1.506e-01	2.236e-01	6.735e-01	5.026e-01	0
Dum_Flag	-4.228e-01	1.701e-01	-2.485e+00	1.502e-02	0.001
Lean	9.726e-01	3.621e-02	2.686e+01	4.287e-42	0.943

The stepwise regression procedure for model (6) converges in 6 steps into

$$\begin{aligned} y_{4,i} &= \mathrm{LnFleet}_i + 0.9726\mathrm{LnBen}_i = -23.92 - 1.276\mathrm{Dum\_OilEx}_i + 1.353\mathrm{Dum\_TopOilEx}_i \\ &+ 0.2113\mathrm{LnBuild}_i + 1.212\mathrm{LnTrade}_i + 0.4809\mathrm{LnReg}_i + u_{4,i} \end{aligned} \tag{18}$$

The 95%-confidence interval of the standard error of the residuals is [1.76, 2.41] with point estimate 2.04. The R^2=0.830, whereas R^2_{adj}=0.819. The model is adequate with p-value of ANOVA test of less than 10^{-14}. The coefficients of the regression model are significant according to Table 8, where the last column shows the contribution $\Delta R^2_{adj,j}$ of the *j*-th regressor to R^2_{adj}. The HC4 correlation matrix of the coefficients is given in Table 9.

Table 7. HC4-correlation matrix of the regression coefficients for model (5)

	Constant	Dum_Flag	LnBen
Constant	1.000	0.200	-0.986
Dum_Flag	0.200	1.000	-0.246
LnBen	-0.986	-0.246	1.000

The model is homoscedastic since the auxiliary model of the absolute predicted residual value is insignificant (ANOVA *p*-value of 0.084) with negligible $R^2_{adj} = 0.059$. The residuals are normally distributed since the Jarque-Bera Monte-Carlo test p-value is around 0.53.

Table 8. Regression coefficients in model (6)

Variable	Mean	HC4sigma	HC4t_stat	HC4Pvalue	$\Delta R^2_{adj,j}$
Constant	-2.392e+01	4.774e+00	-5.011e+00	3.304e-06	0
Dum_OilEx	-1.276e+00	5.000e-01	-2.552e+00	1.267e-02	0.011
Dum_TopOilEx	1.353e+00	5.783e-01	2.339e+00	2.190e-02	0.005
LnBuild	2.113e-01	5.474e-02	3.860e+00	2.328e-04	0.130
LnTrade	1.212e+00	2.393e-01	5.065e+00	2.673e-06	0.634
LnReg	4.809e-01	1.624e-01	2.960e+00	4.070e-03	0.038

The criteria and their respective SCI ranks are given in Table 10 (for the first 20 and the last 5 countries, for the sake of limitation of space). The results show that the adaptive SCI (A-SCI) with significant coefficients is unable to discriminate the countries according to their shipping competitiveness (all countries but two have the same ranking). However, the model (5) produced the value of the positive constant *a* (0.9726), which in turn allowed to calculate the weighted SCI (W-SCI). The other five indices produce practically the same results, which shows that OWA-SCI is robustly estimating the rank. However, using the latter has certain advantages. First, OWA-SCI utilizes the information in the two basic criteria unlike NAT-SCI and BEN-SCI. Second, it does not make unreasonable assumptions like equal weight of the basic criteria unlike C-SCI. Third, OWA-SCI naturally eliminates the problem of defining externally the weights of the two basic criteria unlike the W-SCI, which has to use information from A-SCI. Fourth, the work [Yager, 1988] contains a generalization of the OWA operator to deal with criteria that have equal importance, which allows flexible OWA-SCI ranking similar to the original version of the W-SCI described in [Nguyen, Bandara, 2015].

Table 9. HC4-correlation matrix of the regression coefficients for model (6)

	Constant	Dum_OilEx	Dum_TopOilEx	LnBuild	LnTrade	LnReg
Constant	1.000	0.115	0.181	0.597	-0.948	0.337
Dum_OilEx	0.115	1.000	-0.233	-0.012	-0.176	0.168
Dum_TopOilEx	0.181	-0.233	1.000	0.005	-0.166	0.047
LnBuild	0.597	-0.012	0.005	1.000	-0.482	-0.179
LnTrade	-0.948	-0.176	-0.166	-0.482	1.000	-0.609
LnReg	0.337	0.168	0.047	-0.179	-0.609	1.000

All six SCI-ranking methods rely on linear regression models. The predicted values of the outliers, poorly describe the measured dependent variable values. In our case the outliers have to be identified and the rank of an outlier country has to be flagged because the shipping competitiveness index may contain unknown level of error. We will identify separately the outliers in the models (3) and (4) by using the CODPA algorithm developed in [Nikolova et al., 2021]. CODPA is organized in cycles allowing to identify outliers with different order of magnitude. The single comparison significance level is set to 1%, whereas the selected maximum false discovery rate is 30%. The maximum number of cycles was selected to be 10. The resulting procedure conservatively defined as outliers for model (3) only Greece and Korea (both in the first cycle). For model (4), only Greece was identified as an outlier (again in the first cycle). The second cycles for the two models never discovered new outliers. It follows that the OWA-ranks of Greece and Korea are doubtful and should not be taken at face value.

Table 10. Criteria values and SCI ranks for selected countries[1]

Country	NAT-Crit	NAT-SCI	BEN-Crit	BEN-SCI	C-Crit	C-SCI	W-Crit	W-SCI	A-Crit	A-SCI	OWA-Crit	OWA-SCI
China	23.97	1	24.95	1	48.93	1	47.27	1	0	40.5	100.00	1
Germany	23.42	3	24.37	2	47.80	2	46.17	2	0	40.5	44.44	2
USA	23.46	2	23.71	6	47.17	4	46.08	3	0	40.5	33.33	3
Japan	23.26	4	24.20	3	47.45	3	45.85	4	0	40.5	30.77	4
UK	22.95	5	23.91	4	46.86	5	45.27	5	0	40.5	23.53	5
Korea	22.85	6	23.78	5	46.63	6	45.05	6	0	40.5	19.05	6
India	22.44	7	23.37	7	45.81	7	44.24	7	0	40.5	14.29	7
Singapore	22.32	9	23.36	8	45.68	8	44.06	8	0	40.5	12.12	8
Belgium	22.31	10	23.22	9	45.53	9	43.96	9	0	40.5	10.81	9
Italy	22.07	12	23.08	10	45.15	10	43.52	12	0	40.5	9.52	10
Taipei, Chinese	22.12	11	23.00	11	45.12	11	43.58	11	0	40.5	9.09	11
Russian Fed.	22.33	8	22.55	21	44.87	14	43.86	10	0	40.5	8.89	12
France	21.96	14	22.96	12	44.92	13	43.28	14	0	40.5	8.00	13
Canada	22.04	13	22.91	13	44.94	12	43.39	13	0	40.5	7.69	14
Turkey	21.95	15	22.85	14	44.80	15	43.28	15	0	40.5	7.02	15
Netherlands	21.84	18	22.83	15	44.67	16	43.04	19	0	40.5	6.35	16
Brazil	21.86	16	22.73	17	44.60	18	43.08	17	0	40.5	6.15	17.5
Norway	21.85	17	22.76	16	44.60	17	43.10	16	0	40.5	6.15	17.5
Greece	21.80	19	22.73	18	44.53	19	43.06	18	0	40.5	5.48	19
Indonesia	21.78	20	22.69	19	44.48	20	42.95	20	0	40.5	5.19	20
...												
Seychelles	15.90	81	16.65	80	32.55	80	31.32	80	0	40.5	1.25	80
Iceland	15.91	80	16.54	82	32.44	82	31.17	82	0	40.5	1.24	81
Guyana	15.90	82	16.60	81	32.50	81	31.25	81	0	40.5	1.23	82
Eritrea	15.19	83	15.85	83	31.04	83	29.85	83	0	40.5	1.20	83
Madagascar	14.75	84	15.44	84	30.19	84	28.91	84	0	40.5	1.19	84

6. Discussion and conclusions

We presented a new competitiveness index based on the OWA operator and compared its effectiveness with competitiveness indices we have presented in previous works. We tested this new index over the data about 84 maritime countries that we utilized in previous research [Nguyen et al., 2019], which also allowed us to make extensive comparisons between the new and the previously proposed indices.

The NAT-SCI (as its name suggests) is useful for the competitiveness of nationally own fleet and not for other variables, whereas the BEN-SCI is useful for the evaluation of the attractiveness of countries' shipping market. The pair W-SCI and A-SCI were presented for the sake of backward compatibility with our previous research works on the topic and also for comparison with the new index. The C-SCI and OWA-SCI are combinations of the NAT-SCI and BEN-SCI indices. We have extensively discussed the advantages of the OWA-SCI.

As direction for future studies, our findings and approaches need to be applied to a broader set of recent data for the same or for a larger pool of countries, to test and explore results and discuss in more detail the performance of specific countries from specific regions. While our work very much concentrated on presenting the competitiveness index based on the OWA operator, ad demonstrate its user over data, another important direction of future work for our study is to explore policy recommendations resulting from our findings. We need to explore how our competitiveness indices can be utilized when drafting economic, environmental, or other policies nationally and internationally. In this way our findings might be of practical use to policymakers, maritime industry representatives, etc.

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Proposal for the introduction of "Shore to Ship Alert System"

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Abstract

Maritime accidents continue to occur despite advanced technology onboard and ashore assisting ships. Human error being the catalyst of most of the scenarios is evident. There are more than a few incidents which occurred in coastal waters, even with warnings and frequent attempts to call on Very High Frequency (VHF) by the Vessel Traffic Service (VTS). To identify the issue, an overview of the assistance of VTS and its contribution to the safety of navigation on board is going to be showcased with relevant past incidents. The present trend of VHF communication on board, its effective use, and instances when the VTS calls went unanswered on VHF will be emphasised and evaluated through case studies, qualitative and quantitative methods. To identify the gap in communications between the VTS and ships, the reasons for being unresponsive will be depicted through the methods of data collection.

This study intends to evaluate how the effective usage of VTS can mitigate maritime accidents and near misses, especially in the coastal waters within the range of VTS. In the meantime, it aims to propose a theory of a new system to be introduced to the maritime industry which could be a breakthrough to minimise navigational accidents particularly in the proximity of the coastal states.

The purpose of the theoretical solution is to improve the communication gap between shore to ship, especially in imminent danger by introducing a "Shore To Ship Alert System" (STSAS). This system could eradicate human error of being non-responsive to VTS advice or warnings. A complete framework of the functions will be described, and the advantages and disadvantages will be discussed for the reader's judgment.

Keywords: Marine accidents, human error, communication, unresponsive, shore to ship alert system.

Introduction

Every year Maritime accidents keep threatening the safety of life and the environment resulting in enormous losses to the owners and stakeholders. Accidents that occur particularly around the vicinity of coastal states pose a dire impact on the nearby community and the local biodiversity [1]. The tragedies not only cause a massive loss to the owners but equally dents their reputation in this extremely competitive industry.

One of the significant causes of accidents in the shipping industry is human error. It is estimated that human error contributes to between 75% and 96% of marine accidents [2]. Although there are several safety measures regulated and implemented by the governing bodies, maritime accidents still occur. The introduction of the Safety Of Life At Sea (SOLAS) convention in 1914 emerged in response to the Titanic disaster, which specifies the minimum standards for equipment, construction, and operation of ships [3]. The loss of the Herald of Free Enterprise in 1987 was a pivotal element in the introduction of International Safety Management (ISM) [4]. ISM has cemented a safety foundation and played an enormous role in improving safety standards. Statistics revealed in 2008, 130 ships sunk within a global fleet of 40,000 ships, and in 2016 less than 100 ships sunk in the global fleet of 80,000 ships [5]. The analysis certainly reveals the improvement of safety standards; however, the casualties continue to be present.

In the modern era, there are various resources available onboard assisting the seafarers with their ideology and decision-making skills in navigation. Additionally, there is a shore-based system known as VTS which plays a huge part in the coastal waters. VTS is a maritime safety mechanism that controls the flow of vessels and enhances the safety of the shipping on waterways [6]. VTS can be delivered on three different levels of service: Information Service (INS), Traffic Organisation Service (TOS), and Navigational Assistance Service (NAS) [7]. The VTS can ask questions to explain the ship's intentions, issue a warning, or even offer general advice, but once the ships have agreed on how they will meet, the VTS normally does not intervene [8]. There are more than a few occasions where the navigating officers failed to take heed of the VTS's advice that resulted in a disaster, and similarly, there are many occasions the ships averted an incident. It is up to the sagacious judgment of the seafarer to utilise the sources effectively.

The communication gap between the VTS and the ships has a significant impact on the maritime industry. Therefore, ships that do not respond to VTS calls need to be addressed and a suitable measure to circumvent vessels not being responsive needs to be established. Maritime experts and governing bodies are constantly looking for innovative solutions to enhance the safety of navigation to minimise fatalities and maritime losses.

This paper aims to highlight the communication gap between the VTS and the ships. To bridge the gap, the author intends to propose a theoretical solution of a new system known as the "Shore to Ship Alert System" in the maritime industry.

Objective

The study intends to assess the effectiveness of VTS's role in the prevention of accidents in the Maritime Industry and the successful usage of VHF communication onboard. The gap in the communication between the VTS and the ship will be showcased through case studies. To improve the effectiveness of communication, a theory of a new system is proposed that can be implemented. The theory is projected to establish an alert from the VTS to the ships in case of any foreseen mishap.

Industry's approach to preventing accidents from recurrence.

The need for a new system in the maritime industry, despite many advanced technologies and systems available onboard and ashore, could be overlooked. However, with the hindsight of the accidents, this often paved a way for the maritime authorities and governments to find a solution from recurrence. The trend has been such that succeeding in an accident, many organisations narrow the events to find the root cause and establishing several barriers to avoid repetition. The typical approach to tackling protection in the workplace was by regulatory means or through physical barriers and related prevention steps that did not entail any extra care from the employee [9]. Another common approach to minimise the accidents was to instil a safety culture at work. The idea of 'safety culture' is demonstrating rising interest in many sectors around the world as a way of mitigating the risk for large-scale fatalities and accidents related to routine activities [9].

Case Studies

There are many maritime accidents where the VTS tried to call the vessel on VHF to alert and recheck her actions or seeking her intentions to assess the traffic situation, but the call is either not answered or delayed or not heeded. This is one of the major concerns which is less emphasised in the maritime industry. Furthermore, there are situations where the vessels responded to the VTS in time and averted an incident. There are several Mariners Alerting and Reporting Scheme (MARS) reports which stated VTS involvement, and VTS is not often viewed in the most favourable light [10]. Let us look into a few cases to emphasise the importance of VTS's role in navigation.

Case 1*- Ignored VTS advice*: The Officer on watch (OOW) noticed two small islands on the radar and intended to navigate between them. After 30 minutes, the local coast guard warned on the VHF that they were on a dangerous course. The OOW acknowledged the call and did not take any action. Around nine minutes later, the local VTS called the vessel and warned about the hazard. Later the OOW swiftly altered the course to steer away, however still ended up grounding the vessel [11].

Case 2- *VTS call unanswered*: The recent case of a marine disaster that resulted in a total loss of the bulk carrier M.V. Wakashio is another example to exhibit. The internal investigation report released by MOL states, a few days before the vessel grounded, she altered her course to pass the island of Mauritius by 5 nautical miles. On 25th July 2020, the day of grounding, she further reduced the range to pass 2 nautical miles to seek a mobile phone signal. Crew members neglected watchkeeping duties both visually and by radar, the vessel ran aground in shallow water with a depth of 10 meters and 0.9 nautical miles off Mauritius coast [12]. As per the preliminary report, the ill-fated vessel later spilled oil and split into two. It is estimated that around 1,000 tons of fuel oil was spilled, causing severe ecological damage to the pristine shores of Mauritius [13]. The investigation of the flag state is still underway.

The first statement issued by Panama Maritime Authority stated, *"confirmed that Mauritius detected the change in the course, which previous reports said prompted repeated calls to the Wakashio from shore stations that went unanswered"* [14].

A report published in a journal stated that the Mauritius coast guard tried to call the ship for an hour, advising that its routing appeared risky. Eventually, the coast guard officials got through to the Master and the Master claimed the route was safe, a few minutes later the vessel radioed the local authorities and reported that she was grounded [15]. The possible cause and key issues onboard are being scrutinised. However, the safety culture appears to be lacking.

These cases have a significant part in the VTS. Prompt response from the bridge team to the VTS could have averted many incidents. Although VTS suggestion may not be suitable at times, however, it is the ship's navigation officer's judgements and state of alertness that plays a key role.

Given these cases, it is intriguing to know, why would the Bridge Team (BT) onboard not respond to the calls made by the VTS or take heed to its advice? What are the circumstances that cause BT to ignore the VHF? Do we have an alternative source to alert a vessel for not being responsive?

Data collection

Convenience sampling was used to collect quantitative and qualitative data from the navigation officers in various sectors like dry, gas and oil using survey questionaries and semi-structured interviews. Primary data collected through UK Marine Accident Investigation Branch (MAIB) reports exclusively focusing on the incidents between VTS and VHF communications. Secondary data was collected via various online resources.

Discussions

A total of 208 participants answered the questionnaire. 102 Masters, 65 Chief Officers, 38 Junior Officers, and 3 were North Sea Pilots. 160 contributors had more than 15 years of sailing experience, 25 had 8 to 15 years of sailing experience and 23 were junior officers between 0 to 7 years of experience. Focusing on the reasons when the bridge team being unresponsive to VTS calls: The top three category results were, 200 participants agreed *"VHF volume levels being low"*, 141 agreed *"VHF switched off"*, and 57 agreed *"Monitoring inappropriate VHF channels"*.

Having identified the possible reason for being unresponsive, let us analyse what has led the bridge team to reduce the volume or VHF being turned off or monitoring inappropriate channels? The human error for switching off VHF or monitoring inappropriate channels can be questionable as this could be termed as a failure of bridge procedures. However, what could have led to the volume levels of VHF being inadequate is spotted in the next question. Participants were asked the possible reasons for the VHF volume levels to be inadequate: 199 acknowledged *"OOW reduced VHF volume intentionally due to the excess interference caused by fishing, coastal and other vessels and forgot to increase the volume later"*. 191 believed *"OOW may not have checked the VHF volume levels before taking over the watch"*.

To analyse the common practice of VHF volume levels onboard, a question was asked to find out how often the volume levels observed onboard were inadequate? It appears that only 1 participant experienced volume levels to be adequate, whilst the remaining 207 participants experienced once or more than once VHF volume levels being low during their tenure. This is evident to know that VHF volume levels onboard are inadvertently not been given much attention.

Participants were asked if they were involved in a situation where the VTS calls were unanswered by another vessel and eventually their vessel had to take a bold action to avoid a collision or a close quarter situation. 180 have faced such a situation and most mentioned the VTS locations. Whereas 25 admitted they have not experienced it and 3 did notice the situations with other ships.

The effectiveness of VTS was also questioned and all the participants agreed the VTS has a significant role in the safety of navigation. However, it is imperative for the mariners to optimise the VTS assistance and maintain effective communication to enhance safety, particularly in coastal waters.

A conversation with the London Harbour master revealed that not answering the VTS calls from some ships is a routinely experienced phenomenon. They go unnoticed or reported as they may have escaped an accident. He further stressed unless an incident occurs, the weak link is not highlighted.

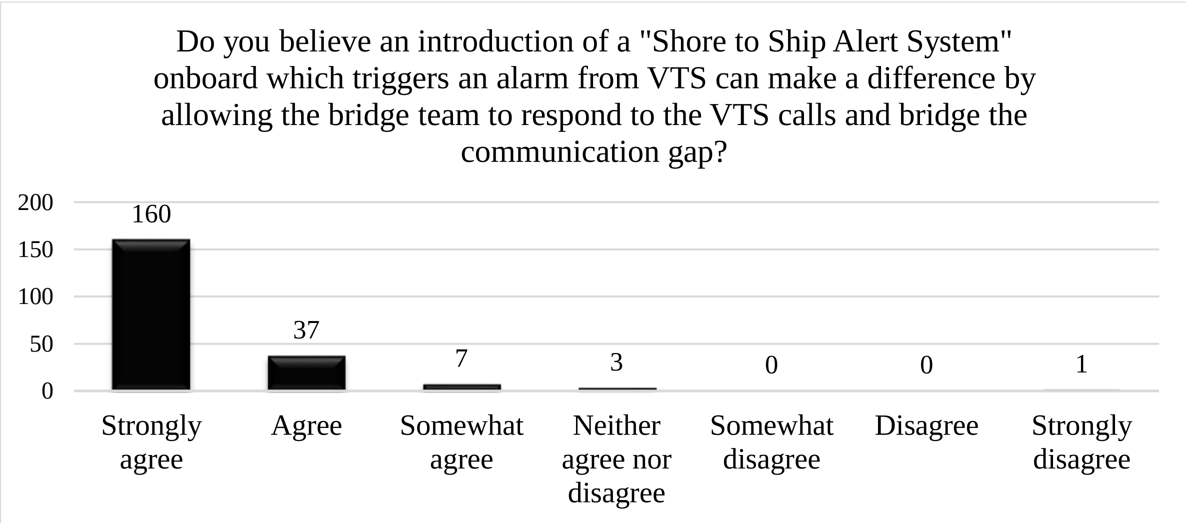
Functions of "Shore To Ship Alert System"

To ensure ships respond to VTS calls, a "Shore to Ship Alert System" could be the answer. This system intends to alert the ship from the VTS station by triggering an audio and visual alarm on the bridge in the event of a foreseeable emergency, provided the vessel being unresponsive after several attempts of VTS calls. The alarm trigger control is meant to be with the VTS centre. This system needs to be fitted on the bridge, display the VHF channel and blink as the alarm triggers on an LCD. The audible alarm is designed to be distinct from other bridge alarms. The volume levels of this system onboard need to be barred to ensure the alarm is audible when activated by VTS and to make sure the user intentionally or unintentionally does not reduce the system volume. Although in extreme situations the system can be isolated due to equipment malfunctions and to avoid alarm fatigue. However, malfunction of the system needs to be conveyed to the next port of call, owners, flag state and be rectified at the next opportunity.

A robust procedure is laid to ensure the alarm is effectively received on the bridge from the VTS. In the event, the alarm is not acknowledged, the escalating procedure is designed to achieve the ultimate goal for the vessels to respond. This is to ensure the ship crew attends the bridge and the VTS call to avoid an emergency. The alarm log is to be maintained in the radio logbook with brief notes of the VTS conversation. This equipment will be incorporated in Form 'R' of the Safety Radio Certificate.

Mariners Opinion on "Shore To Ship Alert System"

The STSAS was opinioned by the participants to know if this system can enhance the safety of navigation by allowing the bridge team to respond to the VTS calls and bridge the communication gap? 160 participants strongly agreed, 37 agreed, 7 somewhat agreed and 3 neither agreed nor disagreed and 1 strongly disagreed. Except for few participants who were unsure about the system, the remaining appeared to be positive and most of them firmly believed the new system could make a difference as displayed in the table below.



To avoid volume levels being tampered with onboard, the participants were asked if they agree about the volume controls on the alert system to be barred? 193 (93%) participants agreed, 9 were unsure whereas 7 disagreed. Once again majority have agreed to the fact that the alert volume levels remain barred.

The participants were asked if they believe the new system can assist to reduce maritime incidents around coastal areas? 194 were positive, 10 were doubtful and 4 disagreed. Nearly 93% expressed their concern and believed the new system can contribute to minimising maritime accidents.

The need for STSAS

The system is deemed to improve the communication between the ship and VTS thus enriching the safe traffic management in the coastal waters. By improving traffic management maritime accidents, ecological and maritime disasters could be avoided or minimised. Furthermore, alarm escalating from the bridge to cabins and common spaces allows the bridge watchkeeper to stay alert and provides a backup measure in case of an emergency. This system can be viewed as an alternative source of VTS communication. For instance, if the watchkeeper is unable to communicate effectively due to a language barrier, the alarm itself allows the mariner to evaluate the situation and take action to avoid an emergency. Since insurance is in inverse proportion to the risks, the insurers may offer premiums reductions. This could be an incentive to the ship owners for investing and thus advancing their commitment to safety. Although ships that respond to the VTS calls may never have to experience an alarm, however, the sole purpose of this system is to raise an alarm to those ships that fail to respond.

It could be argued that the new system installation will incur additional investment and service costs. However, this system has the potential to reduce or avoid maritime accidents and thus saving on damage claims. Another concern is, not all the coastal waters in the world may have advanced VTS equipment. Nevertheless, the basic information can be shared with the vessels to avoid mishaps. To ensure STSAS is regulated worldwide, it needs to be approved by IMO member states, which is usually a lengthy process for ratification.

In a conversation with a North Sea Pilot, when asked about the need for STSAS. He opinioned due to the additional paperwork and commercial pressure on the bridge team, the focus on safe navigation is at times observed to be compromised. There were several occasions he felt that the bridge team gets distracted due to the last-minute correspondence with the company, agents, ship chandlers etc. He further added that due to the officers being rushed to gain the certificate of competencies, the lack of experience and chronic unease is noticeable in modern times. The need for an alarm with a volume control resistant and escalating function will make a difference in the safety of navigation as this is becoming more essential these days to ensure the OOWs are reminded about any unanticipated phenomena, he added.

Conclusions

The bridge team's swift response to the VTS does not guarantee an accident-free scenario. However, it allows the navigating officers to become acutely aware of a dangerous situation that could be developing within the vicinity. Although VTS regulates the traffic, assists the ships in navigation and provides information service, this does not transfer the liability of the vessel’s safety from the ship personnel to the shore operator. The ship’s personnel remain liable for their safety as they are on sight and are deemed to take the best action to avoid an emergency.

The new system could be incorporated into the present Global Maritime Distress and Safety System (GMDSS) to utilise the present resources available onboard. Secondly, the alarm escalating process can be considered with the Bridge Navigational Watch and Alarm System (BNWAS). However, this needs to be checked and scrutinised against the equipment parameters and compatibilities. As this system needs an LCD to display the VHF channel and impose alarm volume restrictions, it could be worth investing in a small unit display in contrast to the colossal monetary and reputation loss to the ship owners.

Shipowners and management companies who take pride in themselves for maintaining high levels of safety standards and compliance will clearly see the advantage in such an alert system. However, given the stress levels, fatigue conditions and adhering to minimum manning levels on board, human error is highly likely. Complacency is another factor that may induce a lax safety culture. The vessels that make landfall are more susceptible to an accident than a vessel that is sailing in the high seas where the traffic and sea room are not a major concern.

To safeguard life, the marine environment, property and to protect the coastal waters, the introduction of a Shore to Ship Alert System is an additional measure to enhance safety. This system could serve to reduce human error and provide a method to the VTS to alert the vessel in a foreseen emergency. It is the responsibility of the ship owners, coastal states and governing bodies to ensure that they are taking every opportunity to safeguard ships in their waters to minimise accidents and provide a safe environment. The proposed system could act as a safeguard to significantly reduce accidents, marine pollution and near misses, especially in the coastal areas.

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The Interrelationship Between Coastal, Great Lakes, Inland, and Deep-Sea Freight Rates: A Longitudinal Approach

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Keywords: water freight rates, forecasting, inland shipping

This study examines freight rates in four key areas of the U.S. water freight transportation industry – coastal, Great Lakes/St. Lawrence River, inland waterways, and deep-sea shipping. The data involved in this study includes more than 20 years of longitudinal data on freight rates on all four of these sectors. The interrelationship between the freight rates is tested through forecasting methods to see if an increase or decrease in a freight rate in a given month leads to increases or decreases in other freight rates in the next month. This method assesses whether or not you can forecast one freight rate using data from another freight rate.

We find that inland freight rates are predictive of all three other freight rates, as an increase in inland freight rates is shown to lead to increases in all three other freight rates in the following month. Coastal and Great Lakes freight rates do not have any predictive power on other freight rates. However, deep sea freight rates do predict inland freight rate but at a much slower rate. An increase deep sea freight rate leads to an increase in inland freight rates after two months instead of one.

Explanations for this result may be that inland shipping is highly fragmented and competitive with more than 500 operators (Schlubach, 2019). Inland shipping also has lower barriers to entry with far less expensive vessels than ocean-going ships. By comparison coastal shipping has far higher barriers to entry than inland shipping due to much more costly ocean-going vessels and thus has fewer market participants (Rodrigue, 2020). As a result, inland shipping faces more competition than coastal shipping and thus may be quicker to adjust freight rates to meet market conditions. Other sectors such as coastal shipping have less flexibility and thus may be slower to adjust their rates to market conditions. Hence the most competitive sector, inland shipping, is the most predictive of the three less competitive sectors.

Deep sea shipping, like coastal shipping, has high barrier to entry but unlike coastal shipping this sector is involved in foreign trade and faces competition from foreign carriers. Hence deep-sea shipping freight rates may be predictive of future trends in international trade and thus may predict future trends in domestic transportation markets such as inland shipping. Implications of this study may be that maritime industry executives as well as customers of water freight transportation freight services can use inland freight rates to better predict trends in revenues and costs. Likewise, investors may be able to use inland freight rates to predict maritime stock prices. Both inland freight rates and deep sea freight rates may have potential to predict domestic and global economic trends and may improve economic forecasting accuracy.

1. Introduction and Literature Review

There has been strong interest in the academic literature on the role of ocean shipping rates as indicators of economic activity, although this has mostly been confined to the Baltic Dry Index (BDI). The BDI is a measure of global dry bulking shipping rates, and prior research has found that the BDI is a leading indicator for global stock market indices (Apergis and Payne, 2013; Manoharan and Visalakshmi, 2019, Lin et al., 2019). Other research has shown that BDI may predict GDP growth (Ghiorghe and Gianina, 2013; Bildirici et al., 2016), industrial production (Bakshi et al., 2012), or exchange rates (Han et al., 2020). The BDI has also been found to have significant interrelationships with prices of commodities such as gold (Bildirici et al., 2016) as well as iron ore (Gu et al., 2019). The BDI has also been found to be a significant predictor of ship prices (Xu et al., 2011, Ma and Sun, 2017).

Proposed reasons for the predictive ability of the BDI include the notion that dry bulk demand is a predictor of future industrial production (Lin et al., 2019; Bildririci et al., 2016). Shipping rates are also less prone to government manipulation than other indicators such as inflation and unemployment (Bakshi et al., 2012) and less prone to speculation than indicators such as stock and bond prices (Köseoğlu and Sezer, 2012). A more general reason for maritime shipping rates to be strong economic indicator includes the central role of all maritime shipping accounting for 80% of all goods shipped in global trade. (Han et al., 2020; Papapostolou et al., 2016). Hence it may be the case that other water transportation freight rates besides the BDI may also be valuable economic indicators.

Research on other water shipping rates has been extremely limited, but also show the potential of shipping rates other than the BDI to have economic forecasting value. Hsiao, et al. (2016) extend prior BDI research to include container shipping rates. They find that the BDI is a better economic indicator during an economic upturn due to dry bulk being a strong indicator of demand for raw materials, and container shipping rates to be a better indicator during an economic downturn due their role as an indicator of demand for finished goods. Similarly, Kim and Chang (2017) find that a Chinese index of global container freight rates predicts the BDI but not vice versa, again indicating that freight rates other than the BDI may be valuable economic indicators. Other research has found that clean tanker rates but not dirty tanker rates are good indicators of future economic trends (Li et al., 2018), perhaps due to clean tankers flexibility to convert to become a dirty tanker if economic conditions warrant it (Michail and Melas, 2020).

In spite of a significant amount of prior research on global ocean freight indices, there has been very little research on domestic water shipping rates. A limited number of studies have examined the domestic China Coastal Bulk Freight Index (CCBFI). This index was found to have no ability to predict the BDI (Xuying, 2009) or port activity (Jarrett et al., 2015), but some ability to predict investment activity (Gong and Lu, 2009). Domestic inland freight shipping rates have been used to predict choice of ports in Colombia (Cantilo et al., 2018) and Taiwan (Chou, 2009), but little or no research has been done on the ability of inland freight rates to predict other transportation freight rates or macroeconomic factors. In particular, little research has been done on inland shipping rates in the U.S. which has a very large inland waterway shipping sector that ships 630 millions tons annual with goods valued over $73 billion (Waterways Council, Inc., 2021). Given the size of the U.S. economy and emphasis on dry bulk in the inland shipping center, it may be the case that inland shipping rates (like the BDI) may be an important indicator of economic activity.

In summary, much research has shown that maritime shipping rates are strong economic indicators but most of this research has been done using the BDI. Some limited research suggests that global container and tanker freight rates may be solid economic indicators. Research on domestic coastal shipping has been limited primarily to China, with some research on inland shipping rates in Colombia in Taiwan. In spite of being the world's largest economy, largest importer, and second largest exporter there has been very little research on water transportation freight rates in the United States. This study will extend the work of Hsiao, et al. on the interrelationship between different global shipping rates by examining the interrelationship between shipping rates in four different sections in the U.S. water transportation market. Similar to prior studies on the BDI, we will also examine the ability of these four freight rates to predict future economic trends. This paper is organized as follows. Section 2 will provide an overview of the four water transportation sectors in the U.S. and explain why they might possess different economic signals. Section 3 will present the data, and Section 4 will present the results. Section 5 will conclude with an overview of the results along with implications and suggestions for future research.

2. Overview of U.S. Water Transportation Sectors

The four main sectors of the U.S. water transportation industry all differ greatly by size of ship, number of competitors, use of long-term contracts, and type of cargo. Coastal shipping refers to shipping along or between U.S. coasts. The primary cargo in this sector is liquid bulk, with 75% of vessels being tankers or tank barges (US MARAD, 2020). The primary routes of these tankers are from Alaska to West Coast refineries, between West Coast refineries, and from the Gulf and East Coasts to Florida.). While they are protected from foreign competition by the U.S. Jones Act, they are required to purchase U.S.-built ships which cost roughly \$190 to \$250 million and are several times more expensive than foreign-built ships (Fritelli, 2017). As a result, this is a relatively small sector with only 27 carriers.

The Great Lakes and St. Lawrence River sector is unique and consists of large fresh-water bodies populated by an aging fleet of lake freighters, some of which are 1000-foot and many are over 30-years old. This aging fleet primarily ships dry bulk, and shipping is done heavily through time charters with fixed freight rates. The cost of a U.S.-built Great Lake freighter is tough to accurately estimate since the last finished construction of a new freighter was in 1983 (Maritime Executive, 2021), but a Chinese-built lake freight was recently purchased by a Canadian carrier for around \$250 million (Tinsley, 2014). A U.S.-built freighter would likely cost considerably more indicating a high barrier to entry. This may explain why there are only 17 carriers in this sector.

The inland waterway sector is by far the most competitive of the four sectors with over 500 carriers (Schlubach, 2019). Vessel costs in this sector are far lower than a U.S.-built coastal-size ship or a lake freighter, with the cost of a U.S.-built river barge tow ship being around \$25 million (Fritelli, 2017). Not only is it the most competitive sector it is also the largest as it ships over 500 million short tons per year, more than all of the other three sectors combined. Like the Great Lakes sector, it also primarily ships dry bulk.

The deep-sea sector involves U.S.-flagged ships that ship between U.S. and non-U.S. ports. This sector is unique in that they are not required to purchase U.S.-built ships, which dramatically lowers the cost of a vessel to \$25 to \$30 million compared to the much higher cost of U.S.-built ships in the coastal sector (Fritelli, 2017). Deep-sea carriers are still required to use a U.S. crew, the cost of which are partially covered by U.S. subsidy programs. There are 21 U.S. carriers in this sector (U.S. Department of Transportation Maritime Administration, 2017), but they must compete with numerous non-U.S. carriers which makes this sector much more competitive. The primary cargo is finished goods – container ships and roll-on/roll-off ships (United States Government Accountability Office, 2018).

In summary, two of the sectors (deep-sea and inland) have lower barriers to entry and operate in more competitive environments. The other two sections (Great Lakes and coastal) are marked by high barriers to entry, long-term charter contracts, and only a small number of competitors. Each sector also specializes in one specific type of cargo – dry bulk (inland and Great Lakes), liquid bulk (coastal), and finished goods (deep-sea). Table 1 provides a summary of the four sectors.

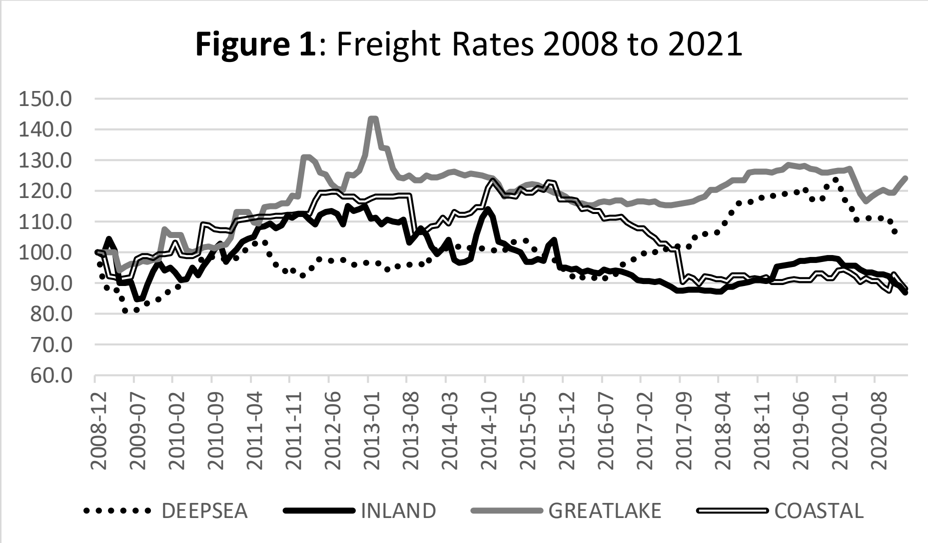
Table 1: Summary of Four U.S. Water Transportation Sectors

Sector	# of U.S. competitors	# of U.S. vessels	Freight (in million short tons, 2019)	Primary Cargo	Avg Vessel Cost***
Great Lakes	17	54	82.1	Dry bulk	Not available (none built since 1983 but likely similar to coastal)
Inland	Over 500*	39,670	502.3	Dry bulk	~$25 million
Coastal	27	~270	154.1	Liquid bulk	$190-$250 million
Deep Sea	10 U.S. ~75 foreign	84	21.2**	Finished goods (containers and vehicles)	$25-$30 million

Data from U.S. Army Corps of Engineers Waterborne Transportation Statistics except where stated.
*(Schlubach, 2019)**(Buzby, 2018, USACE IWR Pt 5, 2019), ***(Fritelli, 2017)

3. Data

Monthly freight data covering the period 12/1/2008 to 1/1/2021 was obtained from the U.S. Bureau of Labor Statistics, which publish a series of producer price indices for different modes of freight transportation. This includes INLAND, which are the freight rates for inland waterway transportation. COASTAL referes to coastal and intracoastal maritime transportation freight rates. GREATLAKES are the freight rates for transportation for the Great Lakes and St. Lawrence River. Finally, DEEPSEA is an index for freight rates for U.S. flagged ships that provide services between U.S. ports and non-U.S. ports. Figure 1 below shows the changes in freight rates over time. The rates appear to move relatively independently from each other, with DEEPSEA and GREATLAKE having a slight upward trend and the other rates having a slight downward trend. All rates are normalized at 100 for 12/1/2008.



Additional macroeconomic variables that might influence cost or demand for freight transportation was also collected. TRADE refers to total U.S. exports and imports, and the source of this data is the U.S. Census Bureau. CRUDE refers to crude oil prices, and the data was obtained from the International Monetary Fund. CPI is the consumer price index published by the U.S. Bureau of Labor Statistics. WATERTON refers to water tonnage shipped through inland waterways. Monthly GDP data is not widely available, so as an alternative measure of economic activity we chose primary industrial production (PRIMIND) which can measure demand for bulk materials. Table 2 summarizes the variables and the sources of data.

Table 2: Data Description and Sources

Variable	Description	Source
COASTAL	U.S. coastal and intracoastal freight rates	U.S. Bureau of Labor Statistics
DEEPSEA	U.S. flagged freight rates between U.S. and foreign ports	U.S. Bureau of Labor Statistics
INLAND	U.S. inland and intracoastal waterway freight rates	U.S. Bureau of Labor Statistics
GREATLAKE	U.S. freight rates on the Great Lakes and St. Lawrence River	U.S. Bureau of Labor Statistics
TRADE	Sum of U.S. imports and exports	U.S. Census Bureau
CPI	U.S. Consumer Price Index	U.S. Bureau of Labor Statistics
WATERTON	Tonnage for internal U.S. waterways	U.S. Bureau of Transportation
INDPRO	Industrial production for U.S. primary industry	Federal Reserve Board of Governors
CRUDE	Crude oil prices	International Monetary Fund

Data analysis was done using logged first differences rather than absolute levels of each variable. The first reason for this is that logged first differences lend to easier economic interpretation, as they approximate percentage changes from month to month. Thus we can assess how a percentage change in one variable can lead to a percentage change in another variable. The second reason is the Dickey-Fuller and Phillips-Perron unit root tests show that the data for all freight rates are non-stationary for levels but stationary for first differences The same holds true for PRIMIND, CPI, and CRUDE. WATERTON is the only variable which is stationary at levels for both unit roots (but also stationary for first differences). Non-stationary data can lead to spurious and unreliable results (Zivot and Wang, 2007) , so first differences are used to ensure all variables used in the analysis are stationary.

Table 3 presents the descriptive statistics for logged first differences of all variables included in this study. All four of the freight rates have similar properties, which mean and median monthly changes of close to zero and standard deviations around 0.02. The low skewness values indicate a normal distribution, but the high kurtosis values indicate that larger outliers are experienced compared to what one would expect with a normal distribution. Of the remaining macroeconomic variables, CPI and PRIMIND have lower standard deviations than the freight rates. WATERTON, TRADE, and CRUDE have considerably higher standard deviations than the freight rates with CRUDE having the highest standard deviation at 0.115 and also by far the largest range between minimum and maximum monthly changes. Overall, the variables show low average monthly changes and generally have leptokurtic rather than normal distributions.

Table 3: Descriptive Statistics of Logged Monthly Changes

	N	Mean	Std. Dev.	Min	Max	Median	Kurtosis	Skewness
COASTAL	143	-0.001	0.022	-0.112	0.091	0	12.783	-1.071
DEEPSEA	143	0	0.019	-0.097	0.045	0.001	9.298	-1.659
INLAND	143	-0.001	0.026	-0.112	0.078	0	6.695	-0.88
GREATLAKE	143	0.001	0.021	-0.068	0.104	0	11.581	1.497
TRADE	143	0.003	0.059	-0.231	0.177	-0.01	4.565	0.286
CPI	143	0.001	0.003	-0.007	0.01	0.001	3.084	-0.039
WATERTON	143	0.001	0.072	-0.249	0.2	0.002	3.555	-0.144
PRIMIND	143	0	0.016	-0.126	0.045	0.001	28.996	-3.328
CRUDE	143	0	0.115	-0.575	0.538	0.011	12.068	-0.841

Another diagnostic we perform is for optimal lag length. We use lagged values of variables in this study to examine whether past values of some variables lead to future changes in other variables. Following Liew we use two different criteria to assess optimal lag length, the final prediction error (FPE) and the Aikake Information Criteria (AIC). Both criteria suggest a lag length of three. One lag is used for the first differencing process, which leaves two lags for the regression analysis. A final diagnostic we perform is the Johansen test for cointegration (Johansen, 1995). The null hypothesis of no cointegrating vectors cannot be rejected, which suggests that it is not necessary to control for a long-term cointegrating relationship in our regression models.

4. Methodology and Results

The primary regression method used for the analysis is a vector autoregressive (VAR) model (Eroglu and Hofer, 2011; Johansen, 1988), which uses the principle of Granger causality (Granger, 1969) to determine if past changes in variables predict future changes in other variables. Granger causality starts with the assumption that future events do not predict past events, but if past events predict future events it is evidence of a causal relationship or an information flow. A VAR model with the four freight rates involves four different regressions, one with each of the four freight rates as a dependent variable. We add TRADE as an indicator of demand for transportation services as a fifth variable. The regressors for each model are identical with lagged values of each of the four freight rates. The purpose of these models is to see if past values of any of the freight rates predict future values of any of the freight rates, and allows us to assess potential directions of causality or information flows.

Equation 1 in the VAR model is:

$$\Delta lnTRADE_t = \alpha_0 + \alpha_1 \Delta \ln TRADE_{t-1} + \alpha_2 \Delta lnTRADE_{t-2} + \alpha_3 \Delta \ln INLAND_{t-1} + \alpha_4 \Delta lnINLAND_{t-2} + \alpha_5 \Delta lnCOASTAL_{t-1} + \alpha_6 \Delta lnCOASTAL_{t-2} + \alpha_7 \Delta lnDEEPSEA_{t-1} + \alpha_8 \Delta lnDEEPSEA_{t-2} + \alpha_9 \Delta lnGREATLAKE_{t-1} + \alpha_{10} \Delta lnGREATLAKE_{t-2} + \mu_t \quad (1)$$

This equation tests the predictive power of the four freight rates on the level of international trade volume. The independent variables are the freight rates and TRADE with a one month lag (t-1) and a two month lag (t-2).

The remaining question equations have identical regressors as Equation 1, but each one of them as a different freight rate. Equations 2-5 with lagged first differences of INLAND, COASTAL,

$$\Delta lnINLAND_t = \alpha_0 + \alpha_1 \Delta \ln TRADE_{t-1} + \alpha_2 \Delta lnTRADE_{t-2} + \alpha_3 \Delta \ln INLAND_{t-1} + \alpha_4 \Delta lnINLAND_{t-2} + \alpha_5 \Delta lnCOASTAL_{t-1} + \alpha_6 \Delta lnCOASTAL_{t-2} + \alpha_7 \Delta lnDEEPSEA_{t-1} + \alpha_8 \Delta lnDEEPSEA_{t-2} + \alpha_9 \Delta lnGREATLAKE_{t-1} + \alpha_{10} \Delta lnGREATLAKE_{t-2} + \mu_t \quad (2)$$

$$\Delta lnCOASTAL_t = \alpha_0 + \alpha_1 \Delta \ln TRADE_{t-1} + \alpha_2 \Delta lnTRADE_{t-2} + \alpha_3 \Delta \ln INLAND_{t-1} + \alpha_4 \Delta lnINLAND_{t-2} + \alpha_5 \Delta lnCOASTAL_{t-1} + \alpha_6 \Delta lnCOASTAL_{t-2} + \alpha_7 \Delta lnDEEPSEA_{t-1} + \alpha_8 \Delta lnDEEPSEA_{t-2} + \alpha_9 \Delta lnGREATLAKE_{t-1} + \alpha_{10} \Delta lnGREATLAKE_{t-2} + \mu_t \quad (3)$$

$$\Delta lnDEEPSEA_t = \alpha_0 + \alpha_1 \Delta \ln TRADE_{t-1} + \alpha_2 \Delta lnTRADE_{t-2} + \alpha_3 \Delta \ln INLAND_{t-1} + \alpha_4 \Delta lnINLAND_{t-2} + \alpha_5 \Delta lnCOASTAL_{t-1} + \alpha_6 \Delta lnCOASTAL_{t-2} + \alpha_7 \Delta lnDEEPSEA_{t-1} + \alpha_8 \Delta lnDEEPSEA_{t-2} + \alpha_9 \Delta lnGREATLAKE_{t-1} + \alpha_{10} \Delta lnGREATLAKE_{t-2} + \mu_t \quad (4)$$

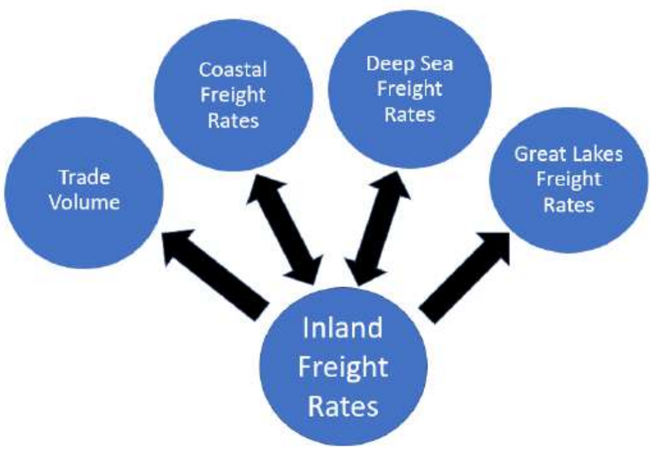
$$\Delta lnGREATLAKE_t = \alpha_0 + \alpha_1 \Delta \ln TRADE_{t-1} + \alpha_2 \Delta lnTRADE_{t-2} + \alpha_3 \Delta \ln INLAND_{t-1} + \alpha_4 \Delta lnINLAND_{t-2} + \alpha_5 \Delta lnCOASTAL_{t-1} + \alpha_6 \Delta lnCOASTAL_{t-2} + \alpha_7 \Delta lnDEEPSEA_{t-1} + \alpha_8 \Delta lnDEEPSEA_{t-2} + \alpha_9 \Delta lnGREATLAKE_{t-1} + \alpha_{10} \Delta lnGREATLAKE_{t-2} + \mu_t \quad (5)$$

Table 4 presents the results of Equations 1 through 5. The most striking result in that lagged values of INLAND significanly predict TRADE as well as all three other freight rates. DEEPSEA also significantly predicts INLAND and GREATLAKE. COASTAL significantly predicts INLAND, but GREATLAKE does not predict any of the other variables. Interestingly TRADE does not predict any of the freight rates. It appears than INLAND may be a predictor of future economic trends, include future import and export trends.

Table 4: Summary of Regression Results With Equations 1 Through 5

Regressor	(5) $\Delta lnTRADE_{t-1}$	(1) $\Delta lnINLAND_{t-1}$	(2) $\Delta lnCOASTAL_{t-1}$	(3) $\Delta lnDEEPSEA_{t-1}$	(4) $\Delta lnGREATLAKE_{t-1}$
	Dependent Variable				
$\Delta lnTRADE_{t-1}$	-0.392***	1.989	0.038	0.004	-0.0281
	(0.084)	(3.823)	(0.033)	(0.026)	(0.033)
$\Delta lnTRADE_{t-2}$	-0.119	3.473	0.011	-0.006	-0.003
	(0.083)	(3.777)	(0.032)	(0.026)	(0.032)
$\Delta lnINLAND_{t-1}$	0.004**	0.0870	0.002**	0.001**	0.001*
	(0.002)	(0.0787)	(0.001)	(0.0005)	(0.0007)
$\Delta lnINLAND_{t-2}$	-0.0005	-0.186**	-0.0001	0.00002	-0.00001
	(0.002)	(0.083)	(0.001)	(0.001)	(0.001)
$\Delta lnCOASTAL_{t-1}$	-0.155	0.554	-0.055	-0.0263	-0.011
	(0.215)	(9.811)	(0.084)	(0.067)	(0.084)
$\Delta lnCOASTAL_{t-2}$	0.187	17.41*	-0.006	-0.051	-0.075
	(0.208)	(9.519)	(0.081)	(0.065)	(0.081)
$\Delta lnDEEPSEA_{t-1}$	0.199	11.53	0.090	0.105	-0.034
	(0.274)	(12.51)	(0.107)	(0.086)	(0.107)
$\Delta lnDEEPSEA_{t-2}$	0.119	24.19**	-0.032	0.174**	0.209**
	(0.250)	(11.41)	(0.097)	(0.078)	(0.098)
$\Delta lnGREAT_{t-1}$	-0.189	-0.401	-0.009	0.096	0.111
	(0.213)	(9.734)	(0.083)	(0.067)	(0.083)
$\Delta lnGREAT_{t-2}$	0.0645	-1.075	0.153	0.030	-0.012
	(0.212)	(9.698)	(0.083)	(0.066)	(0.083)
Constant	0.006	-0.142	-0.0004	0.001	0.0011
	(0.005)	(0.206)	(0.002)	(0.001)	(0.002)
Adjusted R^2	0.127	0.056	0.072	0.028	0.006
Observations	141	141	141	141	141

Figure 2: Summary of Regression Results



For additional analysis, we include CPI, PRIMIND, CRUDE, and WATERTON as substitutes for TRADE in Equation 1 through 5 in a series of additional VAR models. This allows for an analysis as to whether or not INLAND can predict other economic indicators. Table 5 summarizes the results of these VAR models.

Table 5: Regression results with INDPRO, CPI, CRUDE, and WATERTON

	INDPRO	CPI	CRUDE	WATERTON
INLAND	n/a	INLAND (-) → CPI*	n/a	INLAND→ WATERTON**
COASTAL	n/a	COASTAL (-) → CPI*	n/a	n/a

DEEPSEA	DEEPSEA →INDPRO*	DEEPSEA → CPI**	DEEPSEA → CRUDE*	n/a
GREATLAKES	n/a	n/a	GREATLAKE← CRUDE*	n/a

The freight rate with the most explanatory power in these regressions is DEEPSEA, which significantly predicts INDPRO, CPI, and CRUDE. INLAND significantly predicts CPI and WATERTON, and COASTAL predicts CPI. Interestingly, CPI does not predict freight rate changes but three of the freight rates significantly predict CPI. The macroeconomic variables show little ability to predict freight rates, with the exception of CRUDE which significantly predicts GREATLAKE.

5. Conclusion

Overall this study finds that inland and deep sea shipping rates have the best predictive power. Inland freight rates can predict deep sea, coastal, and Great Lake shipping rates. Inland freight rates can also predict trade volume, inflation, and water tonnage. Deep sea freight rates can predict inland freight rates but not other freight rates, but it is a significant predictor of inflation, industrial production, and crude oil prices. Interestingly, the macroeconomic variables are not effective predictors of freight rates. These results suggest that freight rates may possess signals about the future direction of the economy.

Inland in particular is highly competitive with a large number of carriers and low barriers to entry, which means their freight rates can rapidly adjust to changes in freight demand. Inland also primarily ships dry bulk which is an indicator of an early stage of an economic upturn. Deep sea freight only has a small number of competitors, but unlike other U.S. flagged water transportation modes they face competition from foreign competitors. Deep sea also primarily ships finished goods in container or roll-on/roll-off ships. Finished goods represent the level of demand from consumers, which can also be a valuable indicator of future economic trends. The lack of much significant predictive ability of coastal and Great Lake freight rates may be due to the smaller number of carriers, high barrier to entry, and long-term fixed contracts which all means that these freight rates cannot quickly adjust.

A major implication of this study is that the BDI is not the only water freight rate that can be used for economic forecasting. More accurate forecasting may be achieved if inland and deep sea freight rates are included. Maritime professionals might also be able to better prepare future projections of trends in the water transportation industry by using inland and deep sea freight rates. An implication for policymakers is that while inland and deep sea transportation seem to have competive, market based freight rates, the same cannot be said for coast and Great Lake shipping. Given the large scale energy efficiencies of water transportation compared to ground or air transportation (Berg, 2016), policymakers may wish to change regulations to make these freight rates more competitive to encourage more marine shipping over less energy efficient transportation modes.

A limitation of this study is that the data is limited to U.S. shipping companies and it is not clear if the results are generalizable to other countries. Inland shipping in the U.S. is primarily limited to north/south transportation and mostly to the central and east portion of the U.S. Other regions of the world such as the European Union, Russia, and China have more extensive inland waterway networks. Coastal shipping in the U.S. is unique in that carriers are legally required to purchase domestic ships which cost two to fours times as much as the international market rate for ships. It is possible that coastal freight rates may be a better economic indicator in countries without the domestic ship purchase requirement. Thus future research should be done to see if the results from this study hold up in countries considerably different market conditions in the water transportation sectors.

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The journey towards autonomous ships and the role of seafarers in the future: a bibliographical perspective

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Abstract

Autonomous ships have become a buzzword in recent years, encouraging technological development on board systems. Many different approaches have been undertaken over the years to figure out how future vessels will look like and whether artificial intelligence (AI) will take over ship operations. There is a need to capture the progress made by the global research community in recent years and highlight trends and developments. This should be done based on an unbiased and in-depth analysis and quantitative evidence. The emphasis of this work is to provide an objective scientometric analysis based on publisher peer-reviewed articles and to contextualise the results against the competencies required for deck officers in the Standards of Training, Certification and Watchkeeping for Seafarers (STCW) Convention. The results show that the digitisation of on-board operations is focused on path planning and tracking, taking collision avoidance rules into account. However, the new concepts and possible systems are not covered by STCW requirements, and future seafarers may be overwhelmed by the new technologies.

Keywords: Autonomous vessel, scientometrics analysis, maritime research trends, STCW Convention

Introduction

The foundation of maritime education and training (MET) is the STCW code that provides a clear framework regarding the competence and the examination process of maritime personnel. The convention, in its major Manila 2010 amendment [1], is based on years of international experience and cooperation and is regularly updated by the Maritime Safety Committee (MSC), which takes the latest developments in the maritime industry into account. The competence catalogue defines the minimum training requirements for a seafarer and provides the institutions of MET with some room for interpretation in the creation of maritime curriculum. Moreover, as recommended from the International Maritime Organisation (IMO), model courses precisely define learning objectives and course structures according to the internationally familiar Bloom's taxonomy [2].

The expected changes by the digitalisation of shipping will have an impact on a seafarer's job description, with the focus on human-automation collaboration and shore-based ship operation [3–6]. It is the role of an MET institution to initiate progress and ensure the employability of future maritime professionals, whether it is the case of vocational training or the academic path.

There are a large number of literature reviews addressing autonomous shipping; however, to best of our knowledge, they do no attempt to cover the bigger picture and rather focus on a specific area, for instance, decision support systems [7], artificial intelligence [8], business models [9] and seafarer training needs [10]. Therefore, main objectives of this article are (1) to map out the main areas where progress is being made, (2) to contribute to the scientific debate and quantify research efforts and (3) to draw conclusions on the role of seafarers in the future based on progress made in key areas.

A bibliometrics research, as defined by Prithard [11], is "application of mathematical and statistical methods" for dealing with recorded values. The analysis is based on the co-occurrence of distributions and bibliographic coupling derived from data such as keywords, citations and references of the extracted research publications. Emphasis is placed on bibliometric coupling to define the main underlying topics of future automation and recent development. The results of the analysis stretch to a holistic view of future seafarers' future competencies and skills as a step to evaluate the conformity of the STCW code. The scope considers newly evolving shore-based professions and possible adaptive positions for personnel with seafaring experience.

Research Methods

For the purpose of this study, data was obtained from Web of Science (WOS) on the 1st of January 2021. It is one of the major bibliometric databases [12]; inclusion of other catalogues was considered but discarded due to comparability and stability of the statistics obtained from different sources, for instance, abbreviation of sources, categories and number of citations. By using the search terms listed below in the title, abstract and keyword, the query was kept straightforward while allowing for a very broad search. Associated additional terms such as Shore Control Center (SCC) and Shipping 4.0 were not included, as an initial query revealed that articles directly related to autonomous shipping contain some of the terms in the abstract, title or keyword, which are expanded by additional terms not included in the search query.

TITLE-ABS-KEY (autonomous AND vessel OR autonomous AND shipping OR autonomous AND ship* OR unmanned AND ship* OR unmanned AND vessel*)*

Data cleaning is divided into two parts, as shown in Figure 1. Based on the general wording of the query in the first stage, we evidently removed unrelated research areas, languages other than English and entries based on keywords in the title. Thus, peer-reviewed publications in English that were directly related to autonomous ships and published between 1990 and 2020 were filtered. This was done by a semi-automatic script (i.e., rows were removed based on predefined criteria). In the second part, the results of the included and excluded articles were verified by the authors, a further reduction based on the article abstracts.

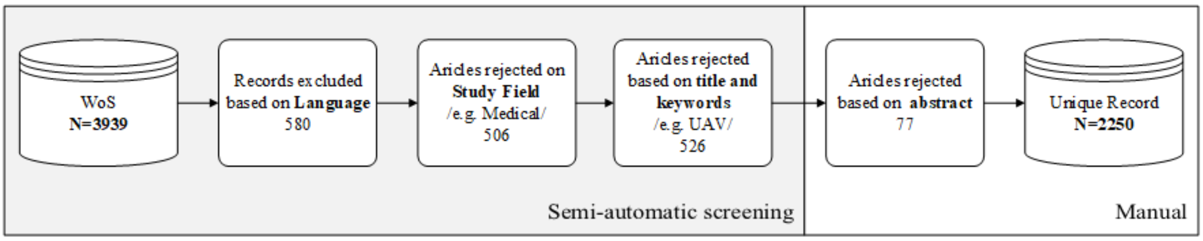

Figure 1. Data pre-processing steps showing the total number of included and excluded articles

The raw data were processed in bibliographic software: (1) BiblioTool 3.2, for the creation bibliometric maps [13], and (2) ScientoPy, for a scientometric analysis [14]. As described below, bibliographic coupling is based on the similarities in the references/links shared by any two articles. This does not provide a direct view of trend development, whereas a frequency-time distribution, as proposed by Ruiz-Rosero et al. [14], offers a measurable result derived from relative and absolute growth indicators. Both tools have been proven in numerous large-scale studies on bibliometric analysis [15]–[18]. Hence, this research firstly exhibits a sequential analysis to identify trending topics based on growth indicators, and secondly, it presents a science map to describe the structure in the field of autonomous shipping, whereby we use the results to interpret the future competencies for virtual seafarers.

In the "Results" section, initially, we present an analysis of the bibliometric variables based on all 2250 publications, which provide information on:

- Country and institute frequency: to define the main contributors in this field

- Average growth rate (AGR), average documents per year (ADY) and percentage of documents in last years (PDLY) as indicators for topics that gained momentum in the past years

AGR (Eq.1), ADY (Eq.2) and PDLY (Eq.3) are the indicators required to estimate the relative and absolute growth of an item within the corpus, where, for the temporal analysis, the user defines start(Y_s) and end(Y_e) years that are compared to the numbers of documents per year(P_i) or in relation to the total numbers of documents (TND). Ruiz-Rosero et al. [14] apply the following reckonings methods:

$$AGR = \frac{\sum_{i=Y_s}^{Y_e} P_i - P_{i-1}}{(Y_e - Y_s) + 1} \, (1) \quad ADY = \frac{\sum_{i=Y_s}^{Y_e} P_i}{(Y_e - Y_s) + 1} \, (2) \quad PDLY = \frac{\sum_{i=Y_s}^{Y_e} P_i}{(Y_e - Y_s + 1) * TND} \, (3)$$

The development of the concept of autonomous vessel has gained momentum in the last decade. We, therefore, further considered bibliographic coupling to be convenient; its main advantage is that it can detect even weak signals (new articles without citations) [13], [19], [20]. As Equation 4 shows, a bibliographic link between two publications is created if they jointly cite a third (it all depends on which publications are in the bibliography of the articles). In this respect, clusters are formed based on the similarity of the article citations, according to Kessler's [21] omega value, defined as shared references $(R_i \cap R_j)$, divided by the square root of the product of all references (Eq. 4). Therefore, the more common references two articles have, the higher the omega value and the more likely they are to be placed in the same cluster.

$$\omega_{i,j} = \frac{|R_i \cap R_j|}{\sqrt{|R_i| \times |R_j|}} \, (4) \qquad \sigma = \sqrt{N} \frac{f - f_0}{\sqrt{f_0(1 - f_0)}} \, (5)$$

The omega similarity value quantifies the relationship between the articles, as it expresses the link weight between two objects. Grauwin [13] adopts the Louvain algorithm to find partitions based on the Newman-Girvan modularity function, which is widely used to detect communities in a complex system. The algorithm is using a greedy optimisation for identifying the maxima of modularity, which is further enhanced by a hierarchical refinement [22]. Roughly, it indicates the density of links (in our case references) within communities in a ratio to the total number of edges in the corpus, expressed as a scalar value between -1 and 1 [23]. As suggested by Grauwin [13], the characterisation of the communities can be indicated based on the significativity (σ) of an item, by comparing the frequency distribution of an item (f) in the cluster to the overall item frequency in the corpus (f_0), normalised as shown in Equation 5.

Results

A total of 2,250 articles related to autonomous shipping were identified, where we count autonomous underwater vehicles (AUV), autonomous survey equipment or, in fact, just about any autonomous floating object related publications. Consequently, the top 10 countries and academic institutions in the corpus are shown in Figure 3 and Figure 4. Some inferences on the curiosity of autonomous shipping, especially in China, Norway and Poland, are clearly visible. These countries have published more than 40% of the articles included in the corpus since 2019 on this topic than in previous years.

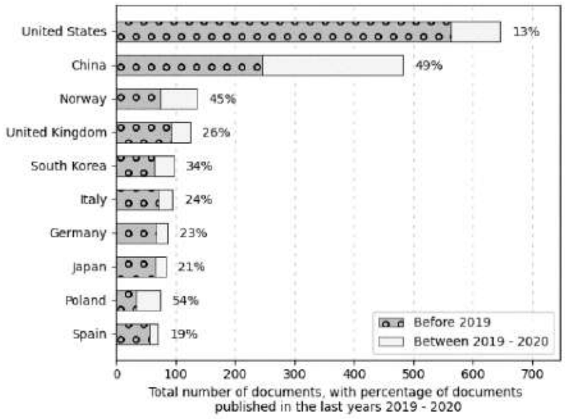

Figure 3. Top 10 contributing countries compared to the percentage publish article since 2019

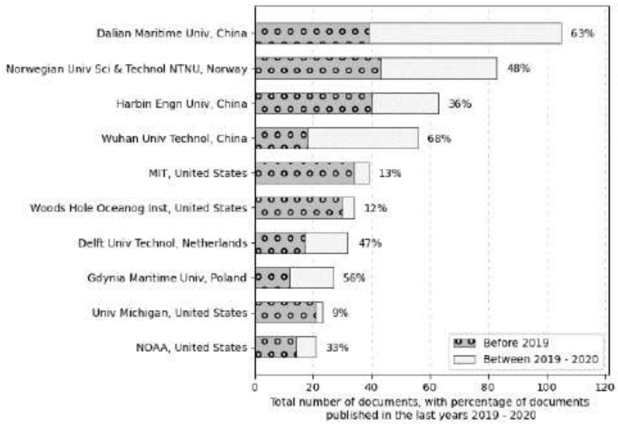

Figure 2. Top 10 contributing institutions in relation to the percentage of documents published since 2019

The detection of trending topics shown in Table 1 are based on authors' keywords, where we have identified the top 10 topics using the indicator $PDLY$ greater than 60% and AGR greater than 2. The excluded keywords are *SHIP, VESSEL, SYSTEM* because they do not convey a direct indication.

Table 1. Trending topic according to the absolute and relative indicators

Author's Keyword	N	AGR	ADY	$PDLY$
collision avoidance	65	7.5	19	58.5
neural network	41	2.5	11	53.7
sliding mode control	27	2.5	9	66.7
MASS	17	4.5	8.5	100
input saturation	14	3	6	85.7
Uncertainty	13	2.5	5	76.9
Maritime safety	9	2	3.5	77.8
Deep reinforcement learning	8	2	4	100
Trajectory	7	2.5	3	85.7
Heuristic algorithm	6	3	3	100

With the aim of understanding the structure of a research subject more efficiently, we applied cut-off points to select the most interconnected, in this sense, representative articles. The bibliometric-coupling network is constructed by connecting pairs of publications that share at least 3 references and exhibit greater than 0.050 Kessler similarity. From the dataset of 2,250 publications and 54,374 references in total, we were able to find 985 publications that met the criteria. Further defined is that a main cluster should consist of at least 25 publications and the sub-clusters should consist of at least 5 publications. Based on these criteria, the Louvain algorithm categorises 7 main clusters and 37 sub-clusters. In this article, the main clusters are presented, while a comprehensive and interactive summary of the results can be found at https://maritime-research.gitlab.io/iamu/. Henceforth, the corresponding network structure for the remaining corpus is: average links (k) of 13.46, the density of links ($d = 2k/(N-1)$) of 0.027 and the internal modularity(Q_i) of 0.626 for the corpus. Additionally, the average publication year (PY) and the average age of the references in the cluster (A_{ref}) provide information about the freshness of a cluster. Table 2 delivers a summary of the statistical results.

Table 2. Quantitative characteristics of the top 7 clusters

Main Clusters	N	k	d	$\omega_{in} * 10^{-3}$	Q_i	PY	A_{ref}
All	*985*	*13.46*	*0.027*	*0.857*	*0.626*	*2015.42*	*8.59*
Collision Avoidance	171	10.56	0.124	7.382	0.428	2017.56	9.02
Neural Network	129	25.41	0.397	23.153	0.248	2018.21	6.63
Tracking Control	109	15.85	0.294	24.885	0.322	2012.29	9.64
STPA	69	9.91	0.292	13.978	0.280	2018.64	7.48
Path Following	58	17.86	0.627	43.895	0.251	2017.50	7.40
Visual Inspection	57	6.11	0.218	17.243	0.536	2013.04	8.99
Object Detection	47	4.47	0.194	14.268	0.489	2018.40	7.80

Furthermore, Figure 5 offers a graphical representation that provides a thematic overview of the connectedness between the clusters (edges). The central role in the corpus is taken by the “Collision Avoidance” cluster and its connection between all clusters. It can be reasoned that the “Collision Avoidance” cluster may be regarded as the most influential in terms of connectivity and essential for the progress in autonomous shipping. In addition, the “Path Following”, “Neural Network” and “Tracking Control” clusters have stronger interconnectivity (shared references) compared to the other clusters. “Visual Inspection” is more remote and shows minimal connectivity to the other clusters.

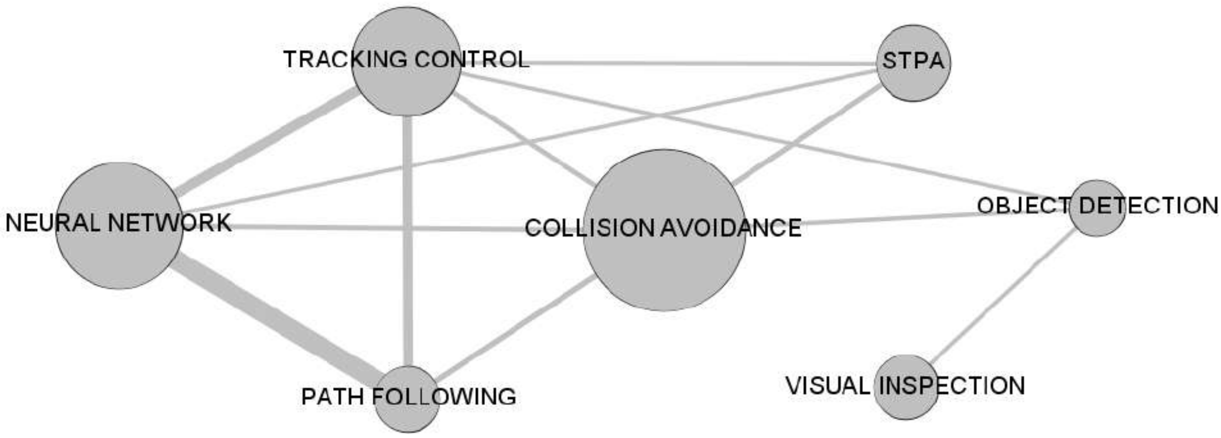

Figure 4 Main clusters identified in the corpus, where the circles are proportional to the size and edge thickness proportional to the similarity of two topics

“STPA” and “Object Detection” are connected to the largest cluster but have low connectivity to the other clusters. However, they can be considered as new areas of exploration in terms of both size and average publication age.

The largest cluster dealing with autonomous operation includes 171 publications. Based on the most significant keywords, namely *COLLISION-AVOIDANCE* ($\sigma = 10.73$), *COLREGS* ($\sigma = 9.44$) and *PATH PLANNING* ($\sigma = 8.36$), the research focus within the cluster lies in providing suitable options for adaption of the collision avoidance rules in autonomous shipping. The People’s Republic of China is represented within the cluster with a participation of 38.01% and significancy of 5.01, followed by the USA, represented with 13.45% participation and significancy of -4.77, indicating that the country is more active in other clusters; Norway and UK present 11.70% participation and significance of 2.88 and 3.20, respectively. Table 3 exhibits the five most representative articles for the clusters, where in-degree (d_{in}) represents the number of publications in the cluster that are linked to the article. Therefore, researchers are actively working to define sustainable solutions for target tracking and motion prediction, collision detection and risk evaluation of alternative paths, and conflict resolution, to execute a collision-free solution [24].

The second largest group, “Neural Network”, consists of 129 publications. The most active countries are the People’s Republic of China with 83.72% participation with significancy of 16.89, followed by Australia with 6.20% and 2.34, USA with 5.43% and -6.13 and Iran with 3.88% and 4.84. In this cluster, we identified five sub-clusters with most significant keywords as extended state observer, trajectory tracking, formation, prescribed performance and dynamic surface control. The cluster shows some similarities with the first cluster in terms of keyword and research direction, but articles are more focused in trajectory tracking, AUV and coordinated path tracking of multiple autonomous vessels. It is noteworthy that the bibliographic linkage is based on the similarities of references and the dominance of one country that may form an independent cluster, as researchers are more familiar with past research from their home country.

The third largest cluster identified in the corpus, “Tracking Control”, consists of 109 publications. The most significant keywords are: *BACKSTEPPING* ($\sigma = 5.96$), *UNDERACTUATED SYSTEM* ($\sigma = 5.81$) and *TRAJECTORY TRACKING* ($\sigma = 4.30$). The most represented countries in this cluster are the United States with 36.70% participation at a measured significance of 1.48, followed by the People’s Republic of China with 33.03% participation at a significance of 2.75 and Canada with 11.01% participation at a significance of 4.93. The research interest within the cluster is mainly focused in motion controls such as cascade control, backstepping, sliding mode and parameter estimation. The researchers’ proposals go beyond the Nomoto model introduced in 1957 [25], which is commonly incorporated into technical navigation curricula. The average publication year for the cluster is 2012, which can be seen as the birth of advance control and automation ideas.

The fourth cluster, in the evaluation identified *STPA* as the most significant keyword, followed by *STAMP* ($\sigma = 8.60$) and *SAFETY OF TRANSPORTATION* ($\sigma = 7.44$). In this cluster, Gdynia Maritime University, Aalto University and Norwegian University of Science and Technology NTNU are the main contributors to the safety evaluation of the new technologies. At the country level, it is Norway with 30.43% at a significance of 8.22, Finland with 18.84% at a significance of 10.53, China with 18.84% at a significance of -0.65, followed by Poland with 17.39% at significance of 6.36. Research efforts are focused on evaluating safety issues related to the adaptation of autonomous technologies and human-autonomy collaboration. Besides, the articles are offering view on possible human or software failure.

The fifth cluster, “Path Following”, contains 58 articles that address challenges related to taking path control and following it. The cluster is similar to “Tracking Control” and explores further scenarios, such as model predictive and adaptive controls. Further, a comparison between the average publication year of the group in 2012 and 2017 shows that this is a newly formed group in which more hypotheses and propositions are explored. The emphasis here is on the practical application of the line of sight

(LOS), control law and exposure to various parameter uncertainties and unknown time-varying external disturbances. It is predominated by China, which contributes 70.69% of all articles with measured significance of 8.92, followed by Norway with 15.52% and significance of 2.87 and Portugal with 10.34% and significance of 3.86.

The cluster "Visual Inspection" focuses on acoustic navigation, localisation and autonomous research sensors for oceanography or archaeology. The next most representative keywords are: *SENSOR COVERAGE* ($\sigma = 8.26$), *VISUAL MAPPING & SLAM* ($\sigma = 6.74$) and *INFORMATION GAIN* ($\sigma = 6.74$). The following countries are more active in the cluster: USA with 66.67% participation and significance of 6.00, Australia with 14.04% participation and significance of 5.14 and South Korea with 12.28% participation and significance of 2.84. As shown in Table 2, the average publication year for the group is 2013, and it is not strongly connected to the other clusters. However, certain parts of the research are relevant to autonomous vessel, for instance, relative positioning such as long-baseline (LBL) systems, motion reference unit (MRU), visual simultaneous localisation and mapping (SLAM), sonars and photometric. In terms, the cluster relates to AUV and survey methods, which, in the past, proved to be probably the most valuable entry points of autonomous maritime technology, as such works tend to be labour intensive, repetitive and operational cost are high. The use of those sensors is currently not covered by the mandatory part of STCW but in the external offshore industry-recognised learning route for dynamic positioning operator (DPO).

The cluster "Object Detection" has 47 publications. The most significant key words are related to image processing and shapes. The leading contributing countries in this field are China with 36.17% and a significance of 2.32, followed by South Korea with 19.15% and a significance of 4.85 and Norway with 14.89% and significance at 2.41. The cluster is in relation to the other cluster "relatively new" ($PY = 2018.40$) and has publications that mainly describe methods for image processing and ship detection in terms of multi-sensor fusion and deep learning (image classification). Moreover, it is the cluster aiming to cover the requirements of lookout in satisfaction of the current international legislation. Here, we have the case of technology that is not covered by the STCW standards.

Table 3. Most representative publications in the clusters

Main Clusters	d_{in}	Times Cited	Publication Ref
Collision Avoidance *(N = 171)*	79	22	Huang YM, 2020, SAFETY SCI (121) [24]
	50	2	Guardeno R, 2020, J MAR SCI ENG(8) [26]
	47	24	Polvara R, 2018, J NAVIGATION(71) [27]
	46	0	Huang YM, 2019, OCEAN ENG(173) [28]
	43	22	Singh Y, 2018, OCEAN ENG(169) [29]
Neural Network *(N = 129)*	78	2	Peng ZH, 2019, OCEAN ENG(191) [30]
	67	16	Liu L, 2019, OCEAN ENG(171) [31]
	65	17	Liu L, 2019, IEEE T NEUR NET LEAR(30) [32]
	64	0	Liu L, 2020, OCEAN ENG(209)
	62	16	Peng ZH, 2018, IEEE T CONTR SYST T(26) [33]
Tracking Control	69	192	Liu ZX, 2016, ANNU REV CONTROL(41) [34]
	69	51	Ashrauon H, 2010, P AMER CONTR CONF() [35]

(N = 109)	59	109	Yu R, 2012, IET CONTROL THEORY A(6) [36]
	54	2	Kim K, 2013, MED C CONTR AUTOMAT() [37]
	51	4	Ashra uon H, 2015, P AMER CONTR CONF() [38]
STPA	40	4	Fan CL, 2020, OCEAN ENG(202) [39]
(N = 69)	33	1	Wrobel K, 2020, SAFETY SCI(129) [40]
	28	6	Zhang MY, 2020, SAFETY SCI(130) [41]
	27	0	Ventikos NP, 2020, SAFETY SCI(131) [42]
	25	32	Wrobel K, 2018, OCEAN ENG(152) System [43]
Path Following	38	6	Xu HT, 2019, OCEAN ENG(194) [44]
(N = 58)	38	1	Li MC, 2019, IEEE ACCESS(7) [45]
	37	0	Xu HT, 2020, EUR J CONTROL(53) [46]
	35	1	Wan LL, 2020, OCEAN ENG(205) [47]
	35	0	Yao XL, 2020, NEURAL COMPUT APPL(32) [48]
Visual Inspection	24	116	Hover FS, 2012, INT J ROBOT RES(31) [49]
(N = 57)	21	3	Hong S, 2019, J FIELD ROBOT(36) [50]
	19	97	Kim A, 2013, IEEE T ROBOT(29) [51]
	16	31	Johnson-Roberson M, 2017, J FIELD ROBOT(34)
	11	13	Ozog P, 2013, IEEE INT C INT ROBOT() [52]
Object Detection	15	1	Huang ZJ, 2020, COMPLEXITY (2020) [53]
(N = 47)	15	0	Lin W, 2019, LECT NOTES ARTIF INT(11741) [54]
	10	12	Farahnakian F, 2020, REMOTE SENS-BASEL(12) [55]
	10	0	Han J, 2020, J FIELD ROBOT(37) [56]
	9	1	Chen ZJ, 2020, SAFETY SCI(130) [57]

When it comes to making sense of the outcomes of above clusters from the educational perspective and the role of future seafarers, there are some significant areas to mention:

- The trending topics in Table 1 suggest that the research focuses on components of automation, such as machine learning, system identification and safety and collision avoidance solutions. Although the STCW code states the paramount importance of safety and collision avoidance, systems theory or machine learning are foreign words for the code and navigators. Yet, competences of understanding these concepts seem relevant, not only for a future of automated vessel environment but also in understanding today's bridge systems.
- The largest cluster "Collision Avoidance" shows that main focus is put on collision avoidance in autonomous systems through tracking, detection, risk assessment of the alternatives and execution of all interconnected actions. The results of all these actions do heavily depend on

commercially available sensors in conjunction with on-board computers. Most importantly, it includes limitations and strong assumptions, such as limitation of the scenarios, constant velocity of the target and simplification of the ship dynamics [27], [55]. This triggers the development of ship motion models, probability risk estimators and fuzzy methods among many other design elements. The STCW code requires navigators to have *"Thorough knowledge of content, application and intent of the International Regulations for Preventing Collisions at Sea, 1972, as amended"* [1] (*STCW* - A-II/2 and A-II/3 for Watchkeeping). Clearly, the future requires more than this, as we are talking about a level of autonomy where the officers are present onboard, but most of the operations are being conducted autonomously, in an environment where there is a remote operator involved in the operation whenever it is deemed necessary. It remains unclear, for the moment, to what extent an officer onboard or an operator in a remote control centre (RCC) must be familiar with the operation principles of the above-mentioned systems.

- The cluster "Path Following" shows the focus of more complex path tracking and makes it clear that, for example, the steering control goes beyond the standard autopilot setup, such as with a proportional-integral-derivative (PID) controller (STCW Table AII-3).
- The "Visual Inspection" cluster refers to *"ability to operate safely and determine the ship position by use of all navigational aids and equipment commonly fitted on board the ships"* (STCW A-II/3); however, the term *'commonly fitted equipment'* seems to become obsolete.
- When it comes to the cluster of "Object Detection", we talk about a technology that is not covered by the STCW code. It is worth mentioning that this cluster aims at covering the requirements of lookout to satisfy the current international legislation.

In summary, the results show that certain areas of good seamanship such as path planning (voyage planning), path tracking (voyage monitoring) and collision avoidance are covered by research articles. Most importantly, the necessary onboard sensors and systems for autonomous or highly automated operations are not within the scope of the mandatory STCW standards. In recent years, newly developed methods for risk assessment have been proposed, with an overview on potential hazards regarding human-machine interactions. Although studies indicate that personnel on board or ashore need to be trained accordingly, and the tasks of SCC are considered from many angles, it remains unclear which skills need to be trained internationally and to what extent. To our knowledge, few publications address the integration of new technologies into MET and provide initial assessments of potential overall improvement [58]–[67]. A clear conclusion from these studies is that the future challenges for seafarers are to have the traditional seafaring knowledge, but also to be flexible and constantly adapt to new technologies through lifelong learning. Emad et al. [67] point out that "…the availability of qualified lecturers who are able to provide the required training" is another issue and that MET institutions need to strengthen their human resource strategy.

In this paper, we used 2,250 articles for evaluating the research effort and created a bibliographical map of most interconnected articles. Based on the results, we found many areas of STCW competences without coverage: provide medical care on board, handling emergency situations, leadership and managerial skills, monitor and control compliance with legislative requirements, control stability and stress, asses reported defects, plan and ensure safe loading, stowage and securing of cargo, and coordinate search and rescue (Table A-II/2). Thus, one of the questions arising is how the manning of a vessel can be reduced or a vessel can be remotely controlled, by ensuring the complete coverage of the current vessel operation requirements. Therefore, we consider that the education of seafarers and the occupation itself will remain relevant for the future. Nevertheless, the concept of the education needs to be more dynamic; the mindset of the seafarers needs to adapt to this dynamic environment.

The objective of this paper is to spot challenges faced by maritime training institutions in preparing seafarers of the future. As highlighted by Sharma [59], the advent of new technologies brings the need to educate seafarers with new technical and non-technical skills. Our study confirms that a large portion of technological development is not being covered, and seafarers may be overwhelmed when trying to understanding the new technologies. It is becoming clear that courses such as maritime data science, where the term itself implies an undergraduate education in mathematics, probability, statistics, machine learning and programming skills, may become an essential part of future maritime operations and one of the prerequisites for serving as an operator onboard or ashore. In this sense, advanced education in computer science and its integration into current maritime education standards may not be possible, particularly in vocational training.

Understanding the principles of technology and components of the system is one side of the coin; the other side is gathering the cognitive skills to be able to not only apply, analyse and evaluate the decisions made by a machine but also to question these decisions. Overreliance on technical equipment has been and still is a major issue within ship operations, and has been proven by numerous accident investigation reports [68]. Seafarers already tend to be overwhelmed by the existing technology. A good and recent example to this is the introduction of the electronic chart display and information system (ECDIS) onboard and the evolvement of the same technology to this date. At the very beginning, there were serious issues with design and user-friendliness. This is showing a positive trend recently; however, accident reports still recognise wrong ECDIS settings or untouched settings for months. Therefore, the partly neglected research subjects—human-machine interaction in a more automated-environment, adaptation to technologies and creating a true understanding of what technology does and what it does not—seem to be the key issues to explore further.

Conclusions and Limitations

One of the limitations and, at the same time, strength of the study is the use of exclusively scientific literature, where the projects, such as newly adopted test field, regulatory changes, ready to use equipment and system from manufacturers, are not considered. Another limitation is that bibliographic cross-linking between multiple databases is impractical for credible analysis of article references, and in this work only the largest identified dataset on autonomous shipping, namely WoS, was used.

The results show the known facts about how interest in the topic is growing and maritime institutions have become very active in research in the recent years. The focus of the research in the field still lies in path planning and following it. Wróbel et al. [40] note that the vast majority of research focuses on the technical aspects and that other aspects such as social, legal or organisational factors are still characterised by uncertainty, which is, once again, confirmed by this study.

The systematic approach in this paper allowed us to convey the results into discussions of the possible need for change in a seafarer’s job description and emerging competencies. The sustainable future as a profession and how the rapid technological development will affect the future of the maritime professions and, therefore, MET were pointed out. Many maritime universities are providing the education at bachelor’s level that ensures a level of content beyond the minimum requirements set by the STCW. It is worth reviewing the scope of the curriculum as early as possible to take steps towards preparing seafarers for a more complex environment, no matter how unclear certain parts of the development with regards to technology, legislation and organisation are.

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The new trend of maritime transport and job opportunities

Abstract:

Maritime transport for over decades now has demonstrated to be the world's largest mode of transport, transporting about 90% of global trade volume and providing the cheapest freight option to shippers. The maritime industry has long been acknowledged as one of the greatest pillars of the world's economy that contribute significantly towards economic growth and social development by linking businesses and market centers globally. Maritime transport over the years has been undergoing series of transitional changes and stages which are believed to be driven by the objective of International Maritime Organization and port users. Technological advancement in the maritime industry has caused tremendous improvement in maritime transport helping to improve issues of environmental, social and economic concern that has been a bottom neck to the industry and authorities. The current trend of maritime transport has caused a significant change in port operational settings with a resultant effect on port logistics and supply chain system. These changes are said to be accompanied by new business and job opportunities. Recent literature suggest that very few studies have been conducted focusing on the new trend of maritime transport and it associated job opportunities. The research gap makes it needful for this study to be conducted to examine the new trend of maritime transport and the available job opportunities for maritime professionals. This study adopt the use Partial Least Square Structural Equation Modeling (PLS-SEM) in examining the model and to establish a positive relationship between new trend of maritime transport and job opportunities. The exogenous variables (including green maritime transport, new capacity, formation of alliance, and green port practices) and the exo-endogenous variable (thus, emergence of technology) were used to examine their predictive relevance on job opportunities (endogenous variable). The rationale behind the use of the PLS-SEM model is it great ability to handle relatively small data. It is also said to be suitable for theory development. Again, the software is robust in nature and has high predictive relevance. The model of the study was assessed by examining the measurement and the structural model. Consequently, the findings of the study highlight on the current trend of maritime transport and it associated job opportunities. It also provide a hint to maritime authorities and investors on the new direction of maritime transport and key areas that can be invested in for business and profitable gains. Again, it serves as a guideline for maritime professionals on how to organize themselves to embrace these new developments for a brighter opportunity and career development.

Key word: Green maritime transport, new capacity, formation of shipping alliances, green port operations, emergence of technology, and job opportunities.

1. Introduction

As mariners always say “sea never dry”, the maritime industry has always been the focal point and the prime sector on which most industries and individuals dwell and secure their source of livelihood and existence. Maritime transport for over decades has strived to maintain its supremacy and dominance over the stiff competition given to her by other modes of transport including air, rail, and road transport. According to UNCTAD (2020), maritime transport transported 11.08 billion tons of world’s freight in 2019 but recorded 4.1% drop down in 2020 due the Covid-19 pandemic. The rise in demand for maritime transport is due to it resilient ability to offer the cheapest and cleanest mode of transport (by cargo volume) and providing an agile, safe, and reliable transportation network that promotes economic growth and development (Sanchez-Gonzalez et al., 2019). Despite the industry’s impressive support to international economic status, most of its associated operations depredate sustainable development which calls for strategic measures and plans to be deployed. In response to this, the International Maritime Organization (IMO) has mandated all maritime stakeholders to adopt and deploy sustainable measures in their operations. In support, various forms of conventions, treaties, and protocols have been enacted and adopted by IMO to help with these enforcements. Also, the implementation of the 17 sustainable development goals (SDGs) by the United Nations serves as a useful guide to these institutions. The intent by IMO as a keynote objective to enhance economic, social and environmental performance within the maritime industry has gradually given maritime transport a new focal lens. Excessive competition and the zeal by shipping lines to achieve competitive advantage (thus, being is a pole position to capture a larger market share) has as well contributed significantly towards the current new trends of maritime transport. For the purpose of this study, the current trends of maritime transport include; green maritime transport (GMT), emergence of technology (ET), new capacity (NC), formation of Shipping alliances (FSA), and green port operations (GPO).

Green maritime transport (GMT) parenthesis the adoption of environmental friendly measures by water vehicles in cargo transport. Statistics reveal that, maritime transport is the greatest contributor of environmental pollutant among the various modes of transport. Carbon component emitted into the atmosphere by a single vessel is equivalent to emission by 12000 road vehicles (Graham, 2007). Other forms of marine pollutant include oil spillage, discharging of ballast water, untreated sewage, garbage, etc. These marine pollutants when been introduce into the environment have it adverse effect on humans. In this regard, the need for sustainable maritime transport measures becomes very crucial for adaptation. To enhance this, IMO and other parties including the Clean Cargo Working Group (CCWG) and environmental NGO's have worked solidly towards the institution of certain fundamental green shipping policies (Coady et al., 2013). GMT policies include the use of energy-efficient fuel, green ship design, container transport, eco-generators, and other forms of enveironmental friendly means (Maringa, 2015; Psaraftis, 2016). The adaptation of these measures is believed to have gotten significant social, economic and environmental impact on stakeholders operations and businesses.

Advent of technology (artificial intelligence) has emerged so strongly in recent days maritime operations. Artificial intelligence is gradually replacing manpower activities within the maritime industry in key areas such as onboard the vessel, shipyards, seaports and port logistics systems. The ET in maritime transport has helped to cause a tremendous improvement on vessel design, work rate, safety and security, and efficiency. The introduction of technology in contemporary seaport operations has helped to enhance the competitiveness and the quality of services offered by seaports. For instance, digital information sharing and automation of certain aspect of port operations has made Tuas port of Singapore very competitive (Heilig et al., 2017). On the other hand, the introduction of technology in the maritime sector has resulted in a serious issue of redundancy as most operations are now fully automated. The use of robotics and other forms of artificial intelligence (AI) are generally considered to be more efficient and feasible compared to human hence maritime operation much more efficient and convenient (hence the future trend for maritime transport)

Maritime transport has experienced a rapid growth in capacity of marine transport vehicles over the past three decades. The size of merchant vessels continues to increase drastically as trade volume increases. Linear shipping has witnessed a steady growth from 8000TEUs in late 1990s to 24000TEUs in 2020. The desire to achieve economies of scale has made it possible for the latest container vessel to transport four times same cargo transported by the biggest container vessels in the late 1990's hence given linear shipping more hope for future prosperity (Parola et al., 2016). According to Notteboom et al. (2017), increase in capacity of marine vessels has contributed substantially towards the control of greenhouse gas effect and the minimization of maritime transport cost. Subsequently, the introduction of mega fleets into the active supply vessels has caused drastic change in port operational settings where mega vessels only calls at very few and limited major seaports across the globe to undertake cargo operations whereas feeder vessels connect to smaller ports. This has actually intensified port logistics system hence calling for the integration of port centric logistics system where wide range of value-added services are provided.

Again, maritime transport has evolved so strongly in recent times that the formation of shipping alliance (FSA) has become a common practice in linear shipping. Shipping alliance is defined as a group of shippers (carriers) with a common interest who come together under one management to have a full control over their shipment in terms of rate, sailing route, and transit time. There are various types of shipping alliance but the most predominant types include the 2M, Ocean Alliance, and THE Alliance. The main objective for the FSA is to provide members to the group a competitive advantage over their competitors (Fusillo, 2006) and enhancing capacity sharing, marketing, cost minimization and profit maximization, and vessel management of the group (Hirata, 2017; Panayides and Wiedmer, 2011). A report by Alphaliner's ranking suggest that the formation of these three shipping alliances has coincidently influenced about 80% of the global container market share in 2017 (thus, 2M-2.1million TEUs, Ocean Alliance- 3.8 million TEUs and THE Alliance- 3.5 million TEUs). Such alliances are usually formed to secure global cooperation on main and major trading routes across the globe (Europe– the Far East, Transpacific, Transatlantic).

Lastly, green port operation (GPO) is discovered as one of the current trends ongoing in the maritime industry. A seaport is a very important node in maritime settings which connects both on-shore and off-shore operations. Most often than not, most seaports operate with less regards to environmental concern. Emission from ships, trucks and pollution from cargo operations exposes the marine environment to harmful substances which are very detrimental to human health and safety. The IMO has therefore charged authorities of seaports to adopt green port practices in their daily operations. In support, various forms of green port practices including emission minimization, waste management, and energy management measures etc. have been implemented by most seaport to help minimize the emission of harmful substance into the marine environment whenever vessels calls at port (Teerawattana & Yang, 2019).

These new trends are strongly supported by sustainable policies implemented by maritime authorities at regional, national and institutional level within the maritime industry. It is also believed that these new trends have gotten significant influence on current jobs and business opportunities. More sustainable jobs and business portfolios are been created which has an improved social, economic and environmental impact. On the contrary, it is discovered that the emergence of these new trends has gotten negative impact on certain old jobs and business avenues. As certain businesses are gradually fading out of the industry, others may have to modify and rebrand themselves to embrace these new developments. More so, maritime professionals are been advised to enhance their technical know-how to meet the current trends and likewise maritime training institutions. In effect, this study examines the current trends of maritime transport and job opportunities (JO) associated with it. The study therefore seeks to address the research question "what are the current trends of maritime transport and job opportunities"? The conceptual framework of the study proposes a research model which examines the direct and mediation impact of the new trends of maritime transport on job opportunities (JO). Given this, the findings of the study will serve as a useful guide for policymakers, investors, business developers and all maritime stakeholders on current developments ongoing in the maritime sector and its impact on social and economic development.

2. Conceptual model

The conceptual model of the study examines the current trends of maritime transport and job opportunities as represented in figure 1 below. From figure 1, green maritime transport (energy efficient fuel, green ship design, container transport, and eco-generators), emergence of technology (big data, automation, and digitalization), new capacity (economies of scale, emission reduction, and freight reduction), formation of Shipping alliance (capacity sharing, marketing, cost minimization, profit maximization, and vessel management) and green port operations (emission minimization, waste management, and energy management) are identified are the current trends of maritime transport and their respective measurement items. GMT, NC, FSA, and GPO are modeled as exogenous variables that have predictive influence on ET and JO. The exogenous variables are external to the model whose values highly determines the output of the endogenous variable. ET is modeled as an exo-endogenous variable mediating the relationship between the exogenous variables and the endogenous variable. Finally, JO is modeled as an endogenous variable that is highly influenced by the existence and performance of the exogenous and exo-endogenous variables. Besides, the model only examines the positive influence of the exogenous and the exo-endogenous variables on JO (thus, the endogenous variable). The conceptual framework of the study is supported by the Natural Resource-Based View (NRBV) theory implemented by Hart in 1995. The model of the study parenthesis the direct and indirect contribution of the variables towards the achievement of sustainable development in the maritime industry.

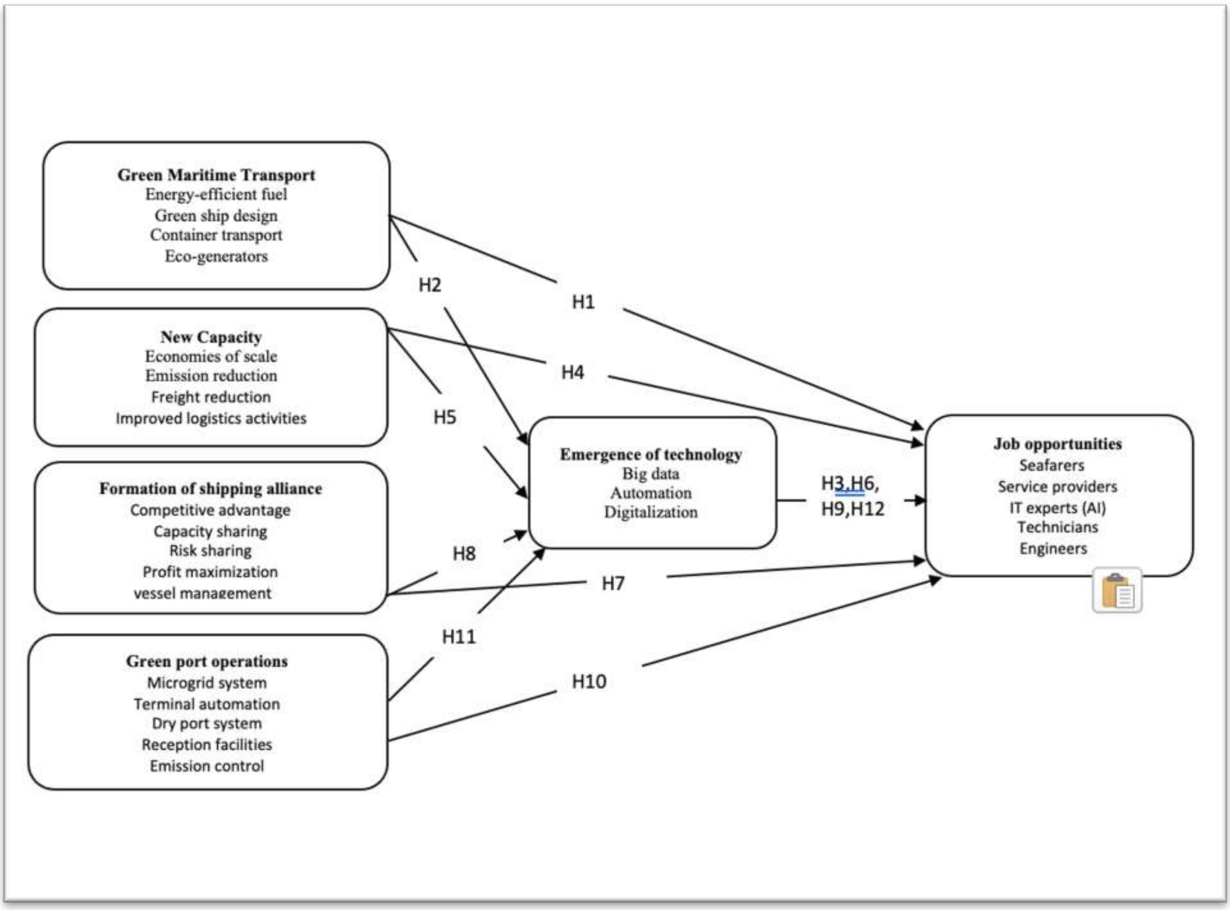

Figure 1: Conceptual Framework

3.0.Hypotheses Development

3.1.Green maritime transport on emergence of technology and job opportunities.

The need to achieve sustainable development within the maritime industry has made it needful for GMT policies to be adopted by authorities (Viana et al., 2014). Vessel operation exposes to the marine environment various forms marine pollutants which are very detrimental to human health and aquatic lives. The implementation of GMT policies as a countermeasure to these adverse effects has subsequently changed the focal lens of maritime transport (Song and Woo, 2013). More green operations are now been required which directly and indirectly provide green business and job opportunities. According to Alves et al. (2015), the implementation of carbon emission policy has increased the demand and supply of low-Sulphur fuel. More jobs and business avenues are been created for logistics service providers in such fields. Lai et al. (2011) also added that, increase in demand for container transport has enhanced container trading and value-added services activities on containers. Technological advancement within the maritime industry has helped to improve GMT (Sanchez-Gonzalez et al. 2019) hence the introduction of green ship design (Song and Woo, 2013), even though it is said to be accompanied with setbacks (Schaeffer, 2017). Green ship design has helped to boost the business prospect in the ship building industry and shipyards (Reni et al., 2020). More shipping companies ae now buying into the concept of unmanned ships (Rødseth, 2017). The demand for the installation of treatment plants and systems onboards vessels continue to be looming (Rivas-Hermann et al., 2015). These therefore gives the indication that the maritime industry has more prospect for green jobs and business opportunities. With the adaptation of NRBV theory, more GMT policies can be implemented that has substantial economic, social and environmental impact on job and business opportunities. In regards to the above literature, we hypothesize as;

H1: Green maritime transport is positively related to job opportunities.

H2: Green maritime transport is positively related to emergence of technology.

H3: Emergence of Technology plays a mediating role between green maritime transport and job opportunities.

3.2. New capacity on emergence of technology and job opportunities.

Maritime transport has experienced a rapid growth in capacity of maritime transport vehicles over the past few decades (Bennett, 2014). The emergence of technology in the maritime industry coupled with the need to achieve economic of scale by shippers has made it needful for mega vessels to be introduced. The introduction of NC into active supply has called for the demand for extra crew onboard these vessels. More crewing and ship management companies have been setup in providing ship agency services (Poulsen and Sornn-Friese, 2015). Apparently, the introduction of these fleets has caused a great change in vessels port call system (structure). Mega vessels only calls at major seaports to perform cargo works whereas feeder vessels connect to feeder ports hence creating business opportunity for both mega and feeder vessels (Lian et al., 2019). Port logistics system have been intensified which calls for the integration of port centric logistics system where all forms of value-added services within the port supply chain system are provided. This provide numerous business opportunities for logistics services providers and third-party suppliers within the port operational settings (Song and Panayides, 2015). The introduction of NC of vessels have gotten significant influence on job creation opportunities on-shore more than off-shore. With the implementation of the NRBV theory, more new capacity of vessels can be introduced as a strategic measure to reduce carbon emission and sustainable job opportunities for seafarers. From the above literature discussed, we hypothesize as;

H4: New capacity is positively related to job opportunities

H5: New capacity is positively related to the emergence of technology

H6: Emergence of technology plays a significant mediating role between new capacity and job opportunities.

3.3. Formation of shipping alliance on emergence of technology and job opportunities.

Excessive competition among shipping lines particularly linear shipping has led to the FSA. The basic objective for the FSA is to provide members of the group competitive advantage over their competitors (Fusillo, 2006; Song and Panayides, 2002). According to Jansson (2012), linear shipping does not only compete among themselves in terms of cargo transport but also marketing and advertising duties. The FSA helps to expand the capacity of the members and providing sustainable job opportunities for seafarers. More businesses and job opportunities are been opened as members to the alliance share capacity, facilities and resources. For instance, such operation calls onboard vessel and port agents, shipping management companies and other forms logistics services providers along the trade routes. The collective effort by these bodies ensures that the intended objectives to the formation of the alliance is achieved. Also, the emergence of technology in the shipping industry has helped to provide a single platform where informations is been shared among these bodies. The integration of technology in maritime transport has helped to create new job portfolios for artificial intelligent experts in programming, cargo planning and tracking, monitoring, cyber security, network developing, blockchain, etc. (Orji et al. 2020) which provide maximum security to the cargoes, containers and vessels (Ding et al., 2021). Port operations and businesses are equally boosted. The formation of shipping alliance contributes substantially towards social, economic, and environmental performance. Based on this, we hypothesized as;

H7: Formation of shipping alliance is positively related to job opportunities

H8: Formation of shipping alliance is positively related to the emergence of technology

H9: Emergence of technology plays a key mediating role between the formation of shipping alliances and job opportunities.

3.4. Green port operations on emergence of technology and job opportunities.

Seaport is a very important node in maritime operational settings that connect on-shore and off-shore maritime operations. It is discovered in recent times that; most seaports operate with less regard to environmental concern. Seaport environment most often than not are polluted with various forms of marine pollutants which calls for the adoption of environmental management policies. Port authorities are therefore mandated to deploy green port practices and measures capable of minimizing emission and managing waste and energy. This concept however support the NRBV theory introduced by Hart in 1995. The adoption of these measures on gradual basis is virtually changing the status quo for seaport operations hence the introduction of GPO, green businesses and job opportunities. According to Fang et al. (2019), the adaptation of the energy management policies by seaports has provided new business opportunities for most seaports (Midilli et al., 2006). Microgrid system enable seaport to supply electricity to visiting vessels when in port with the help of "cold-ironing technology". Other seaports are into the supply of low emission fuels as bunkers to vessels. The mandate by IMO to seaports in providing reception facilities for visiting vessels as a means of managing waste has provided new business opportunity for seaports (Svaetichin and Inkinen, 2017). Jeevan et al. (2018), also emphasis that the integration of dry port system into seaport operations as a strategic pollution control measure has provided the gateway for numerous supply chain related businesses and jobs. Green logistics and supply chain activities is taken oven port logistics system (Kaur and Awasthi, 2018). The automation of certain key aspect of port operations is gradually paving way and creating opportunity for computer and AI experts within the maritime industry (Heilig et al., 2017). From the literature review, we hypothesize as;

H10: Green port operations are positively related to job opportunities

H11: Green port operations is positively related to emergence of technology

H12: Emergence of technology plays a significant mediating role between green port operations and job opportunities.

4.0. Methodology and Data analysis.

The objective of the study is to assess the new trends of maritime transport and job opportunities accompanied. The population of the study involves the 656 registered key maritime stakeholders under Ghana Ports and Harbours Authority (GPHA) operating in either Tema or Takoradi port and or both seaports. It also include academic professionals from the Regional Maritime University of Ghana. The population of the study was purposively categorized into 13 groups including Ghana Maritime Authority (GMA), Ghana Ports and Harbours Authority (GPHA), Ghana Shippers Authority (GSA), Regional Maritime University (RMU), Customs, Shipping lines, Shippers, Freight forwarders, Haulage companies, Terminal operators, Shipping agents, Warehouse operators, and Service providers. A total of 1312 questionnaires which forms the sample size of the study was administered to the targeted population via electronic mail system. The sample size is deemed satisfactory enough to conduct this study as it meet the minimum threshold suggested by Hair et al., (2017). Before the questionnaires were disseminated, an introductory letter detailing the purpose of the study was first mailed to the various institutions seeking for their mutual support and participation in this study. The feedback was positive as all the population acknowledged their invitation. A pilot testing was first made using 50 respondents from the population with satisfactory responses. The validity and reliability of the measurement variables were tested using twenty-six (26) measurement items. The questionnaires were semi-structured in a close-ended format with a five-Likert scale ranging from strongly disagreed to strongly agreed to choose from. The questionnaires were made up of two parts. Part one contains the demographical details of the respondents whereas part two explains how the individual variables correspond to job opportunities. A total 1176 valid responses were received and analyzed using partial least square structural equation modeling (SEM-PLS). The rationale to the use of this model is it robust ability to handle relatively small data. It is also good for model development and have high predictive relevance (Hair et al., 2017). Common method bias of the study was tested using exploratory actor analysis (EFA). Also, the model was equally examined by assessing the measurement model and structural model. PLS-SEM algorithm and bootstrapping of the model were measured to the limited values of 300 and 5000 respectively and blindfolding to the limit of D7 (Hair et al., 2017). The goodness fit (GoF) of the model estimated within the range of 0 to 1. The details to the demographic data of the respondents are in appendix A below.

4.1. Assessment of the measurement model

Assessment of the measurement model as illustrated in **table 2** in the appendix section examines the relationship between the latent variables and their measurement items. It assesses the reliability and validity of the model. It is estimated by examining the internal consistency reliability, convergent validity, and discriminant validity of the model. In regards to the model, internal consistency reliability is estimated by examining Cronbach's alpha (CA), and composite reliability (CR). Convergent validity is examined by average variance extracted (AVE) and discriminant validity also examined by Fornnel-Larcker criterion and Heterotrait-monotrait ratio (HTMT). From table 3 and 4, the values obtained for Larcker criterion and HTMT were within the ranges of (0.467-0.824) and (0.462-0.732) respectively hence meeting the minimum threshold suggested by Henseler, (2017). From **table 2,** the values of AVE were within the range of (0.563-0.681) as suggested Hair et al., (2013). The values for Cronbach's alpha and composite reliability which examines internal consistency reliability of the model values were within the range of (0.78-0.81) and (0.79-084) respectively hence meeting the >0.70 minimum threshold suggested Henseler, (2017).

4.2. Assessment of the structural model

Assessment of the structural model attempt to measure the relationship between the latent variables. Assessment of the structural model is estimated by examining the variance explained (R^2), effect size (f^2), and predictive relevance (Q^2) of the model. From **table 5** below, the model predicted Q^2 values of ET (0.502) and JO (0.647). From the 0.00 minimum threshold suggested by Henseler (2017), the model is said to have achieved perfect predictive values. The values for variance explained (R^2) for the model were ET (0.460) and (0.572) hence considered moderate by Henseler (2017). The effect size values for ET and JO were (0.263) and (0.346) respectively. Again, according to Hair et al. (2013), the model said to have achieved moderate and substantial effect size. Goodness fit (GoF) measures the geometric mean of the average mean of the outer model and the average R-square of the inner model was estimated at a value of 0.682.

5.0. Results and discussion.

The model of the study examines the direct and mediation effect existing between the variables of the study. With reference to the hypotheses of the study been tested at statistical significance of <0.05, all the twelve (12) hypotheses support the model of the study. From the results in **table 6**, the findings suggest that, GMT have a significant impact on JO which is supported by hypothesis H1($\beta = 0.622$, $t = 7.648$, $p = 0.000$). The findings of the study explains that the implementation GMT in the maritime industry have a significant influence on creating environmental friendly jobs and business opportunities for maritime professionals. Again, the findings reveal that GMT have a positive relationship with ET hence in support of hypothesis H2 ($\beta = 0.408$, $t = 6.337$, $p = 0.001$) as represented in **table 6**. The findings depict that the introduction of technology in the maritime industry is gradually changing maritime transport into the digital. The introduction of technology in maritime transport is making maritime transport become more efficient, convenient and safer (environmental friendly). The above findings are supported by the literature by Lai et al. (2011) and Alves et al. (2015). Also, from **table 7,** the results suggest that ET plays a very significant mediation role between GMT and JO and in support of hypothesis H3 ($\beta = 0.352$, $t = 4.652$, $p = 0.000$). According to the findings, technology is now the “sine qua non” of maritime transport. For instance, all the new developments in maritime transport are based on technology. Numerous jobs portfolios have been created for artificial intelligence experts within the maritime industry in areas such as shipyards, ports, onboard vessels and etc. On the other hand, the study conducted by Schaeffer, (2017) established a negative relationship between these variables. According to him, the introduction of technology is rather causing redundancy to most maritime professionals.

Furthermore, the findings in **table 6** establish a positive relationship between NC and JO which is supported by hypothesis H4 (β = 0.336, t = 4.826, p = 0.003) of the model. According to the findings, increase in capacity of maritime fleets does not only provide job opportunities for navigators but also on-shore maritime players in the port logistics system as supply chain activities are boosted. This affirm the findings of the study conducted by Lian et al., (2019). More so, the findings suggest a positive relationship between NC and ET. This relationship support hypothesis H5 (β = 0.482, t = 6.473, p = 0.000) of the model in **table 6**. The findings parenthesis that the advent of technology in the maritime industry has influence the recent size of maritime transport vehicles. The newly discovered designs and sizes of vessels for certain type of trade and operations are highly influenced by technological advancement in the maritime industry. This finding is however supported by the study of Song and Woo, (2013). The findings again reveal that, ET play a significant mediation role between NC and JO hence support hypothesis H6 (β = 0.428, t = 6.211, p = 0.021) as illustrated in **table 7.** The findings suggest that the emergence of technology in the maritime industry have been the backbone behind the success story of the introduction of NC of maritime transport vehicles. The introduction of these NCs calls extra hands been needed onboard in terms of vessel management, cargo mobilization and transport. More supply chain personnel are demanded to undertake service providing duties. This is however supported by the literature of Song and Panayides, (2015).

In addition, the results of the findings indicate that the FSA is positively related to JO as shown in **table 6** hence in support of hypothesis H7 (β = 0.318, t = 5.025, p = 0.010) of the model. According to the findings, the FSA helps to enhance the capacity of the shipping lines. The vessel size, number, market share, and scope of the members to the alliance are been expanded which calls for additional personnel's to be deployed. More management (thus, both crew and ashore ship management personnel's) team are called onboard to help with the vessels management. It also serves as an extended gateway for boosting businesses for geographic cargo forecasters, shipping agents and logistics service providers. This finding therefore falls in line with the study conducted by Jansson, (2012). Again, the findings suggest that, FSA is positively related to ET and hence in support of hypothesis H8 (β = 0.429, t = 6.237, p = 0.006) as shown in **table 6**. The findings explain that the introduction of technology in shipping alliance enables the members to the alliance enjoy competitive advantage over their competitors. Members to the alliance share some risk and cost together including marketing, advertisement, information, and other forms of publications due to technology. This affirm the literature by Panayides and Wiedmer, (2011). Also, the findings suggest that ET plays a significant mediating role between FSA and JO hence in support of hypothesis H9 ($\beta = 0.328$, $t = 4.320$, $p = 0.000$) in **table 7**. According to the findings, the FSA and linear shipping business involves multiple players which requires the exchange of series of information and data. The introduction of technology in the maritime industry provide to the members of the alliance a common interface whereby all these are met exchange. It also provides a common user platform where vessels, cargoes and containers are been monitored and managed by experts. The usage of AI becomes very paramount in linear shipping and FSA hence creating various job opportunities for computer experts in vessel management and port centric logistics system. This finding is supported by the findings of the study conducted by Orji et al. (2020).

Lastly on GPO suggest that, GPO is positively related to JO and in support of hypothesis H10 ($\beta = 0.381$, $t = 4.980$, $p = 0.000$) in **table 6**. The findings depict that, GPO within the seaport area enables and provide green job opportunities for maritime services providers including the supply of green energy to vessels and other green logistics related activities. The findings again suggest that, GPO is positive related to ET hence in support of hypothesis H11 ($\beta = 0.246$, $t = 3.018$, $p = 0.000$) in **table 6**. The findings explain that the introduction of technology in maritime operations has help to improve seaport operations. Most seaport are diverting into the concept of automating their operations which does not only enhance efficiency but also reducing cost and protecting the maritime environment from excessive pollution from marine operations. Also, the findings suggest that the ET play a positive mediation role between GPO and JO. This connection support hypothesis H12 ($\beta = 0.302$, $t = 4.123$, $p = 0.000$) in **table 7** of the model. The findings emphasis that, technology has helped to replace man power with automation of operation in most terminal. Digitalization is now taking over seaport terminals creating opportunities for computer experts. Cargos can now be moved and transported with easy from a service station. Also, most seaports are now developing green energy means of supplying energy services to vessels when in port. For instance, the use of renewable energy has become very come in maritime seaports and terminals. Port logistics system and service provider are all also moving into green logistics system with the advent of technology hence paving way for green logistics jobs. The above findings affirm the findings of the study by Kaur and Awasthi, (2018).

6.0. Conclusion

Maritime transport is gradually taking a new shape with new developments. Gradually, old businesses and job portfolios are fading out of the system as new ones takes over. The objective of this study was to examine the new trends of maritime transport and job opportunities. The model of the study assesses the direct relationship between green maritime transport, new capacity, formation of Shipping alliance, and green port operations on job opportunities. In support, the study examines the mediation role that the emergence of technology play between the exogenous and endogenous variables od the model. The conceptual framework of this study is supported by the natural resource-based view (NRBV) theory implemented by Hart in 1995. According to the theory, the implementation of these new trends has a significant influence on environmental, economic, and social development or performance. The findings of the study reveal that, maritime transport is currently undergoing changes and development which has significant impact on current job opportunities for maritime professionals. Even though these changes negatively are causing other forms of redundancies to mariners and land base professionals, yet, it is discovered to be creating sustainable job employment to maritime base professionals. The world is gradually moving towards the sustainable era and that, it is advisable to all maritime base personnel to enhance their technical know-how and expertise to embrace the incoming green concept in order to take advantage of it associated businesses and job opportunities.

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Appendix A:

Table 1: Demographic information of respondents

Sociodemographic features	Frequency	Percentage (%)
Age range of respondents		
Below 30 years	326	27.7
30 – 40 years	420	35.7
41 – 50 years	364	31
51 and above	64	5.6
Total	***1176***	***100***
Gender		
Male	797	67.8
Female	379	32.2
Total	***1176***	***100***
Marital status		
Single	218	18.5
Married	875	74.4
Divorced	83	7.1
Total	***1176***	***100***
Academic level		
Ph.D.	69	5.9
Master’s	347	29.5
Bachelor’s	611	51.9
High National Diploma	149	12.7
Total	***1176***	***100***

Name of institution		
GPHA	70	6.0
GMA	25	2.1
GSA	25	2.1
Customs	50	4.2
Shipping lines	54	4.6
Shippers	450	38.3
Freight forwarders	157	13.3
Haulage companies	110	9.3
Terminal operators	12	1.0
Services providers	163	13.9
Shipping agents	20	1.7
RMU	10	0.9
Warehouse operators	30	2.6
Total	***1176***	***100***
Location of institution		
Tema	820	69.7
Takoradi	356	30.3
Total	***1176***	***100***
Position		
Directors and managers	172	14.6
Supervisors	448	38.1
Officers	546	46.4
Professors	10	0.9
Total	***1176***	***100***
Years of working		
1 – 10years	223	19
11 – 20years	499	42.4
21 – 30years	370	31.5
Above 30years	84	7.1
Total	***1176***	***100***
Employment status		
Permanent	760	64.6
Contract	416	35.4
Total	***1176***	***100***

Table 2: Cronbach's alpha, composite reliability and average variance extracted

Constructs	Measurement items	Loadings	Items	CA	CR	AVE	Source
GMT	Energy-efficient fuel	0.77	GMT1	0.78	0.80	0.571	Maringa, (2015); Psaraftis, (2016)
	Green ship design	0.81	GMT2				
	Container transport	0.74	GMT3				
	Eco-generators	0.79	GMT4				
ET	Automation	0.82	ET1	0.77	0.79	0.563	Heilig et al., (2017)
	Big data	0.75	ET2				
	Digitalization	0.79	ET3				
NC	Economies of scale	0.80	NC1	0.80	0.81	0.583	Bennett, (2014)
	Emission reduction	0.78	NC2				
	Freight reduction	0.84	NC3				
	Improved logistics activities	0.81	NC4				
FSA	Competitive advantage	0.79	FSA1	0.80	0.80	0.579	Panayides and Wiedmer, (2011).
	Capacity sharing	0.81	FSA2				
	Risk sharing	0.77	FSA3				
	Profit maximization	0.85	FSA4				
	vessel management	0.81	FSA5				
GPO	Microgrid system	0.84	GPO1	0.79	0.83	0.663	Fang et al. (2019), Jeevan et. al., (2018).
	Terminal automation	0.79	GPO2				
	Dry port system	0.84	GPO3				
	Reception facilities	0.77	GPO4				
	Emission control	0.80	GPO5				
JO	Seafarers	0.81	JO1	0.81	0.84	0.681	
	Service providers	0.78	JO2				

IT experts (AI)	0.84	JO3
Technicians	0.89	JO4
Engineers	0.78	JO5

Table 3: Fornel-Larker criterion.

Constructs	GMT	ET	NC	FSA	GPO	JO
GMT	0.824					
ET	0.697	0.798				
NC	0.812	0.742	0.810			
FSA	0.667	0.545	0.773	0.752		
GPO	0.598	0.613	0.541	0.646	0.633	
JO	0.631	0.554	0.489	0.603	0.467	0.741

Table 4: Heterotrait-monotrait ratio (HTMT).

Constructs	GMT	ET	NC	FSA	GPO	JO
GMT						
ET	0.691					
NC	0.732	0.728				
FSA	0.630	0.539	0.669			
GPO	0.711	0.462	0.722	0.652		
JO	0.584	0.619	0.477	0.511	0.622	

Table 5: variance explained (R^2), effect size (f^2) and VIF.

Constructs	f^2	VIF	Q^2	R^2	R^2adj
ET.	0.263	2.526	0.338	0.460	0.451
JO.	0.346	3.162	0.447	0.572	0.601

Table 6: Direct effect

Path	Hypotheses	Beta Coefficient	T-statistics	P-values	Supported
GMT→JO	H1	0.622	7.648	0.000	Supported
GMT→ET	H2	0.408	6.337	0.001	Supported
NC→JO	H4	0.336	4.826	0.003	Supported
NC→ET	H5	0.482	6.473	0.000	Supported
FSA→JO	H7	0.318	5.025	0.010	Supported
FSA→ET	H8	0.429	6.237	0.006	Supported
GPO→JO	H10	0.381	4.980	0.000	Supported
GPO→ET	H11	0.246	3.018	0.000	Supported

Table 7: Mediation (indirect) effect

Path	Hypotheses	Beta Coefficient	T-statistics	P-values	Supported
GMT→ET→JO	H3	0.352	4.652	0.000	Supported
NC→ET→JO	H6	0.428	6.211	0.021	Supported
FSA→ET→JO	H9	0.328	4.320	0.000	Supported
GPO→ET→JO	H12	0.302	4.123	0.000	Supported

Towards Enhancing Maritime Asset Management Value Through Transforming Maritime Expert Knowledge into Machine Learning Models

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Abstract

Over the past decade, Machine Learning (ML) techniques have been utilised as an efficient decision making tool when big data is provided from systems' operators and/ or business developers. To generalise the diagnostic and prognostic analysis respectively for rolling element bearings, two ML models, namely; Weighted KNN classification and Linear regression were developed and are discussed in this paper. These models showed discrepancies in their performance when compared with domain expert's defined and models' defined training and testing datasets. However, considering the limited amount of training data used to train Weighted KNN model and the classification accuracy so obtained, it has been established that there is a strong potential of fostering expert knowledge into ML models. The presented approach can be employed effectively not only for a data-driven decision making to balance cost, risk and performance in a maritime asset management system but also for a better human training.

Keywords

Machine Learning; Maritime Asset Management; Condition Monitoring; Condition Indicators; Domain Expert.

1 Introduction

1.1 Background

Broadly defined, ‘Asset Management’ is the ‘coordinated activity of an organisation to realise value from assets’ (Standards Australia Limited, 2014). Asset Management philosophy encompasses all asset types, tangible and intangible, individual components or complex systems, and all activities involved in the asset’s life cycle – everything from initial identification of requirements or opportunities, acquisition/creation, operations or utilisation activities, asset stewardship or care/maintenance responsibilities, through to renewal or disposal and any remaining liabilities (Global Forum on Maintenance and Asset Managment (GFMAM), 2014). This means Asset Management has a vast scope, and rather than just covering the maintenance of physical assets, its ultimate objective is to realise value from assets throughout the asset life. The values, which drive the Asset Management System of a defence maritime sustainment organisation, could be Capability, Availability and Affordability of the materiel they are sustaining.

A well-established condition monitoring (CM) program is emerging to be the core of all risk management based maintenance philosophies such as Condition-Based Maintenance (CBM), Reliability Centred Maintenance (RCM), Predictive Maintenance (PdM), Prognostics and Health Management (PHM) etc. (Cullum, Binns, Lonsdale, Abbassi, & Garaniya, 2018), and this is the point where these maintenance philosophies leap into the world of “Big Data’ within the asset management framework. Big Data (Oracle Corporation, 2018) can be defined as the “data sets which are so voluminous that traditional data processing software just can’t manage them”. ML is one of the most popular techniques used for Big Data management, which apart from extracting useful information also drives the AI for a large number of engineering and other business applications (Han Jiawei, Chapter 2 - Getting to Know Your Data, 2012).

The Maritime Industry poses unique challenges from data acquisition, data quality and data accessibility point of view, in order to establish required condition monitoring analytics. CBM and PdM philosophies are getting acquaintance for maritime applications, but Periodic Preventive Maintenance (PPM) is still favoured by Maritime Industry due to the ease of resource planning (Cullum, Binns, Lonsdale, Abbassi, & Garaniya, 2018). In addition to this, due to the specific nature of missions that maritime materiel is supposed to undertake throughout its lifecycle, the probability of complying with the data acquisition schedule as per the approved condition monitoring programme is challenging and unlikely.

A key challenge in collecting high-quality data is the competence of shipboard crew which has the potential to directly affect the quality of measured data due to their lack of experience within this context. The data accessibility is also inhibited by security requirements for data protection, which may result in delays in accessing the data and restrict the amount of published data. In view of these challenges, ML provides a promising opportunity where the available condition monitoring data can be generalised to define the behaviour of a particular system, equipment or its component(s) with a limited variety of data, which may be just enough to define the condition indicators (CIs) required for a ML algorithm.

Furthermore, even in the absence of any design flaw, every machine operates in a unique system environment and owes to a set of specific inherent operational problems due to that particular system environment. Over a certain period of time, its operators and maintainers learn about operational issues of the machinery and eventually become ‘domain experts’ of the machinery for its various aspects, such as operation and maintenance etc.

Apart from the owners of the machinery, original equipment manufacturers (OEMs) of the machinery make best use of such domain expertise to improve their design and to develop services and products for their customers. In many instances when there is a consistent involvement of the operator and/or maintainer organisation with specific systems and its equipment, the domain expertise can reach to the level where they can make sometimes better decisions than OEM for the operation and maintenance of their system and equipment within a particular system environment. A classic example of domain expertise’s precedence over OEM is the merchant shipping industry where the direct involvement of OEM, outside the warranty obligations, is considered to be an expensive solution and all the technical decisions are made by the ship crew and shore management balancing vessel’s contractual engagement and commercial viability. ML in combination with artificial intelligence (AI) has the capability to foster such domain expertise particularly for risk management based maintenance philosophies. This is the main driving motivation to undertake this industrial research project which is mainly focused on identifying and addressing the challenges, risks and opportunities of transforming expert knowledge into a ML model.

Such a ML model has a potential to provide a data-driven framework in the maritime asset management system, which can be employed effectively to balance cost, risk and performance in the value (capability, availability and affordability) realisation of maritime assets.

1.2 Research Objectives

This research is aimed to explore solution propositions for the following notions:

i. How can we transform human expert knowledge about any process or analysis into ML models?

ii. How can we validate and improve the effectiveness of a ML model developed based on the available human expert knowledge?

iii. Can a human expert knowledge based ML model add value to an asset management system in maritime context?

2 Numerical Model

ML describes purposely designed "algorithms which use computational methods to 'learn' information directly from data without relying on a predetermined equation as a model" (MathWorks, Inc., 2016). The most interesting aspect of ML is that its algorithms improve their performance with an increase in the number samples used for learning. ML has emerged as the game changer in the space of data science and AI in the recent years (Press, 2015).

However, adopting ML poses its own challenges which include the requirement of using an enormous amount of data in order to generalise a ML model with a high level of accuracy, and with the limited availability of people with right skills to adopt this technology. Some (Marouani, 2018) believe that it is high time that engineers need to develop their skills in the domain of data science in general, and for ML development and its implementation in particular, in order to fill the gap of a lack of data scientists. Figure 1 provides mapping of commonly used ML techniques, methods and models, developed based on the learning analysis from (MathWorks, Inc., 2018), (MathWorks, Inc., 2016), and (Witten, 2005).

2.1 Developing a ML Model

Developing a ML model in a real world scenario is predominantly an iterative process. It involves test and trial of different ideas emerging from the developer's domain expertise in ML modelling and in the process to be generalised through ML modelling. Figure 2a illustrates typical workflow of a ML model development, established based on the learning analysis from (MathWorks, Inc., 2018) and (Han Jiawei, Chapter 2 - Getting to Know Your Data, 2012). Figure 2b illustrates the average time consumed to accomplish each stage of the ML model development workflow based on 0.125 equivalent full time study load (EFTSL).

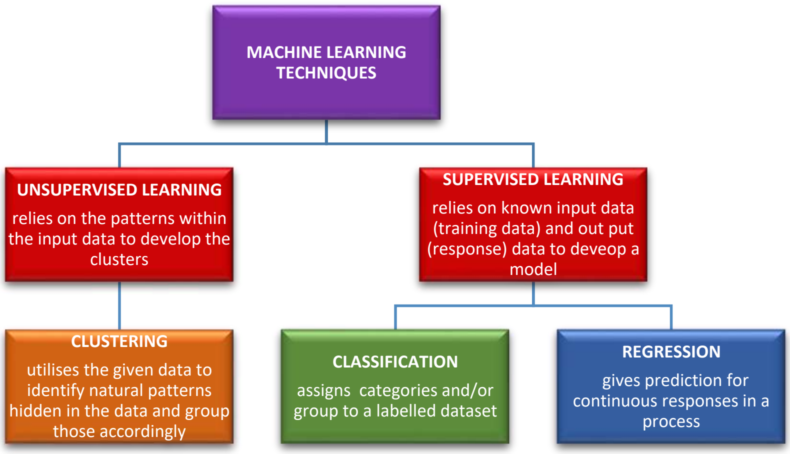


Figure 1a: Broader classification of Machine Learning techniques

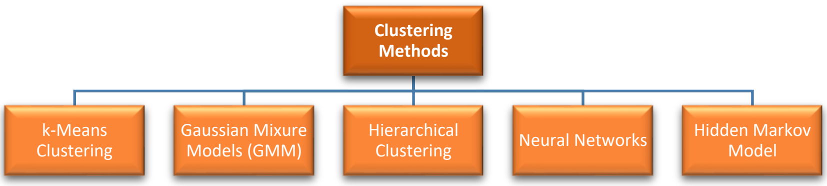


Figure 1b: Clustering methods flowing down from Figure 1a

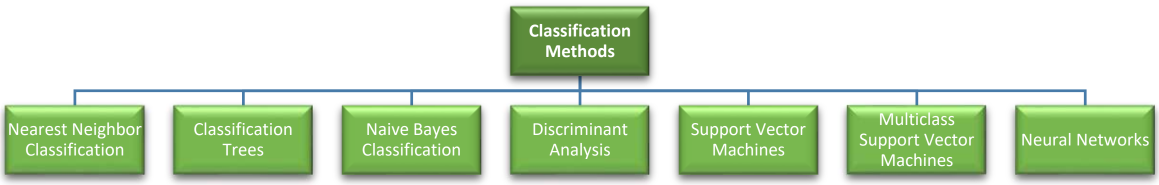


Figure 1c: Classification methods flowing down from Figure 1a

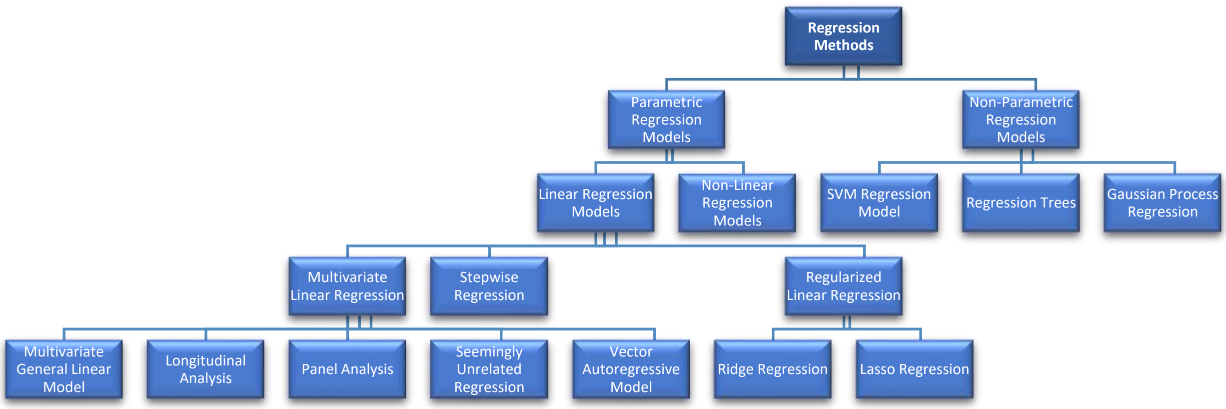


Figure 1d: Regression methods flowing down from Figure 1a

Figure 1: Figure 1: Mapping of ML techniques, methods and models.

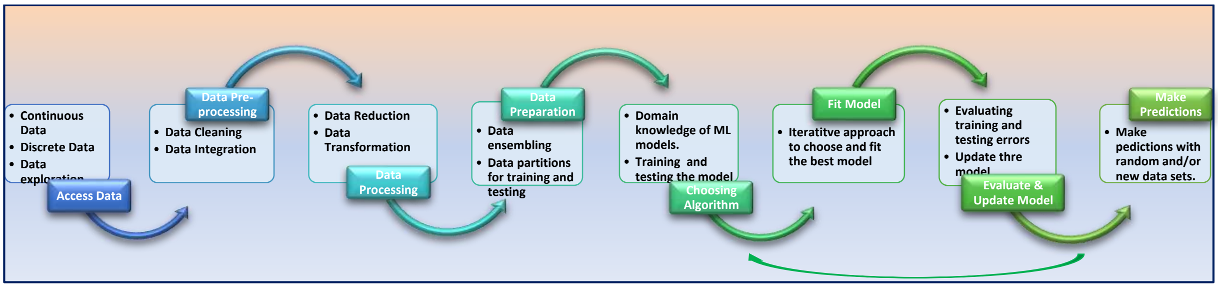


Figure 2a: Typical workflow of ML model development, based on the learning analysis from (MathWorks, Inc., 2018) and (Han Jiawei, 2012)

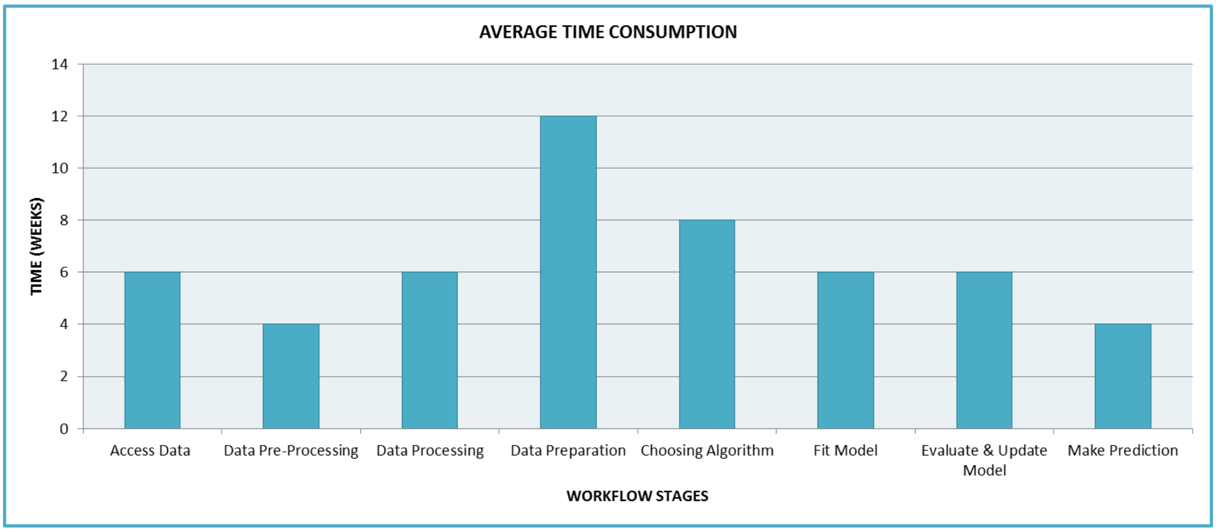


Figure 2b: Average time consumption for each stage of work flow based on 0.125 EFTSL

In order to develop a prototype ML model in this research, a commonly used and tested machinery component which was under the CM program was selected as the test subject. Vibration analysis datasets obtained from rolling element bearings of similar specification but used in various rotating equipment applications were chosen for the ML model development. The specifications of the selected rolling element bearing model and design cannot be disclosed due to commercial and other reasons.

Bearing defect frequencies, also known as fundamental fault frequencies, of a rolling elements bearing play an important role in its vibration analysis. These frequencies are the function of bearing geometry (i.e. pitch diameter and roller diameter), the relative speed between the two raceways and the number of rolling elements (Rolling Element Bearing Analysis, 2012). For a known bearing geometry, the set of fundamental fault frequencies can be calculated as illustrated in Figure 3. This research works with the relative amplitudes of the fundamental fault frequencies for rolling element bearing of chosen specification to develop a ML model.

A lot of theoretical work has been conducted previously in relation to the application of ML for fault analysis of rolling element bearings which predominantly discusses how various techniques of ML can be applied for bearing fault analysis, classification and training, such as: (A Comparative Study on Bearings Faults Classification by Artificial Neural Networks and Self-Organizing Maps using Wavelets, 2010), (Ball Bearing Fault Diagnosis Using Supervised and Unsupervised Machine Learning Methods, 2015), (Fault diagnosis of rolling element bearings via discriminative subspace learning: Visualization and classification, 2014) and (Remaining Useful Life Prediction of Rolling Bearings Using PSR, JADE, and Extreme Learning Machine, 2016) are to name a few. However, this paper focuses on the application of most suitable ML techniques in a real world scenario using the algorithms and toolboxes of MATLAB in order to get the best possible generalisation of ML model such that it should identify different stages of bearing faults in its life cycle before reaching a permanent failure.

2.2 Data Gathering

The research made use of two datasets; a training dataset, and a testing dataset. The training dataset was comprised of 22 labelled samples of bearing vibration data and was used to train the ML model. The testing dataset was comprised of 12 random samples of bearing vibration data and was used to evaluate the generalisation of the developed model. Each data sample included 1600 observations of Amplitude (gSE-Peak), measured corresponding to each sampling frequency interval. Each of the labelled data samples (training data samples) included one of bearing fault stages i.e. 'Normal', 'Fault Stage 1', 'Fault Stage 2', and 'Fault Stage 3', according to the judgement of the domain experts. However, the testing data samples were without any label attached pertaining to any of the bearing fault stages.

Equation 1 – Ballpass frequency, Outer race (BPFO)

$$BPFO = \frac{nf_r}{2}\left(1 - \frac{d}{D}cos\emptyset\right)$$

Equation 2 – Ballpass frequency, Inner race (BPFI)

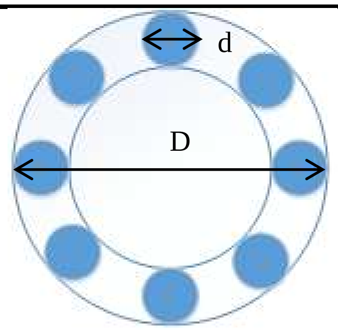
$$BPFI = \frac{nf_r}{2}\left(1 + \frac{d}{D}cos\emptyset\right)$$

Equation 3 – Fundamental Train Frequency (FTF)

$$BPFO = \frac{nf_r}{2}\left(1 - \frac{d}{D}cos\emptyset\right)$$

Equations 4 – Ball (roller) Spin frequency (BSF)

$$BSF = \frac{D}{2d}\left[1 - \left(\frac{d}{D}cos\emptyset\right)^2\right]$$



$d = Ball\ Diameter;\ D = Pitch\ Diameter$

$f_r = Shaft\ Speed;\ \emptyset = Bearing\ Contactg\ Angle$

$n = number\ of\ rolling\ elements$

Figure 3: Equations of fundamental fault frequencies (Rolling element bearing diagnostics—a tutorial, 2011)

Each sample also contained the manufacturer's defined ratios of BPFI, BPFO, BSF and FTF, as presented in Figure 3.

2.3 Data Pre-processing and Processing

Prior to reaching the stage of a ML model development, it takes an enormous effort to organise the data required to test a chosen model. Analysis (CrowdFlower, Inc., 2016) reveals that data scientists spend only 19% of their time in collecting the datasets, whereas they spend 60% of their time in cleaning and organising datasets before they can prepare the data for further application. Figure 4 illustrates the data pre-processing and data processing techniques and process based on the learning analysis from (Han Jiawei, Chapter 2 - Getting to Know Your Data, 2012). It reveals that data pre-processing and data processing comprise of four main processes as follows:

a. Data Cleaning – It involves applying the appropriate data science techniques to remove the noise and rectifying inconsistencies in the data (Figure 4a).
b. Data Integration – This implicates merging data from multiple sources into consolidated object such as data ensembles (Figure 4b).
c. Data Reduction – Data reduction techniques are applied to extract the data of interest and importance for intended application (Figure 4c).
d. Data Transformation – Data transformation techniques are extensively applied to make the data normalised, standardised and smoothened for further processing in the work flow (Figure 4d).

Although all the four processes have some common techniques which can be applied from one process to the other, a set of solid data science skills is required to make selection of the appropriate technique as similar techniques do not produce similar results for a given dataset due to their limitation based on the size of data, different boundary conditions and theory of application. An iterative approach prevails to get best possible results in data processing.

Preparing the data to progress through workflow (as illustrated in Figure 2a) using MATLAB required the datasets to be stored in a specific format. This was achieved by transforming the data into a specific format suitable for input to ML algorithms in MATLAB and then developing ensemble data store objects using MATLAB defined functions.

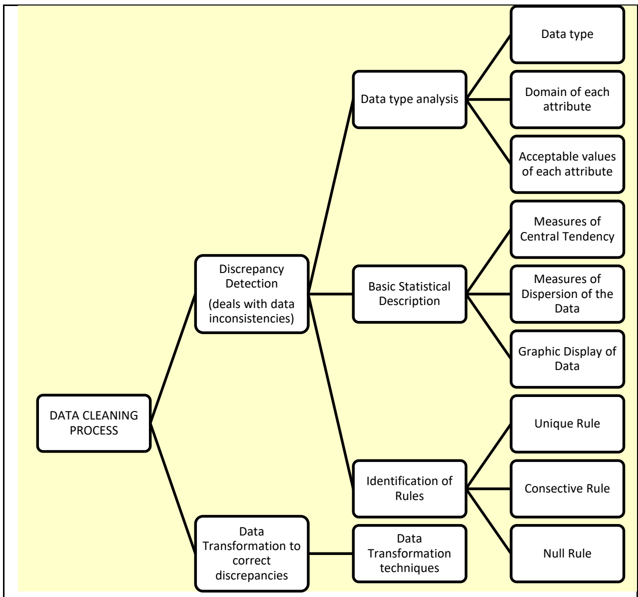


Figure 4a: Data cleaning processes

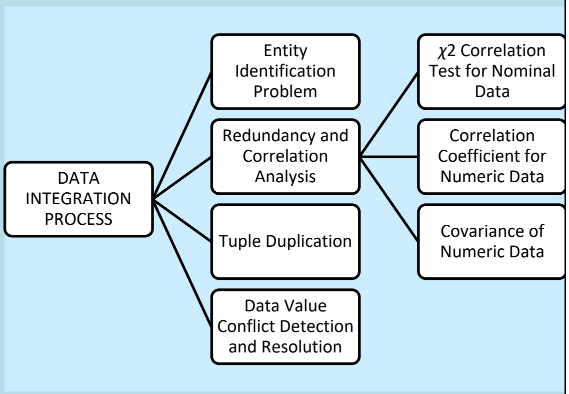


Figure 4b: Data integration processes

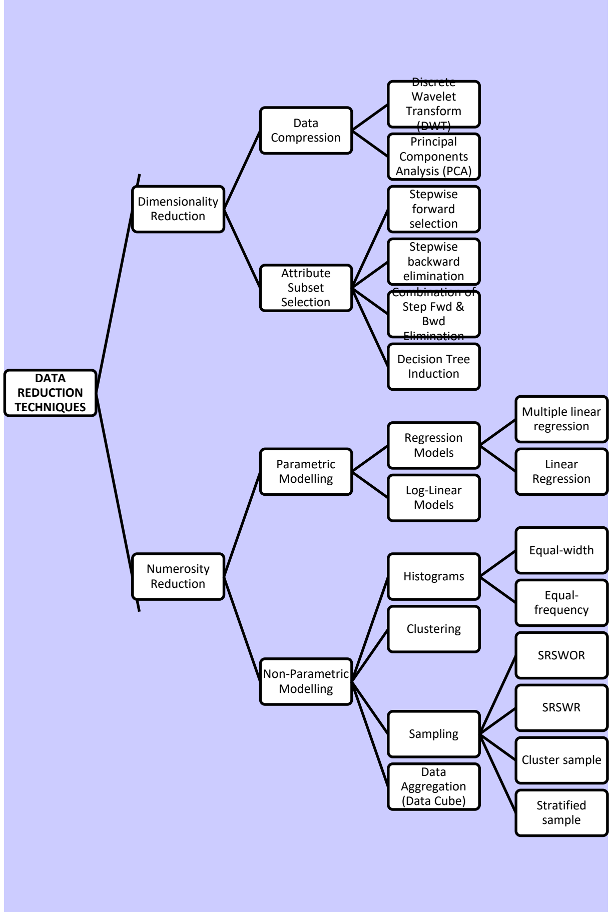


Figure 4c: Data reduction techniques

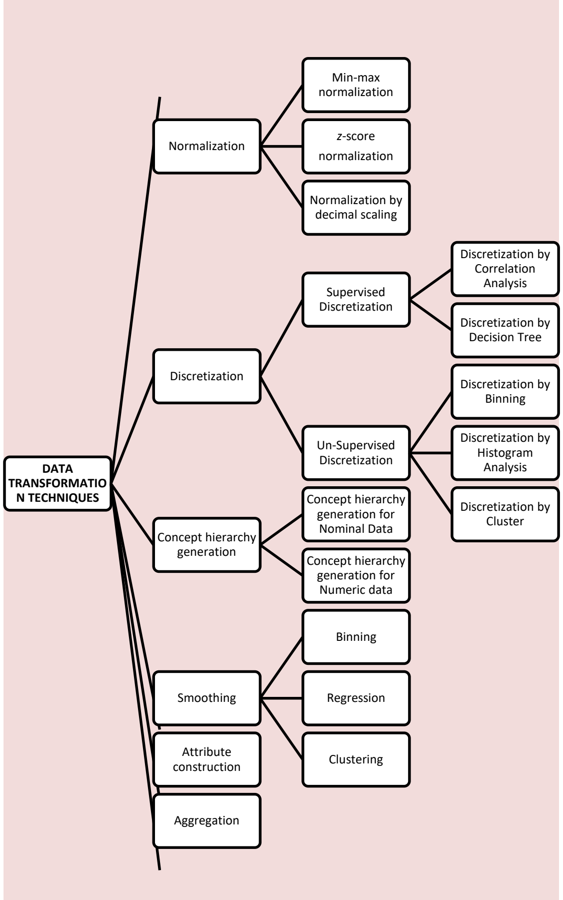


Figure 4d: Data transformation techniques

Figure 4: Data pre-processing (Figure 4a and 4b) and Data processing (Figure 4c and 4d) processes and techniques, based on the learning analysis from (Han Jiawei, 2012).

MATLAB has a number of specially defined functions which are used to manage relatively large and complex datasets of machinery operations and condition monitoring etc. by creating ensemble data store objects which can be further used for predictive maintenance and machine learning algorithms (MathWorks, 1994-2018). The two datasets (i.e. training and testing dataset) were transformed into separate ensemble data stores for training and testing of the ML model respectively prior to their application for ML algorithms.

3 Methodology

Figure 5 illustrates the methodology employed in a sequential manner to accomplish the research objectives.

(Zhou, et al., 2018) reveals the importance of bringing together the end users and developers of a ML model in order to build the confidence of end users about the capabilities, strengths and weaknesses of the developed ML model. This approach necessitates maximum engagement of the stakeholders (i.e. domain expert of vibration analysis in this case) from the concept development phase to product deployment. This approach has been incorporated in the methodology through feedback loops, as illustrated in Figure 5.

3.1 Selection of CIs

Bearing defect frequencies are the set of frequencies presented when rolling elements strike a localised fault on the inner or outer race, or conversely, a fault on any rolling element strike the inner or outer race (Bearing Envelope Analysis Window Selection, 2009).

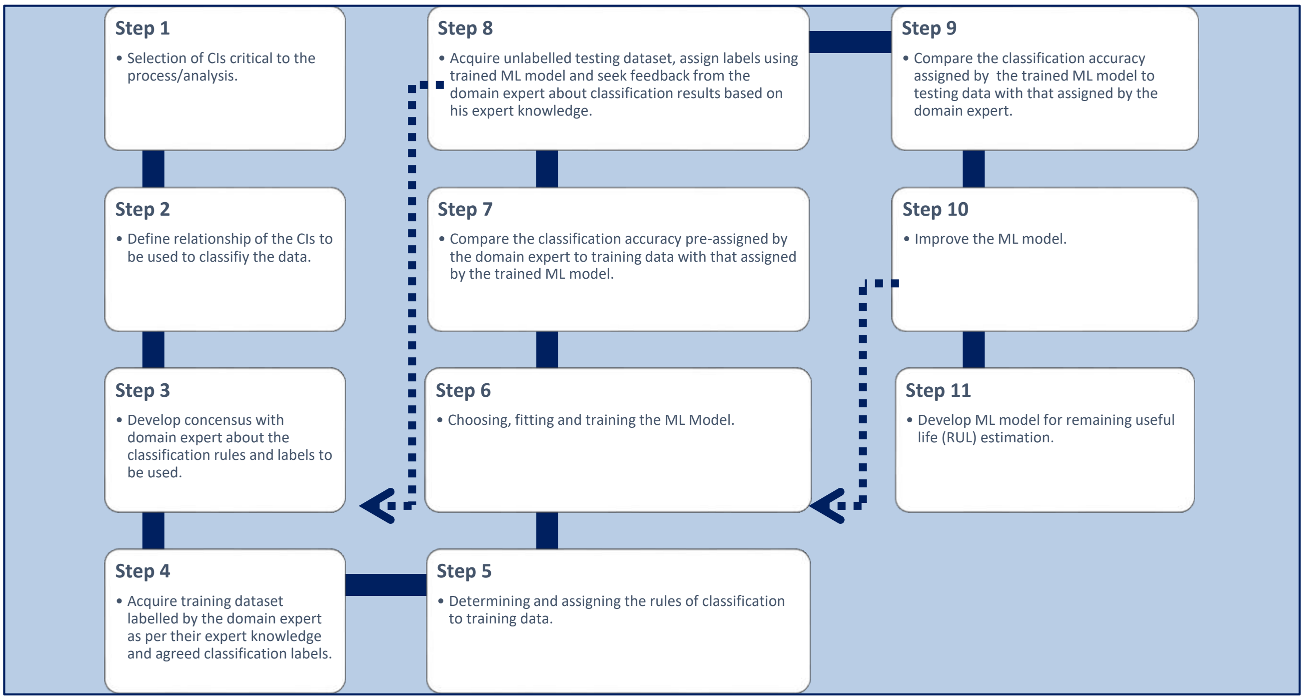


Figure 5: Work flow of methodology

The result of this phenomenon is the production of cyclic impacts which can be traced in bearing envelope analysis, due to an increase in vibrational energy at the time of impact. Analysis (An Overview on Vibration Analysis Techniques for the Diagnosis of Rolling Element Bearing Faults, 2013) reveals that the most common contributors towards the initiation of localised faults are cracks, pits and spalls and their cause usually attributed to a number of interlinked mechanisms such as excessive loads, fatigue, lack of lubrication and excessive temperatures etc. These faults have a strong likelihood of propagating with different operating conditions.

Identifying the deterioration trends of a rolling element bearing and attributing a right cause to each of these trends is not a straight forward process. Generally (Howieson, 2003) the harmonics appearing in a Fast Fourier Transform (FFT) of time domain signals of a defective bearing can be attributed to a combination of non-bearing related defects such as looseness, misalignment, or unbalance or equipment's internal defects etc. Such a combination of harmonics produces a 'haystack' effect in the high frequency region of the spectrum. However, it can be misleading if the frequency spectrum is analysed in isolation. Bearing envelope analysis, on the other hand, involves the demodulation of high frequency resonance associated with bearing element impacts (Bearing Envelope Analysis Window Selection, 2009). In other words, the impacts due to a localised fault modulate a vibration signal at the associated fundamental fault frequencies of the bearing. The vibration signal is then passed through a high pass (or band pass) filter which rectifies the signal into half or full wave. This rectified signal is passed further through a low pass filter which separates the modulation (or defect) frequency from carrier frequency.

Analysis (Bearing Envelope Analysis Window Selection, 2009) also reveals that the amplitudes associated with each of the bearing fault frequencies can be used as CIs reflecting the health of the bearing components. However, using four CIs corresponding to each fundamental fault frequency of the bearing, it is very likely that each sub element (i.e. ball, train, inner and outer race) of the bearing will have its own resonant mode. As a result, a selection of window for frequency and bandwidth to capture the amplitudes associated with one of the fault frequencies of the bearing might not be an optimal choice for other three sub elements. Moreover, as CI values indicate health in different parts of the spectrum, each will have different nominal amplitude values.

The load of the machine was not taken into consideration for spectrum analysis and amplitude calculations, in order to develop a prototype ML model with a set of minimum predictor variables.

3.2 Relationship of CIs to classify data

The ML model to be developed postulates the relative values of amplitudes associated with the BPFI and BPFO (see Section 1.3 and Figure 3) can be used as the CIs of the rolling element bearing if we use the log ratio of BPFI and BPFP amplitudes {i.e.$\log\left(\frac{BPFIAmplitude}{BPFOAmplitude}\right)$} to categorise various fault stages in the lifecycle of the bearing (MathWorks, Inc., 1994-2018). With an understanding (Rolling Element Bearing Analysis, 2012) of the four fault stages in the lifecycle of a rolling element bearing, the lifecycle of the bearings used in this research are considered to be comprised of three fault stages (i.e. Fault Stage 1, Fault Stage 2, Fault Stage 3), avoiding Fault Stage 4 in order to prevent any 'run to failure' scenario in accordance with applicable maintenance policies.

Furthermore, the domain expert would also determine any particular 'Fault Stage' (assigning the label) in the training dataset based on his 'expert knowledge' and this classification would be compared with that assigned by the trained ML model as described in the Steps 4 to 7 of the methodology (Figure 5).

3.3 CI extraction

In order to extract two CIs as discussed above, a set of pre-existing MATLAB codes were modified to develop a batch processing algorithm meeting the requirements of available data specifications and the abovementioned ML model hypothesis. This algorithm makes use of MATLAB functions such as envelope spectrum analysis, spectrogram and spectral kurtosis, in order to extract the relative values of amplitudes associated with the BPFI and BPFO from each of the samples of given dataset (MathWorks, Inc., 1994-2018).

4 Results and discussion

Section 3 discusses in detail the developed methodology and the gained results. The section also includes a detailed uncertainty analysis to provide the reader with confidence in the computed results.

4.1 Determining and assigning the rules of classification to training data

This step involved the determination of log ratio of relative amplitudes of BPFI and BPFO {i.e.log $\left(\frac{BPFIAmplitude}{BPFOAmplitude}\right)$}in the training dataset and then assigning a best-fit range of these values to each of the four class labels i.e. 'Normal', 'Fault Stage 1', 'Fault Stage 2', and 'Fault Stage 3', as illustrated in Figure 6. A customised MATLAB code was used to extract the values of relative amplitudes associated with BPFI and BPFO and their log ratio for each of the given samples of training dataset stored in an ensemble data store. The log ratio vector of training data samples was discretised into four bins using the histogram function of MATLAB. The bin edges obtained approximately define the boundaries of each of the class label as mentioned in Figure 6a. Applying the histogram function on pre-labelled training data samples by the domain experts, a general trend for each of the classification label was revealed and the bins were assigned 'labels' as mentioned in Figure 6b and 6c. Figure 6d shows the sample counts in a narrower bin width in each of the assigned class. The training data samples were relabelled by applying a newly defined classification rule at their log ratio vector and results were then compared with the class labels assigned by the domain experts.

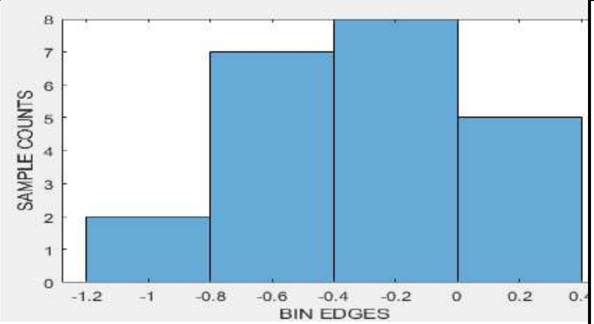


Figure 6a: Bin edges of log(BPFIAmplitude/BPFOAmplitude) defining the boundaries of each of the class label

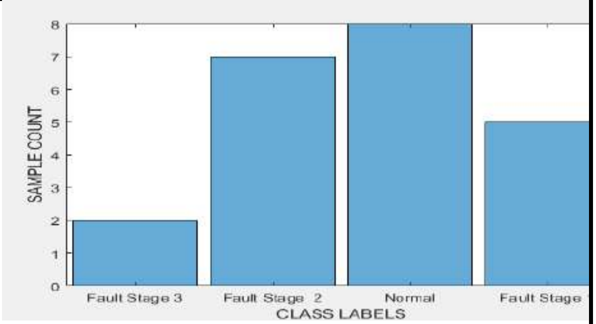


Figure 6b: Class labels corresponding to each bin

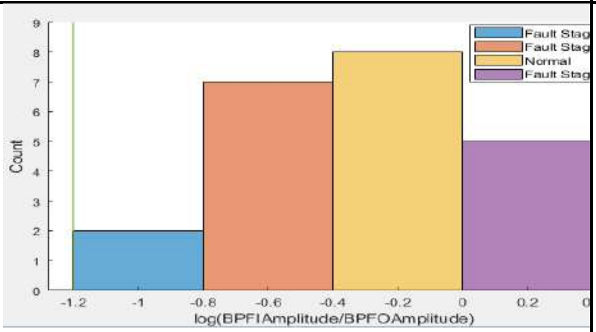


Figure 6c: Bin edges and class labels

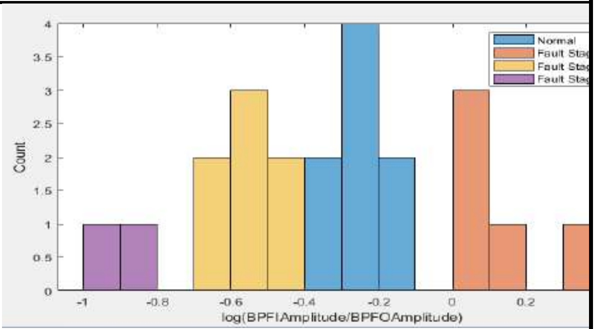


Figure 6d: Sample counts in each of the defined class bins

Figure 6: Determining and assigning the rules of classification

The classification accuracy of approximately 55% was recorded according to the defined classification rule as illustrated in Figure 6a. The error of 45% due to the misclassification of pre-labelled data (defined by the domain experts) could be attributed to the limited number of data samples, and also no distinctly and specifically defined boundary distinguishing one stage fault from another in the spectrum and envelope analysis of vibration signals, thus providing the domain expert a leverage of open choice to make judgement about the fault stage. It is, therefore, highly likely that human judgement can assign a misclassified label relative to the classification defined in Figure 6 as it can vary from person to person due to his/her expertise and experience in vibration analysis.

4.2 Choosing, fitting and training the ML Model

A specific data table was created in MATLAB for choosing, fitting and training the ML using MATLAB's Classification Learner App (CLA) (MathWorks, Inc., 1994-2018). The data table was comprised of three predictor variables i.e. 'BPFI Amplitude', 'BPFO Amplitude' and their log ratio {i.e.log $\left(\frac{BPFIAmplitude}{BPFOAmplitude}\right)$}; the response variable being 'Class Label' as discussed in the Section 3.1. The vector 'Class Label' was comprised of data labels assigned to each training data sample according to the determined classification rule as per the Figure 6. CLA in MATLAB allows using the training data for a number of classification models simultaneously with an output of overall validation accuracy score (expressed in percentage) displayed for the models trained. The validation accuracy score is the indicator of a model's performance on new data compared to the training data (classification performance). Making use of this capability of CLA, weighted nearest neighbour classifier (Weighted KNN) with an accuracy of 90.9% (as calculated by CLA) was finally selected for further analysis. A Weighted KNN model works on the principle of making distinctions between the classes using a distance weight (MathWorks, Inc., 1994-2019). The algorithm applied by CLA to develop Weighted KNN model categorised the training data into 10 numbers of neighbours based on the distance between the standardised data points and applied Euclidean metric for distance determination. The algorithm also used squared inverse method to determine the distance weight between the classes. Another reason for making the choice of Weighted KNN over other models with the similar accuracy scores was the simplicity and effectiveness of the model particularly given all the predictors of the training datasets are numeric.

4.3 Visualisation of ML Model

The appropriateness of chosen ML model can be further analysed and compared with other ML models trained with the same training data by using various visual techniques available in MATLAB and its CLA function. Such techniques include scatter plots, confusion matrix, parallel coordinates plot, Receiver Operating Characteristics (ROC) curve etc. (MathWorks, Inc., 1994-2019).

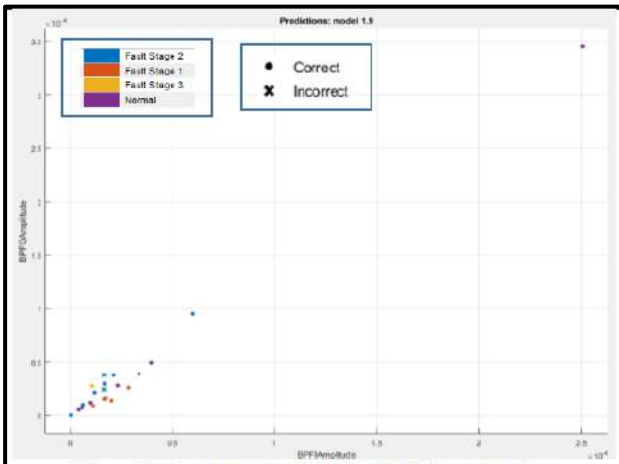


Figure 7a: Scatter plot of Weighted KNN model gives visualisation about the misclassified points out of the training data

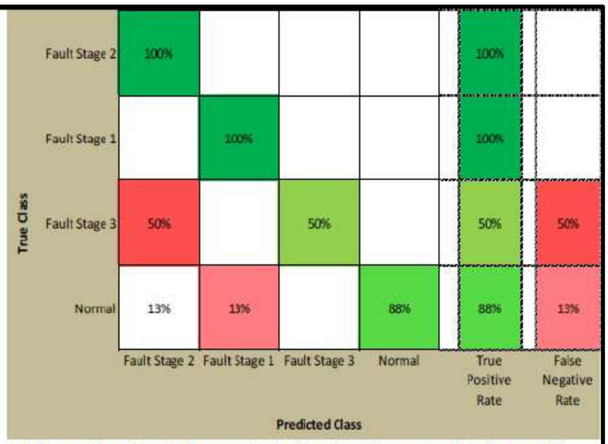


Figure 7b: Confusion matrix showing the numerical as well as heat map indications for the match between true and predicted classes of the Weighted KNN model

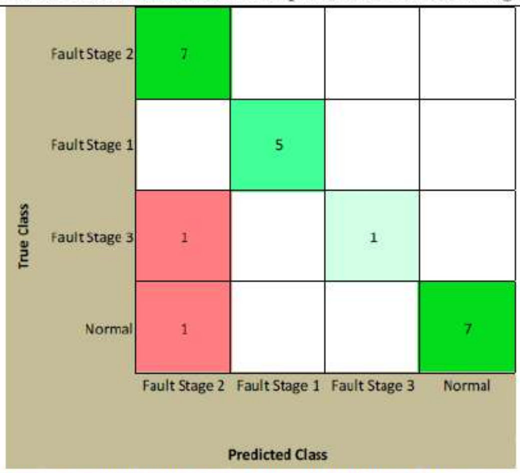


Figure 7c: Confusion matrix in terms of no. of observations

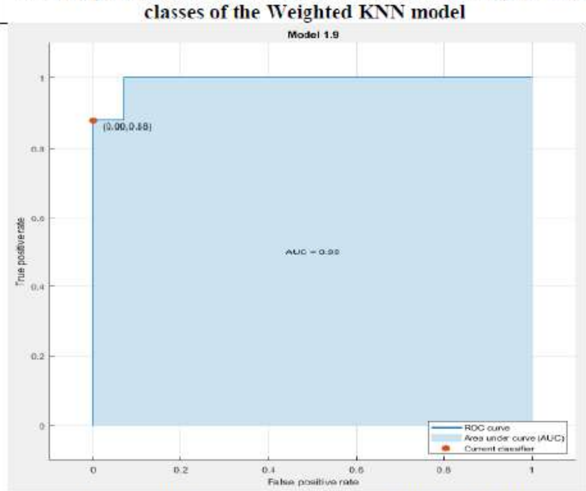


Figure 7d: ROC curve in terms of TPR and FPR

Figure 7: Visualisation of and performance of Weighted KNN model

The scatter plots give visualisation about the misclassified points out of the training data and also help to make feature selection in order to get best possible generalisation of chosen ML model. Figure 7a is the scatter plot of chosen ML model i.e. Weighted KNN and shows the misclassification of two points. Parallel coordinates plot is another technique commonly used for feature selection. However, due to very limited number of predictors, feature selection is not applicable in this case.

The model can be further analysed in confusion matrix plots which provide an indicative performance evaluation for each of the class in the ML Model, as mentioned in Figure 7b for Weighted KNN model. The diagonal cells in Figure 7b provide the numerical (in percentage) as well as heat map indications for the match between true and predicted classes, and True Positive Rate (TPR) and False Negative Rate (FNR) for each classifier. Figure 7c provides the similar visualisation in terms of actual number of observations for each of the class.

ROC curve is another technique to assess the performance of each of the classifier included in the chosen ML model in terms of TPR and false positive rate (FPR). Figure 7d shows the TPR of 0.88 for the classifier 'Normal', in concurrence with TPR mentioned in Figure 7b, which means that the class 'Normal' assigns 88% of the observations correctly in the chosen Weighted KNN model. Similarly the ROC for each of the class can be visualised separately.

4.2 Testing the trained ML model

Testing of the developed ML model involved making predictions of classes for new datasets. In other words, the developed ML should allocate a correct class label to each of the random samples of bearing vibration data in the Testing Dataset. The accuracy of the prediction is the measure of generalisation of the developed ML model. The testing dataset, comprised of 12 random (unlabelled) samples of bearing vibration data, was processed and prepared for ML model testing using once again a customised MATLAB code (as discussed in Section 1.3.2) which also extracted the values of three predictor variables i.e. relative amplitudes associated with BPFI and BPFO and their log ratio for each of the given samples of testing dataset stored in a separate ensemble data store.

The predict algorithm of Weighted KNN model was then run to get the class labels for each of the data sample. The model performed with 0 % testing error i.e. none of the data samples in testing dataset was misclassified by the ML model. The reason for this perfect performance can be attributed to the quality of testing dataset in which none of the samples had any parameter unrecognised by the trained Weighted KNN model. The test results for each of the samples were shared with domain experts and their concurrence with the model test results based on their expert knowledge was obtained. Comparing the concurrence results received from the domain experts with that of produced by the ML model, it was revealed that the ML model assigned the class labels to 42% of the samples correctly relative to the expert judgement i.e. 58% of the samples were not classified correctly as per the expert judgement.

It was also found that the misclassifications allocated by the domain experts were closely interfaced in terms of fault stages in the most cases.

4.3 Comparison of classification accuracy

The relative classification accuracy of training data (as discussed in Section 4.1) and testing data (as discussed in Section 4.3) with respect to both ML model and expert judgement results were validated and the summary of the comparison were presented in Figure: 8.

	Classification Accuracy for Training Data	Classification Accuracy for Testing Data
ML Model	55%	100%
Expert Judgement	100%	42%

Figure 8: Comparison between ML model and expert judgement for relative classification accuracy of training and testing data

Learning (MathWorks, Inc., 2018) also reveals that classification accuracy required from a ML model is driven by the importance of information in a given decision making framework. For example, the accuracy of information required by a ML model in a medical diagnostics framework cannot be compared with the one which is used for making decisions in a typical condition monitoring program. Additionally, the more complex a ML model is to fit the training data near perfection, less efficiently it would perform with the new datasets. However, in any case the generalisation and thus the accuracy of a ML are dependent on the amount and variety of training datasets. Apart from human error, the discrepancies in expert judgement with respect to the developed ML model can also be attributed to the system's environment specific operational features taken into consideration by the domain experts, which are not the part of training data.

In case of Weighted KNN model which is a prototype ML model developed for this research, the classification accuracy (as mentioned in Figure 8) appears reasonable considering the fact that the model was trained with one dataset containing only 22 data samples with four different class labels.

The most desirable way to minimise accuracy discrepancies between the human judgement and Weighted KNN model is an iterative training of the ML model with as many data samples for each of the class label as possible.

If the ML model performance does not improve proportionately to the iterative training, the other options worth considering could be reviewing the rules of classification such as reviewing the bin edges (as mentioned in Figure 6) so as to include the misclassified samples and/or fitting other ML models most appropriate to the data type, quality and quantity. Other contributing factors to maximise the accuracy of a ML model could be improving the human judgment with further training of domain experts and/or operators and incorporating system's environment specific dynamics in the training data.

4.4 Estimating Remaining Useful Life (RUL)

Estimating RUL is one of the main objectives of prognostic analysis for any system, equipment or its components. It generally involves the development of a model which can provide estimation of RUL based upon the time evolution or statistical properties of CI values (MathWorks, Inc., 1994-2019). Prognostic analysis can make use of mathematical models, machine learning or a combination of both to predict the values of CIs which can be used to compute RUL metrics (MathWorks, Inc., 1994-2019). However, in order to develop such RUL models with an acceptable accuracy a large amount of life data is required. In the case of this research, using expert knowledge about the average time a bearing takes to develop one of the labelled fault stages, and then the average time it requires to reach the stage where it should be considered for an immediate replacement, a simple ML regression model can be developed.

Given the amount of data and significant feedback from domain experts, a linear regression ML model was developed using 'Regression Learner App' of MATLAB. The training data was comprised of four predictor variables i.e. 'BPFI Amplitude', 'BPFO Amplitude', log ratio {i.e.log $\left(\frac{BPFIAmplitude}{BPFOAmplitude}\right)$} and bearing fault stages (class labels); the response variable being the average RUL corresponding to each of the fault stages (class labels). The performance and accuracy of the developed liner regression ML model was mainly dependant on the allocation of class labels by the classification ML model i.e. Weighted KNN as the average RUL values (in hours) were trained corresponding to the allocated fault stage. Figure 9a shows the response plot of linear regression ML model trained with the same training data as that used to develop Weighted KNN model. Figure 9b shows the response plot of the same regression trained model with respect to log ratios.

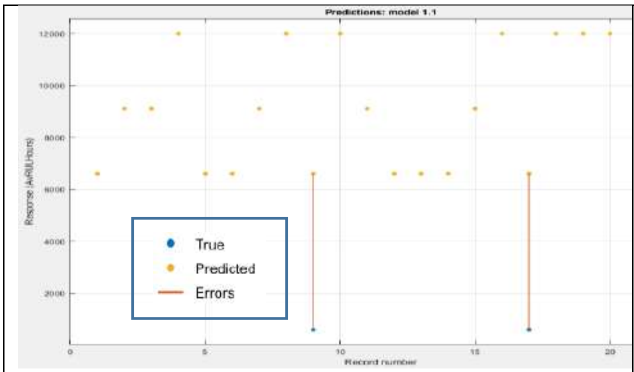


Figure 9a: Response plot of linear regression ML model trained to estimate average RUL corresponding to the classifications allocated by Weighted KNN model

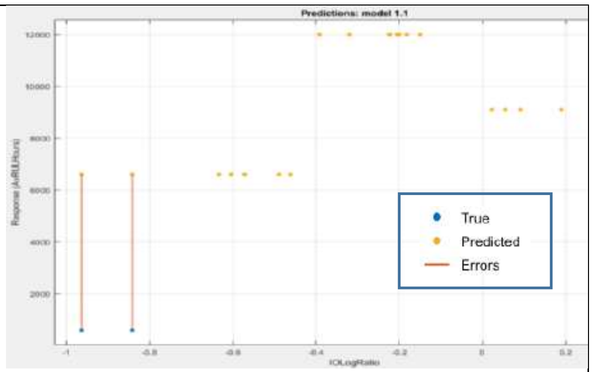


Figure 9b: Response plot (IOLogRatio vs AvRULHours) of linear regression ML model trained with the same training dataset as that used to train Weighted KNN model

Figure 9: Response plots of linear regression ML model

5 Conclusion

Similar to its application for many other data driven systems, processes and operations, ML can also be a game changer for the performance optimisation of an Asset Management System and thus enhancing the value of asset management tangibly or intangibly. The approach of transforming human expert knowledge into ML models can be applied effectively to capture and preserve the knowledge, experience and expertise of humans for any process and/or analysis. Such a ML model with high level of accuracy can be utilised not only to improve the process control due to a tried-and-tested decision making framework but number of humans required to do the job can also be reduced significantly. Furthermore, such ML models also provide an opportunity to improve the training standards of future humans and to define new benchmarks of system and equipment design.

Due to a number of specific challenges involved pertaining to the logistics of data acquisition for a defence maritime materiel, a ML model inculcated with human expert knowledge can play a pivotal role in developing a decision making framework for the adoption and implementation of risk based maintenance philosophies such as PdM and CBM etc. For instance, such ML models can employed effectively to make more accurate and timely decisions on the replacement of parts in order to minimise the failures at sea and reducing their replacement earlier that required, thus enhancing the availability and affordability of the materiel respectively.

ML models can be developed for both diagnostic and prognostic analysis of the systems, equipment and their components. However, similar to the diversity of techniques used in data processing, there is no pre-determined best method, algorithm or technique which can be applied to any specific real world scenario even, if a similar scenario has previously been analysed. Every application of ML is unique and, therefore, significant investment of time and effort is required by appropriately skilled people to achieve the best possible application of a ML model.

The more a model is trained with a variety of datasets, the more it will generalise the given process and, thus, the more meaningfully it will produce the results.

The next version of the developed ML model can include the load of the rotating machines as one of the predictor variables. The application of ML is not limited to the condition monitoring only, but it can be very effectively applied for the operations of the machinery wherein the critical operational parameters of the machinery specific to the system environment can be used as CIs to establish the diagnostic and prognostic analysis.

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Proceedings

Efficiency of Shipping Port Management from Environmental Perspectives

Title: Applicability of International Law in Development of Sustainable Port Policy: An Analysis of Good Practices and Future Policy of Gwadar Port

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Abstract: With the emergence of Sustainable Development Goals (SDGs), the port governance models attempt to incorporate more sustainable practices in their operational policies. As nodes of international trade, ports play a significant role in global financial growth, and their operations are subject to environmental protection. However, the literature on port governance models is limited with the perspectives of either national economic growth or environmental hazards or ports interface with the hinterland. There is much margin in examining the role of the port in SDGs, which seems effective to accommodate the role of sustainable ports in achieving economic growth, environmental protection and social development simultaneously. The intricacy is due to the undeveloped connection between 'sustainable port' and 'SDGs.' On the other hand, good national port policies are effective and practical in harmonising port governance models and SDGs. The futuristic policy for a developing port will be further constructed to assist the international community in establishing policy for 'sustainable ports' and their influential role in global sustainability.

Keywords: **Sustainable Ports, International Maritime Organization, Sustainable Development Goals, Port Governance, Sustainability.**

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1 Introduction

Recently, the Secretary-General of International Maritime Organisation (IMO), in reply to a question 'do ports need international regulation?' stated that, 'some IMO instruments extend to port operations, however, there are many opportunities to explore further and enhance the cooperation between shipping, ports and the logistics industries.'[1] In terms of international law, the IMO instruments are known as 'port State control,' which are limited to the shipping regulations, specifically regulate ships' surveys to ensure compliance of environment, labour, and safety standards.[2] International Convention for the Safety of Life at Sea, International Convention for the Prevention of Pollution from Ships, and International Convention on Standards of Training, Certification and Watchkeeping for Seafarers are placed for international shipping and as the port State control regulations mainly regulate ships.[3]

Other than the IMO instruments as mentioned earlier, the international law deals with the port and shipping interfaces, specifically, the ports' safety and security for shipping activities or particular to the port-State control for some particular violations.[4] The only international multilateral treaty on the ports is the Convention and Statute on the International Régime of

[1] 'IMO Considers Regulating Ports' (*The Maritime Executive*) <https://www.maritime-executive.com/article/imo-considers-regulating-ports> accessed 22 October 2019.
[2] 'Procedures for Port State Control' (*Resolution A.1119(30) IMO Assembly, 1-114*, 2017) <http://www.imo.org/en/KnowledgeCentre/IndexofIMOResolutions/Assembly/Documents/A.1119%2830%29.pdf>.
[3] International Convention for Prevention of Pollution from Ships 1973 (1340 UNTS 61, 184); International Convention for the Safety of Life at Sea 1974 (came into force on 25 May 1980, (1184 UNTS 3)); International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978 (as amended in 1995, came into force on 28 April 1984, (1361 UNTS 2/1362 UNTS 2)).
[4] Stephan Gollasch and others, 'Critical Review of the IMO International Convention on the Management of Ships' Ballast Water and Sediments' (2007) 6 Harmful algae 585.

Maritime Ports (Geneva Convention).[5] The purpose of the Geneva Convention obliges the port-States to treat the ships equitably flying their flags with the facilities at ports as berthing, loading, charges and dues [6]. Apart from the Geneva Convention, there are regional agreements in quest of harmonising policies in port State control to protect the marine environment from shipping and ensure maritime safety [7].

Secretary-General of the IMO also said that by streamlining the port policies to remove trade barriers, rethinking safety, security, and environmental protection is obliging due to the importance of the interplay between the ports and United Nations Sustainable Development Goals (SDGs).[8] SDGs aiming towards environmental protection, social development, and economic growth simultaneously may complicate the future regulation of ports.[9] As SDGs are overgeneralised, arising from international law, and coincided in the global epoch Anthropocene simply, their precise impact on the governance of usual business, including ports and shipping, is not addressed technically. The governance of ports under SDGs is crucial because the ports host 90% of international trade and 40% of the world's population economically and adversely impact the marine and terrestrial environments.[10] Moreover, hypothetically considering the growing demands of international trade causing new ports or expansion of old ports is threatening to the space used for beaches, port cities, leisure activities and aesthetic purposes.

[5] Convention and Statute on the International Régime of Maritime Ports 1923 (came into force on 26 July 1926, League of Nations Treaty Series (Vol 58, p 285)).
[6] Louise de La Fayette, 'Access to Ports in International Law' (1996) 11 The International Journal of Marine and Coastal Law 1.
[7] Ted L McDorman, 'Regional Port State Control Agreements: Some Issues of International Law' (2000) 5 Ocean and Coastal Law Journal 207.
[8] 'IMO Considers Regulating Ports' (n 1).
[9] Ilse R Geijzendorffer and others, 'Ecosystem Services in Global Sustainability Policies' (2017) 74 Environmental Science & Policy 40.
[10] 'Factsheet: People and Oceans' (United Nations 2017) Available at: https://www.un.org/sustainabledevelopment/wp-content/uploads/2017/05/Ocean-fact-sheet-package.pdf <https://www.un.org/sustainabledevelopment/wp-content/uploads/2017/05/Ocean-fact-sheet-package.pdf>.

The two practical examples of port governance models harmonising the SDGs in business policies are developed under the Canada Marine Act (CMA) of Canada and the Sustainable Ports Development Act (SPDA) of Australia.[11] Both frameworks implement international law (soft and treaty law) in the implementation of SDGs. The regulation under the CMA governs the operations of the port in order to reduce environmental impacts.[12] SPDA governs the development of new ports or expansion of old ports to minimise the adverse impacts on the Great Barrier Reef.[13] However, any of the frameworks do not harmonise SDGs holistically; both the frameworks address SDGs in a specific manner. As CMA focuses the environmental protection with economic growth and SDPA is for protection of the land-spaces which are threatened due to ports' development.

Given above, the complicated role of ports in the implementation of SDGs requires serious redressal. However, the literature converging on the SDGs implementation in port policies confuses the international law application with the enforcement of strong sustainability, which means that environmental protection or restoration hampers economic growth.[14] On the other hand, the development or growth rationalists opines that the port operational role in economic development could be balanced with the SDGs under the global trade liberalisation policies.[15] Perhaps a combination of SPDA and CMA provides a way forward if analysed with the

[11] Richard Gaudreau and others, 'Review of the Canada Marine Act' (Transport Canada 2002) ISBN 0-662-67359-X/Catalogue No. T22-120/2003/TP14107B, Available at: http://www.bv.transports.gouv.qc.ca/mono/1150299.pdf <http://www.bv.transports.gouv.qc.ca/mono/1150299.pdf> accessed 19 December 2019. And See, David Nicolls, Robyn Lamb and Ruby Rayner, 'Update: "Sustainable Ports Development Act 2015"' (2016) 35 Australian Resources and Energy Law Journal 3.
[12] Ramon Baltazar and Mary R Brooks, 'The Governance of Port Devolution: A Tale of Two Countries' (Citeseer 2001).
[13] Nicolls, Lamb and Rayner (n 11).
[14] L Sislian, A Jaegler and P Cariou, 'A Literature Review on Port Sustainability and Ocean's Carrier Network Problem' (2016) 19 Research in Transportation Business & Management 19.
[15] Mary R Brooks, Kevin PB Cullinane and Athanasios A Pallis, 'Revisiting Port Governance and Port Reform: A Multi-Country Examination' (2017) 22 Research in Transportation Business & Management 1.

operationalisation of the international (soft and treaty) law and the literature on governance of SDGs.

Nevertheless, the effectiveness of harmonisation of diverse port policies is determined when a futuristic approach is attained, including their applicability to a national port.[16] This futuristic approach on a national port contributing to economic growth while protecting the environment and preserving the natural resources can be determined by the future port of Gwadar, located in Pakistan. The port of Gwadar is under the infrastructure development phase, and its old policy framework is under reconsideration.[17] China's Belt and Road Initiative most lubricated corridor China-Pakistan Economic Corridor (CPEC) routed towards the Gwadar, making it one of the busiest ports in Asia.[18] Additionally, the Central Asian States, the Russian Federation and the Middle Eastern States have drawn their interests in Gwadar port as a trade route.[19] Howbeit, the existing policy framework of Gwadar port entitled as the Gwadar Port Authority Ordinance (GPAO) has ignored the sustainability in totality.[20]

A new framework for Gwadar port will be notable by harmonising sustainable port policy with CMA and SPDA. The development of the sustainable policy framework intends to assist the global ports community that is already moving towards sustainable ports.[21] Nevertheless, the

[16] Yehezkel Dror, 'Policy Analysts: A New Professional Role in Government Service' (1967) 27 Public Administration Review 197; Giuliano Mingardo, 'Cities and Innovative Urban Transport Policies' (2008) 10 Innovation 269.
[17] Maham Hameed, 'The Politics of the China—Pakistan Economic Corridor' (2018) 4 Palgrave Communications 1; Uzair Ikram, 'Federal Minister Khusro Bakhtiar Reviews Gwadar Master Plan' (*China Pakistan Investment Corporation Global*, 31 January 2019) <https://www.cpicglobal.com/federal-minister-khusro-bakhtiar-reviews-gwadar-master-plan/> accessed 9 May 2020.
[18] Zahid Anwar, 'Gwadar Deep Sea Port's Emergence as Regional Trade and Transportation Hub: Prospects and Problems' [2010] Journal of Political Studies <https://go.gale.com/ps/i.do?p=AONE&sw=w&issn=19941080&v=2.1&it=r&id=GALE%7CA253609189&sid=googleScholar&linkaccess=abs> accessed 10 May 2020.
[19] Sajjad Ashraf, 'Gwadar Will Be the Economic Funnel for the Region, Op-Ed, Page - 24.' (*Gulf News*, 24 May 2017) <https://gulfnews.com/opinion/op-eds/gwadar-will-be-the-economic-funnel-for-the-region-1.2032494> accessed 21 July 2019.
[20] Faisal Chaudhry, 'Perspectives from Balochistan's Natural Gas Fields and the Port City of Gwadar' [2014] Globalization, Development and Security in Asia - The Political Economy of Energy.
[21] Verhoeven, 'World Ports Sustainability Program Started' (*International Association of Ports and Harbours*, 23 March 2018) <https://www.iaphworldports.org/news/4718> accessed 19 November 2019.

literature is not as organised to determine the importance of a sustainable port for global sustainability.[22] There are sets of asymmetric ideas and notions lacking uniformity, posing a hurdle to suggest paths in harmonising policies.

Therefore, in its first part, this research will revisit the literature in reckoning the role of a sustainable port in SDGs. The corresponding parts are with analysis of the applicability and operationalisation of the international law for sustainable ports and good national practices contributing to the achievement of SDGs. The following part analyses the policy of Gwadar Port. It provides strong recommendations for it in following the international law and competent practices (CMA and SPDA) and with the foresight of implementing SDGs.

1 The Role of Sustainable Port in SDGs

The fundamental obstacle emerges with the commonly accepted definition of a 'sustainable port,' which is the one provided by the American Association for Port Authorities (AAPA). AAPA defines a sustainable port as 'business strategies and activities that meet the current and future needs of the port and its stakeholders while protecting and sustaining human and natural resources.'[23] While reviewing from the perspective of SDGs, this definition lacks a complete design of a sustainable port. This definition focuses the business strategically, which depicts limited to the port operational and management policies. Although it is urging to formulate policies to protect and sustain humans and natural resources, it seems that the definition prioritises the needs of the ports and their stakeholders. The predicament is with 'business strategies' because it does not include environmental protection and resource preservation

[22] Dalwon Kang and Sihyun Kim, 'Conceptual Model Development of Sustainability Practices: The Case of Port Operations for Collaboration and Governance' (2017) 9 Sustainability 2333.
[23] Gul Denktas-Sakar and Cimen Karatas-Cetin, 'Port Sustainability and Stakeholder Management in Supply Chains: A Framework on Resource Dependence Theory' (2012) 28 The Asian Journal of Shipping and Logistics 301.

policies.[24] Whereas, preservation of natural resources requires effective and efficient port operational policies to mitigate ports' expansion.[25] Likewise, environmental protection is a broad phenomenon, and due to port operations, the environment of port cities (major stakeholder in ports) is compromised.[26]

AAPA's definition is with a rationalist approach, which conceives that a sustainable port has nothing to do with SDGs or economic growth must be prioritised over SDGs. Notwithstanding, a comprehensive view of the current and upcoming needs of the port and its stakeholders are novel to support an argument that 'a sustainable port is necessary for the implementation of SDGs.' As the principal economic stakeholder in port, the State provides policy mechanisms to gain maximum through its operations.[27] The economic growth of any State in terms of industrialisation and trade development heavily relies on effective port operational management. More precisely, the State authorities regulating ports, the private sector and the port cities are primary stakeholders seeking swift employment, entrepreneurship, business and trade opportunities.[28]

Besides economic growth, the stakeholders and port cities valiantly demand a clean environment, as the port operations substantially impact the air, terrestrial and oceans adversely.[29] As a matter of cultural and national recognition, heritage sites are among the other

[24] Andreas E Fousteris and others, 'The Environmental Strategy of Businesses as an Option under Recession in Greece' (2018) 10 Sustainability 4399.
[25] John RM Gordon, Pui-Mun Lee and Henry C Lucas Jr, 'A Resource-Based View of Competitive Advantage at the Port of Singapore' (2005) 14 The Journal of Strategic Information Systems 69.
[26] Will Focht, 'Governance for Sustainability' (2008) 17 Environmental Politics 131. See also, Magdalena Klopott, 'Restructuring of Environmental Management in Baltic Ports: Case of Poland' (2013) 40 Maritime Policy & Management 439.
[27] GS Dwarakish and Akhil Muhammad Salim, 'Review on the Role of Ports in the Development of a Nation' (2015) 4 Aquatic Procedia 295.
[28] Zhen Chen, 'Research on the Interaction between Innovation and Port-City Economic System: A Case from China' (2015) 2015 Discrete Dynamics in Nature and Society 9.
[29] Sulan Chen and Juha I Uitto, 'Governing Marine and Coastal Environment in China: Building Local Government Capacity Through International Cooperation' [2003] China Environment Series 67; Klopott (n 26).

interests of any State.[30] These sites are threatened due to port expansion and the development of a new port. Additionally, the waterfront is a leisurely interest, not limited to a State but also the port cities. Hence, summing up the needs of the port and its stakeholders construe a connexion between 'sustainable port policy' and 'policies for national economic, environmental and intergenerational sustainability.'[31] The diverse interests of the port stakeholders are for the implementation of SDGs. However, the literature misconceives a complete visionary and integrated policy for 'sustainable port' from all aspects.

The literature developed by the rationalists focusing on economic growth also misinterprets the development needs of the stakeholders. As with the emergence of SDGs, global economic growth is not limited to finance; it extends to the social development of humans.[32] Similarly, environmental protection calls to protect the environment beyond human needs as an ecosystem and natural habitat.[33] Moreover, intergenerational sustainability in terms of preservation of natural resources forwards energy conservation and conservancy of land spaces.[34] As the land-spaces fronting, the oceans are primarily natural resource endangered due to port expansion or development.

An inclusive visual of SDGs, seeking its output from a 'sustainable port,' is to balance economic growth with environmental protection and resource preservation,[35] as ports are a point of customs collection contributing to the economy of a State, a border area of immigration control

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[30] David Pinder, 'Seaport Decline and Cultural Heritage Sustainability Issues in the UK Coastal Zone' (2003) 4 Journal of Cultural Heritage 35.
[31] Chen and Uitto (n 29); Vitalii Nitsenko and others, 'Business Model for a Sea Commercial Port as a Way to Reach Sustainable Development Goals' [2017] Journal of Security and Sustainability Issues 155.
[32] Sudhir Anand and Amartya Sen, 'Human Development and Economic Sustainability' (2000) 28 World development 2029.
[33] Stephen J Jordan and others, 'Accounting for Natural Resources and Environmental Sustainability: Linking Ecosystem Services to Human Well-Being' (2010) 44 Environmental Science & Technology 1530.
[34] Brian Barry, 'Sustainability and Intergenerational Justice' (1997) 44 Theoria 43.
[35] Nitsenko and others (n 31).

susceptible for the security, and the area connecting intermodal transportation networks.[36] Thus, SDGs' harmonisation goes beyond when ports interplays with economic growth, environmental protection, and security simultaneously.

Surprisingly, the literature is not covering the security aspect influentially because it is a grave national concern that cannot be harmonised and not tethered with SDGs. Conversely, in a few developed States, the port security policies are integrated with economic growth, promoting cooperation and coordination for good port performance through swift utilisation of advanced technology.[37] These integrated policies forward a mechanism of collaboration among security and regulatory authorities.[38] However, taking account of the port security policies in harmonisation for SDGs is quite complicated due to diverse national security arrangements.[39] A way forward may be to adopt technological means as utilised in a few developed States.

On the other hand, environmental protection and resource preservation, both are observed as an obstacle while balancing it with economic development.[40] Moreover, at national levels, and more precisely in developing States, coupling ports with global sustainability is invasive for economic growth.[41] If tethered with strict environmental compliance, the influx of transportation and trade activities at ports hinders the economic activity.[42] Likewise, hitching

[36] Gregory Parnell and others, 'Decision Analysis Tools for Safety, Security, and Sustainability of Ports and Harbors In: Linkov I., Wenning R.J., Kiker G.A. (Eds) Managing Critical Infrastructure Risks. NATO Science for Peace and Security Series C: Environmental Security' [2007] Managing Critical Infrastructure Risks 245.
[37] Tahazzud Hossain, Michelle Adams and Tony R Walker, 'Sustainability Initiatives in Canadian Ports' (2019) 106 Marine Policy 103519.
[38] Khalid Bichou, 'Risk-Based Cost Assessment of Maritime and Port Security. In: Bell M., Hosseinloo S., Kanturska U. (Eds) Security and Environmental Sustainability of Multimodal Transport. NATO Science for Peace and Security Series C: Environmental Security' [2010] Security and Environmental Sustainability of Multimodal Transport 183.
[39] DE Onwuegbuchunam, 'Assessing Port Governance, Devolution and Terminal Performance in Nigeria' (2018) 2 Logistics 6; Marisa A Valleri, Maria Lamonarca and Paola Papa, 'Chapter 6 Port Governance in Italy' (2006) 17 Research in Transportation Economics 139, 6.
[40] Jong-Kyun Woo, Daniel SH Moon and Jasmine Siu Lee Lam, 'The Impact of Environmental Policy on Ports and the Associated Economic Opportunities' (2018) 110 Transportation Research Part A: Policy and Practice 234.
[41] AD Couper, 'Environmental Port Management' (1992) 19 Maritime Policy & Management 165.
[42] Bart W Wiegmans and Harry Geerlings, 'Sustainable Port Innovations: Barriers and Enablers for Successful Implementation' (2010) 3 World Review of Intermodal Transportation Research 230.

the port development or expansion with resource preservation delays trade and economic activity.[43]

Given the problems with ports and SDGs implementation, if the literature on SDGs governance is formulated in conjunction with the corporate regulatory practices will maintain the balance.[44] As the liberalisation of international trade regulation demands to remodel of port fiscal policies.[45] The model of port privatisation under the governmental authority's regulatory framework allowing private sector investment is beneficial for economic growth and the implementation of SDGs.[46] Such harmonisation will be a challenge; it seeks sufficient input from each sector or stakeholder of the port, as the ports evolve around the environment, employment, safety, trade, transportation, shipping and security regulations, all at the same time.[47] These regulations with the two exemplary policies conceivably determined by opting two phases of 'sustainable port,' i.e. i) development of a sustainable port and ii) operations of the sustainable port.

Policy for port development initially calls to avoid port expansion, but if there is no other resort, it seeks mitigation of the risk to natural resources. A policy for better port operations is to improve its management and security, cater to investment, trade and employment opportunities in line with environmental protection and social development. Both the policies are determined in the next section with the interplay of international law. The guidelines and programmes of

[43] CA Schipper, H Vreugdenhil and MPC de Jong, 'A Sustainability Assessment of Ports and Port-City Plans: Comparing Ambitions with Achievements' (2017) 57 Transportation Research Part D: Transport and Environment 84.
[44] KarenL Higgins, 'Economic Growth and Sustainability – Are They Mutually Exclusive?' (*Elsevier Connect*, 16 May 2013) <https://www.elsevier.com/connect/economic-growth-and-sustainability-are-they-mutually-exclusive> accessed 7 October 2019.
[45] Mary R Brooks, 'Port Governance as a Tool of Economic Development: Revisiting the Question' [2016] Dynamic Shipping and Port Development in the Globalized Economy 128.
[46] A Grech and others, 'Guiding Principles for the Improved Governance of Port and Shipping Impacts in the Great Barrier Reef' (2013) 75 Marine Pollution Bulletin 8.
[47] Marcella De Martino, Fabio Magnotti and Alfonso Morvillo, 'Port Governance and Value Creation in the Supply Chain: The Case of Italian Ports' [2019] Case Studies on Transport Policy <http://www.sciencedirect.com/science/article/pii/S2213624X18303626> accessed 16 November 2019.

the various international organisations are previewed to examine a holistic vision of a 'sustainable port.'

2 Policy for Development of a Sustainable Port

2.1 Operationalisation and Application of International Law for Development of Sustainable Ports

The United Nations Conference on the Human Environment (Stockholm Declaration), recognising intergenerational sustainability, urges to ratify the policies to mitigate the risk of exterminating natural resources.[48] Similarly, the Agreement Establishing the World Trade Organisation (Marrakesh Agreement) maintains this intergenerational balance as 'allowing for the optimal use of the world's resources following the objective of sustainable development.'[49] Moreover, principle 12 of the United Nations Declaration on Environment and Development (RIO Declaration) states that 'trade policy measures for environmental purposes should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade.'[50] This purview of SDGs under international law aggregates the policies for development and the preservation of natural resources, balancing economic growth with environmental protection.

Establishing port policies and governance models accommodating the international law for SDGs endorses that the State authorities avoid additional land allocation to ports. The maximum economic gain to be achieved through the existing land spaces of port and connected logistics. While defying the earlier claims that SDGs hinders economic growth, it is

[48] Declaration of the United Nations Conference on the Human Environment 1973 (UN Doc A/Conf48/14/Rev 1).
[49] WTO Agreement: Marrakesh Agreement Establishing the World Trade Organization 1995 15 April 1994.
[50] United Nations Conference on Environment and Development/Rio Declaration on Environment and Development 1992 (UN Doc A/CONF151/26 (vol I)).

acknowledged that a sustainable port policy under international law is not a barrier to economic development. Such policy encourages 'more utilisation of renewable resources and extracting best from non-renewable resources .' It intends to constitute balanced instruments [51].

The sustainable policies balancing is the *modus operandi* of international treaty law, which can also be observed through the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol.[52] The UNFCCC and Kyoto Protocol encourage eco-friendly cheap energy to minimise the utilisation of existing energy resources.[53] Though the IMO acceleration of UNFCCC through Sulphur 2020 to reduce the emissions is still problematic due to the extra energy requirements of ships.[54] On the other hand, eco-friendly electric rail and road transport connected to ports has significantly reduced the monetary amount and emissions.[55]

A sustainable port policy according to the objectives of the UNFCCC and Kyoto Protocol is constituted to preserve energy and promote eco-friendly. Although such energy transformation for States is challenging, the balance for intergenerational sustainability is obligatory. It is substantiated through the International Court of Justice opinion in *Gabcikovo – Nagymaros Case* as "Owing to new scientific insights and a growing awareness of the risks for mankind - for present and future generations of pursuit of such interventions at an unconsidered and

[51] Couper (n 41).

[52] United Nations Framework Convention on Climate Change 1992 (came into force 21 March 1994, (1771 UNTS 107)); Kyoto Protocol to the United Nations Framework Convention on Climate Change 1997 (came into force on 16 February 2005, (UN Doc FCCC/CP/1997/7/Add1, Dec 10, 1997)).

[53] Ron Benioff and others, 'Strengthening Clean Energy Technology Cooperation under the UNFCCC: Steps toward Implementation' (National Renewable Energy Lab(NREL), Golden, CO (United States), https://www.eldis.org/document/A59713 2010) NREL/TP-6A0-48596 <https://www.eldis.org/document/A59713>; Kyoto Protocol to the United Nations Framework Convention on Climate Change; United Nations Framework Convention on Climate Change.

[54] Mike King, 'Shipping Coalition Takes Aim at IMO 2020 Fuel Preparations' (*Frieght Waves*, 11 September 2019) <https://www.freightwaves.com/news/shipping-coalition-takes-aim-at-imo-2020-fuel-preparations> accessed 16 November 2019.

[55] Grigore Danciu and others, 'Ecological Transportation System Based on Light Electric Vehicles', *2011 7th International Symposium on Advanced Topics In Electrical Engineering (ATEE)* (Institute of Electrical and Electronics EngineersIEEE 2011).

unabated pace, new norms and standards have been developed, outlined in a great number of instruments during the last two decades. Such new norms have to be considered, and such new standards are given proper weight, not only when States contemplate new activities but also when continuing with activities begun in the past. This need to reconcile economic development with protection of the environment is aptly expressed in the concept of sustainable development."[56]

There are two subsequent challenges of the port's stakeholders and substantial harm to the State's economic development. One is the heritage preservation to safeguard and conserve the national identity and history, and the other is the protection of waterfronts of the port cities. The heritage sites and waterfronts are tourist attraction and require management and rehabilitation, conceivably a cost. Conversely, these sites are valuably contributing to the local economy, though their economic impacts compared to trade are less, notwithstanding, their educational importance is far high as compared.[57]

Therefore, the Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention) distinctly protects the heritage for learning and experiencing history.[58] In addition to this, Article 2 of the World Heritage Convention defines cultural heritage to cover the protection of aesthetic waterfronts to port cities. Article 2 of the World Heritage Convention states' natural features consisting of physical and biological formations or groups of such formations, which are of outstanding universal value from the

[56] *Case Concerning the Gabcikovo-Nagymaros Dam (Hungary v Slovakia)* (1997) (1998) Rep 37 LLM 162 (International Court of Justice).

[57] Marcin Poprawski, 'Intergenerational Transmission of Values and Cultural Sustainability: The Cultural Participation of Local, Small Town Communities in Poland' (2016) 20 Law, Social Justice & Global Development 1; Donovan D Rypkema, 'Heritage Conservation and the Local Economy' (*Global Urban Development Magazine, 4, 1, 1,* August 2008) <http://www.globalurban.org/GUDMag08Vol4Iss1/Rypkema.htm> accessed 15 November 2019.

[58] Convention Concerning the Protection of the World Cultural and Natural Heritage 1972 (came into force on 17 December 1975 (1037 UNTS 151)).

aesthetic or scientific point of view.'[59] Hence, operationalising the port policies with the provisions of the World Heritage Convention impulses to minimise the risk to heritage sites and waterfronts of the port cities.

2.2 Sustainable Ports Development Act (SDPA) of Australia

SPDA is a competent national policy forwarding a path towards economic growth while protecting the environmental, social and cultural values of the Great Barrier Reef World Heritage Area.[60] It prioritises efficient and effective utilisation of existing ports instead of constructing new ports or expanding old ports.[61] Additionally, it recognises the diverse challenges of culture and tourism, besides business, environmental and social policies concerning port development.[62]

SPDA reconciles the planning, development, economic, environmental, coastal and forestry legislation of both the central (Australia) and provincial (Queensland) governments to ensure intergenerational sustainability (as referred to in Table – I).[63] The reconciliation of diverse legislation allows the regulatory authorities to work symbolically. The master plan for a new port or expansion of the old port is drafted by the State Development Minister, Coordinator-General of the Department of State Development, and Public Work Organisation, involving the relevant local government and port authority. The local government and port authorities disclose the environmental and cultural impacts due to the development of ports. The master plans incorporate a strategic vision with objectives, outcomes and environmental management

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[59] Grech and others (n 46).
[60] Simona Duke, 'Port Sustainability Leadership in Tropical Australia' [2017] Australasian Coasts & Ports 2017: Working with Nature 416.
[61] GBRMPA, 'Planning for Priority Ports: For Public Consultation' [2017] Great Barrier Reef Marine Park Authority Townsville.
[62] Antra Hood and Matthew Roach, 'Complex Industrial Uses, Community Engagement and Environmental Issues-Challenges of Planning for Ports in Queensland' [2015] Australian Environment Review 1.
[63] Sustainable Ports Development Act 2015 (2015 Act No 28, Enforced by Queensland Government, 2015, https://www.legislation.qld.gov.au/) 1.

framework for ports' development. Though the master plan follows all the sustainability measures still, it seeks further consultation from the head of departments in any case of risk.[64]

Regulatory Authority	***Title of the Legislation***	***Year of Enactment***
State Development and Public Work Organisation	Sustainable Ports Development Act	2015
	Economic Development Act	2012
	Planning Act	2016
Department of Environment and Heritage Protection	Great Barrier Reef Marine Part Act	1975
	Forestry Act	1959
	Aboriginal and Torres Strait Islander Communities (Justice, Land and Other Matters) Act	1984
	Environmental Protection Act	1994
	Aboriginal Cultural Heritage Act	2003
	Marine Parks Act	2004

[64] ibid.

Department of the Environment and Energy (Central Department)	The Environment Protection and Biodiversity Act (Central Legislation)	1999

Table – I (Legislation of Queensland, Australia for Sustainable Ports Development)

Source: Department of Transport and Main Roads, Queensland Government, Australia (https://www.tmr.qld.gov.au/business-industry/Transport-sectors/Ports/Sustainable-port-development-and-operation/Sustainable-Ports-Development-Act-2015)

The Department of Environment and Heritage Protection of the Queensland government and the Department of Environment and Energy of the Australian government collaborates for compliance and enforcement of the Forestry Act, Aboriginal and Torres Strait Islander Communities (Justice, Land and Other Matters) Act, Environmental Protection Act (Queensland government legislation), Aboriginal Cultural Heritage Act, Marine Parks Act, and Environment Protection and Biodiversity Act (Australian government legislation).[65]

The authorities further coordinate for the compliance to maintain and protect the forests, underwater and land-based cultural heritage and other natural resources while the development of ports. This compliance is mandated under the Forestry Act, Environmental Protection Act, Environment Protection and Biodiversity Act, Marine Parks Act, Aboriginal Cultural Heritage Act and Aboriginal, and Torres Strait Islander Communities (Justice, Land and Other Matters) Act.[66]

[65] Nicolls, Lamb and Rayner (n 11).
[66] Sustainable Ports Development Act.

The Great Barrier Reef as an underwater cultural heritage site was brought to the limelight by the effort of UNESCO,[67] and its influence on the Australian and Queensland governments lead them towards the policy framework of SPDA. The policy framework in the form of SPDA had configured the totality of international law to develop sustainable ports contributing to SDGs. The reconciliation of environmental and cultural laws to protect the environment and preserve natural resources and cultural heritage is quite beneficial in this single policy. The aim of the SPDA for optimum utilisation of existing ports and to avoid construction of new ports is in line with the Stockholm Declaration, RIO Declaration and the World Heritage Convention.

3 Policy for Sustainable Port Operations

3.1 International Trade Liberalisation and its Impact on Port Policies

Since 1990, international trade liberalisation policies are the presage of national economic development.[68] The economic growth not only for State development is achieved, but the influential multilateral and bilateral trade and investment treaties and practices had also substantively reduced poverty.[69] As the Marrakesh Agreement unfolding the boundless opportunities of international trade 'recognises the relations in the field of trade and economic endeavour should be conducted to raise standards of living, ensure full employment and a large and steadily growing volume of real income and effective demand, and expanding the production of and trade in goods and services.'[70]

The evolutionary trade liberalisation policies had enabled the World Bank and the United Nations Conference on Trade and Development (UNCTAD) to assist the States in pacing the

[67] Grech and others (n 46).
[68] Sara Dillon, 'A Farewell to Linkage: International Trade Law and Global Sustainability Indicators' (2002) 55 Rutgers Law Review 87.
[69] Rafael Leal-Arcas, 'New Frontiers of International Economic Law: The Quest for Sustainable Development' (2018) 40 University of Pennsylvania Journal of International Law 83.
[70] WTO Agreement: Marrakesh Agreement Establishing the World Trade Organization.

port policies. States for their port policymaking are assisted by the World Bank's 'Port Reforms Toolkit (WBPRT)' and UNCTAD's 'Port Management Series (PMS)' to improve its competitiveness in the global market.[71]

WBPRT stipulates the States to liberalise its trade and corporate policies about port operations. WBPRT suggests opting Public-Private-Partnership (PPP), a corporate policy model of collaboration between the port authorities and the public/private corporations to ensure free movement of goods, services and capital.[72] A comparable elucidation is observed under the PMS; it recommends listing the statutory powers of investment, finance, tariff, licensing and legal to the port authorities or a central authority (Port and Shipping Commission) regulating the ports.[73] PMS suggests that the devolution of powers to port authorities increases the private sector involvement influencing the business market positively. The port's competitiveness is maintained if the policies are constructed under the greater integration of the diverse public-private sectors. The policy entailing and assimilating the port-city transportation networks is beneficial for the interests of both.

PPP model aims to maximise the port operational efficiency, as the inclusive functions of ports from the formation of financial, labour, logistics and other arrangements to its execution are carried independently by the port authorities and private sector.[74] The State authorities under the PPP model works as a regulator and supervises port authorities for compliance. The private sector enhances the capabilities of port operationalisation because it solely focuses on trade

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[71] AKC Beresford and others, 'The UNCTAD and WORKPORT Models of Port Development: Evolution or Revolution?' (2004) 31 Maritime Policy & Management 93; 'Port Reform Toolkit | Module 4, Legal Tools for Port Reforms' (World Bank 2007) <http://www.worldbank. org/transport/ports/toolkit/>.
[72] Zengqi Xiao and Jasmine Siu Lee Lam, 'Willingness to Take Contractual Risk in Port Public-Private Partnerships under Economic Volatility: The Role of Institutional Environment in Emerging Economies' (2019) 81 Transport Policy 106.
[73] 'Port Management Series (Volume - 4)' (United Nations Conference on Trade and Development 2016) UNCTAD/DTL/KDB/2016/1 <https://unctad.org/en/Pages/DTL/TTL/Port-Management-Series.aspx>.
[74] ibid.

influx.[75] The port's land is usually leased to the private sector for infrastructure development and operationalisation under a contract with the State. Customs and immigration authorities of the State cooperate with the private sector in enhancing the logistics and immigration operations to maximise economic benefits.[76]

3.2 International Environmental Treaty Law and ISO 14001 Environmental Management Systems

Under the PPP model, the 'ISO 14001 Environmental Management Systems (EMS) – specifications with guidance for use gives general guidance on maintaining a satisfactory quality of environmental provision' at ports.[77] The EMS is a set of internationally recognised standards to minimise environmental risk by providing mechanisms for waste management, reducing pollution and improving energy efficiency. The elements of EMS provide steps to legislate, plan, implement, monitor, audit and review the environmental management policy.[78] Primarily, EMS is a mechanism to harmonise port environmental management policy according to regional or national environmental legislation.[79]

As internationally ratified standards, the purpose of EMS is to cohabitate with international environmental treaty law.[80] Although the international environmental treaty law is fragmented, its integration is the only way to harmonise the environmental protection policy at ports.[81] The interaction of port operations with air, marine and terrestrial ecosystems, all at the same time,

[75] 'Port Reform Toolkit | Module 4, Legal Tools for Port Reforms' (n 71).
[76] Khalid Bichou and Richard Gray, 'A Logistics and Supply Chain Management Approach to Port Performance Measurement' (2004) 31 Maritime Policy & Management 47.
[77] Jasmine Siu Lee Lam and Theo Notteboom, 'The Greening of Ports: A Comparison of Port Management Tools Used by Leading Ports in Asia and Europe' (2014) 34 Transport Reviews 169.
[78] Nasrin Asgari and others, 'Sustainability Ranking of the UK Major Ports: Methodology and Case Study' (2015) 78 Transportation Research Part E: Logistics and Transportation Review 19.
[79] Haoliang Yao, 'Lessons Learned from ICOM Initiatives in Canada and China' (2008) 36 Coastal Management 458.
[80] Jennifer Clapp, 'The Privatization of Global Environmental Governance: ISO 14000 and the Developing World' (1998) 4 Global Governance 295.
[81] GF Maggio, 'Inter/Intra-Generational Equity: Current Applications under International Law for Promoting the Sustainable Development of Natural Resources' (1996) 4 Buffalo Environmental Law Journal 161.

are addressed through various international environmental treaties. Such as the air pollution emerging from port operations, intermodal transportation network and shipping activities to be controlled and minimised under the specific application of the UNFCCC and its Kyoto Protocol.[82] The provisions of UNFCCC and the Kyoto Protocol aiming to control and reduce emissions by incentivising, subsidising and promoting renewable energy are noteworthy for port operations.

Similarly, a particular application of the United Nations Convention on Law of the Sea (UNCLOS) to take precautionary measures to prevent marine pollution is valuable for port operations.[83] This general endorsement of UNCLOS specifies installing such machinery at ports that minimise the marine environment's risk. More precisely, the Convention on the Prevention of Marine Pollution by Dumping of Waste and Other Matters (London Convention) and its London Protocol prevents the deliberate disposal of waste due to ports' operations.[84] The London Convention and London Protocol are constituted to ensure marine environmental protection from dumping through any land-based source.

3.3 United Nations Environment Programme (UNEP) Initiatives under International Environmental Treaty Law

3.3.1 Key Principles for Port and Harbour Development

UNEP, with the International Association of Dredging Companies, the International Association of Ports and Harbours and the Global Programme for Action Coordination Office,

[82] Kyoto Protocol to the United Nations Framework Convention on Climate Change; United Nations Framework Convention on Climate Change.
[83] United Nations Convention on Law of the Sea 1982 (came into force on 16 November 1994, (1833 UNTS 397)).
[84] 1996 Protocol to the London Convention 1996 (came into force on 24 March 2006, 36 ILM 1 (1997)); Convention for Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (26 UNTS 2403).

had developed 'Key Principles for Port and Harbour Development.'[85] These principles comprehensively envision the mechanisms to enact high standards of environmental performance and conduct impact assessment before developing or expanding ports. Further, assist the States in developing such port policies balancing the environmental protection with the port operations and expansion.

The basic 'precautionary' principle as provided by the Convention on Biological Diversity is incorporated to conduct impact assessment before the development and operations of ports.[86] Protection of the environment is endorsed in conformity with the Convention on Biological Diversity as an ecosystem. The London Convention, London Protocol, Montreal Convention on Land-Based Sources of Pollution, Montreal Guidelines for treatment of dredged material and other pollution sources, and the Resolution of a Dredged Material Assessment Framework are re-endorsed to protect the marine environment.[87]

These Principles recalls the integration of the rural/urban development (port cities) and the socio-cultural aspects of port development and operations. The impact on air pollution is also framed, but generally, and the focus remains on marine environmental protection. It is recommended to utilise environmentally sound technologies and implement environmental management practices while conducting dredging, cargo handling, infrastructure, and superstructure development.

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[85] 'Key Principles for Port and Harbour Development' (*UNEP/GPA Coordination Office*, 24 November 2012) <https://dredging.org/documents/ceda/downloads/environment-keyprinciples%20.pdf>.

[86] Convention on Biological Diversity 1992 (came into force on 29 December 1993, (1760 UNTS 79)); 'Environmental Considerations for Ports and Harbour Development' (World Bank/United Nations Environmental Programme, Available at: https://iadc-dredging.com/publication/key-principles-port-harbor-development/ 1990) Technical Paper no. 126 <https://iadc-dredging.com/publication/key-principles-port-harbor-development/> accessed 18 November 2019.

[87] Gregory P Tsinker, 'Port (Harbor) Elements: Design Principles and Considerations' in Gregory P Tsinker (ed), *Handbook of Port and Harbor Engineering: Geotechnical and Structural Aspects* (Springer US 1997) <https://doi.org/10.1007/978-1-4757-0863-9_2> accessed 20 November 2019; 'V.I.24 Montreal Guidelines for the Protection of the Marine Environment Against Pollution from Land–Based Sources (With Annexes)' [2015] International Law & World Order: Weston's & Carlson's Basic Documents.

3.3.2 Sustainable Global Clean Port Hub Programme

Since 2012, the UNEP is working to harmonise the policies controlling emissions at the port under its 'Global Clean Port Hub' programme.[88] This programme focuses on air pollution under the specific implementation of UNFCCC and Kyoto Protocol within the State jurisdiction. The programme assists the States to develop a single policy framework integrating air pollution sources, such as intermodal transportation, cargo-handling equipment, and shipping. This UNEP's programme has comprised global partnerships with multilevel stakeholders at various national and regional levels.[89] This programme also forwards fiscal and financial guidelines to promote environment-friendly transportation networks. Those guidelines provide a mechanism for sponsoring, financing and subsidising renewable energy in transport machinery and integrates with trading policies.

3.4 Canada Marine Act

The ports of Canada are an excellent example of endeavouring the trade liberalisation policies, as the port authorities are a body corporate, incorporated without share capital and are financially self-sufficient. The ports of Canada are under the direct control of the central government, with few devolve functions of the provincial governments.[90] CMA is a mechanism to involve the private sector under the regulatory control of the port authorities under the 'letter patent.'[91] The ports authorities are liable to issue financial and trade indexes for analysis and feedback by the Ministry of Transportation in the province's centre and Ministry of Finance.[92]

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[88] 'Global Clean Ports | UNEP - UN Environment Programme' <https://www.unenvironment.org/explore-topics/transport/what-we-do/global-clean-ports> accessed 1 November 2019.
[89] UN Environment, 'Why Does Global Clean Ports Matter?' (*UNEP - UN Environment Programme*, 26 July 2017) <http://www.unenvironment.org/explore-topics/transport/what-we-do/global-clean-ports/why-does-global-clean-ports-matter> accessed 17 November 2019.
[90] MC Ircha, 'Port Strategic Planning: Canadian Port Reform' (2001) 28 Maritime Policy & Management 125.
[91] Gaudreau and others (n 11).
[92] Tony R Walker and others, 'Harbour Divestiture in Canada: Implications of Changing Governance' (2015) 62 Marine Policy 1.

There are 14 board of directors in each port authority, one nominated by the Minister, one from the local authority, one from the Province and remaining with the consultation between the three nominated.[93]

The port authorities of Canada and private/public corporations bear the regulatory burden under the specific guidelines, rules, regulations or frameworks established by the regulatory authorities.[94] The regulatory authorities under this model compel the port authorities and public/private corporations to issue interim reports, or these reporting practices are conducted jointly. The Canadian ports have enacted the EMS system, and it derives its policies from the national and provincial legislation (as referred to in Table – II).[95] Transport Canada is the transportation agency that manages the transport and ensures compliance with environmental regulations. Transport Canada works under the Canada Marine Act and Canada Shipping Act to regulate shipping and other transportation.[96]

The Department of Fisheries and Oceans Canada is responsible for fisheries, habitat, marine environment and aquaculture protection under the Oceans Act, Fisheries Act, Canada National Marine Conservation Areas Act, and Coastal Fisheries Protection Act.[97] The Department of Fisheries and Oceans Canada, Environment and Climate Change Canada and the Port Authorities collaborate in regulating the marine environment from the threats of port operations. Precautionary measures are endorsed for protecting the marine environment as per the obligations of the UNCLOS, London Convention and London Protocol, including the guidelines of UNEP's under the Key Principles for Port and Harbour Development.

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[93] Canada Marine Act 1998 (SC 1998, c 10, Revised 28-08-2019, Enforced by Canadian Parliament, 1998).
[94] Mary R Brooks, 'The Governance Structure of Ports' (2004) 3 Review of network economics 168.
[95] Rafael Sardà and others, 'A Proposed Ecosystem-Based Management System for Marine Waters: Linking the Theory of Environmental Policy to the Practice of Environmental Management' (2014) 19 Ecology and Society.
[96] Hossain, Adams and Walker (n 37).
[97] Canada Marine Act.

Regulatory Authority	***Title of the Legislation***	***Year of Enactment***
Transport Canada and Port Authorities	Canada Marine Act	1998
	Port Authorities Operations Regulations	2000
	Canada Shipping Act	2001
	Canada Transportation Act	1996
Environment and Climate Change Canada	Canada Environmental Protection Act	1999
	Canada Waters Act	1985
Department of Fisheries and Oceans Canada	Canada National Marine Conservation Areas Act	2002
	Coastal Fisheries Protection Act	1985
	Oceans Act	1996

Table – II (Legislation of Canada for Sustainable Port Operations)

Source: Justice Laws Website, Government of Canada **(**https://laws-lois.justice.gc.ca/)

Air quality is monitored, maintained and protected through a collaborative mechanism among the port authorities and Transport Canada.[98] The port authorities with Transport Canada and private corporations promote eco-friendly technologies and transportation. The ships receive discounts on voluntary practices reducing emissions along with other environmental impacts.[99] The incentivising eco-friendly programme in line with the UNFCCC, Kyoto Protocol and the UNEP Global Clean Port Hub programme is succinctly contributing to improving air quality.

Environment and Climate Change Canada are empowered to review and monitor the air, water and land environment quality under the Canada Environmental Protection Act and Canada Waters Act.[100] Each corporation operating at ports is responsible for developing a process to monitor and record the environmental plan and legal obligations reviewed and audited by a third party before the Environmental Protection Agency's inspection.[101] The port authorities prepare environment compliance reports for inspection conducted by the Environment and Climate Change Canada under a centralised reporting mechanism. The reports are analysed and forwarded horizontally through the local and provincial government officials to the central government for environmental compliance.

Although, the security, including customs and immigration, are not under the framework of CMA. As it is mandated for customs, immigration, security and surveillance operations, Canada Border Service Agency closely collaborates with port authorities for effective port

[98] Hossain, Adams and Walker (n 37).
[99] Kenneth Chan, 'Port of Vancouver to Invest in Improvements for Crab Park' (*Daily Hive*, 9 April 2019) <https://dailyhive.com/vancouver/port-of-vancouver-container-ships?auto=true> accessed 8 January 2020.
[100] 'Canada's 7th National Communication and 3rd Biennial Report' (Environment and Climate Change Canada 2017) Cat. No.: En4-73/2017E-PDF/ISBN: 978-0-660-23785-5, Available at: https://unfccc.int/files/national_reports/national_communications_and_biennial_reports/application/pdf/82051493_canada-nc7-br3-1-5108_eccc_can7thncomm3rdbi-report_en_04_web.pdf <https://unfccc.int/files/national_reports/national_communications_and_biennial_reports/application/pdf/82051493_canada-nc7-br3-1-5108_eccc_can7thncomm3rdbi-report_en_04_web.pdf>.
[101] 'Environmental Management Systems and ISO 14000 An Overview' Pollution Prevention Factsheet 4/ Reviewed/Revised-01/2004, Available at: https://www.novascotia.ca/nse/pollutionprevention/docs/EMS_factsheet.pdf <https://www.novascotia.ca/nse/pollutionprevention/docs/EMS_factsheet.pdf>.

operations under the Canada Border Service Agency Act.[102] It provides an advanced technical mechanism for adequate security and regulatory compliance.[103]

4 (Un)Sustainable Port Policy of Gwadar

Effective implementation of international law is overall futile in Pakistan, as the economic demands are much higher than other concerns. Such futility has compromised the position of SDGs within the existing policy framework of Gwadar Port. Its framework lacks regulatory compliance mechanisms; neither the clarity of jurisdiction mandates any authority to enforce its rules and regulations.[104] The investment policy framework of Gwadar port has been drafted, finalised and implemented without involving the local community, stakeholders and regulatory authorities. The main issues highlighted as 'hotchpotch governance' are the jurisdictional overlaps between the central and the provincial governments.[105] The local authorities had addressed their particular concerns as they were ignored throughout the development phase, and they are seeking their position in the operational phase.[106] The alarming situation has led the government of Pakistan to reconsider the existing GPAO and the Gwadar Port Master Plan.

The Gwadar port is one of the projects under the CPEC, a bilateral set of agreements between China and Pakistan on infrastructure, energy and industrialisation.[107] Hence, the environmental impact assessment for overall CPEC, carried out by the International Union for Conservation

[102] Mary R Brooks, 'Port Devolution and Governance in Canada' (2006) 17 Research in Transportation Economics 237.
[103] Canada Border Services Agency Act 2005 (SC 2005, c 38, Revised 03-12-2019, Enforced by Canadian Parliament, 2005, Available at: https://laws-lois.justice.gc.ca/eng/acts/c-14/).
[104] Muhammad Naveed Iftikhar and others, 'The Institutional and Urban Design of Gwadar City' (International Growth Centre, UK Aid, London School of Economics, Available at: https://www.theigc.org/wp-content/uploads/2019/05/Iftikhar-et-al-2019-Final-report.pdf 2019) Analytical C-37422-PAK-1.
[105] Rorry Daniels, 'Strategic Competition in South Asia: Gwadar, Chabahar, and the Risks of Infrastructure Development' (2013) 35 American Foreign Policy Interests 93.
[106] Usman Shahid, 'Balochistan: The Troubled Heart of the CPEC' (*The Diplomat, Features - Security - South Asia, Pakistan*, 23 August 2016) <https://thediplomat.com/2016/08/balochistan-the-troubled-heart-of-the-cpec/> accessed 7 January 2020.
[107] Asmat Naz and Fatima Ali, 'Gwadar Port: As an Economic Hub for Maritime Trade in the World Corridor (CPEC)' (2018) 4 Journal of Business and Social Review in Emerging Economies 7.

of Nature, which the Pakistan Environmental Protection Agency rejected.[108] This rejection was sanctioned without any apparent justification, as the Pakistan Environmental Protection Agency only stated that the report was prepared by amateurs and lacked specific details about cutting trees.[109]

The infrastructure phase of the Gwadar port, following the PPP model, is in the process of implementation. The Board of Investment, Gwadar Port Authority (GPA), Federal Board of Revenue of Pakistan and China Overseas Port Holding Company Ltd (COPHCL) of China are collaboration partners for infrastructure development.[110] Initially, the Ministry of Commerce, Ministry of Maritime Affairs and Ministry of Finance supervise the infrastructure development. The Gwadar port is leased to COPHCL, and the Gwadar Port Authority is empowered to regulate the infrastructure development of roads and port infrastructure.[111]

The central government is empowered to appoint the Chairman, Board and the Management of the GPA. The involvement of other departments and ministries have compromised the independent position of the GPA.[112] The Ministry of Maritime Affairs supervising GPA is not privy to any policy, legal or operational matters. The central government is kept in the loop for

[108] Shah Meer Baloch, 'CPEC's Environmental Toll' (*The Diplomat*, 18 April 2018) <https://thediplomat.com/2018/04/cpecs-environmental-toll/> accessed 18 March 2020; Dr. Abdul Rauf, 'Environmental Impact Assessment of CPEC Projects and Mitigation Strategy' (*Pakistan Observer*, 23 August 2019) <https://pakobserver.net/environmental-impact-assessment-of-cpec-projects-and-mitigation-strategy/> accessed 18 March 2020.
[109] Jamal Shahid, '"Environmental and Economic Sustainability" of CPEC Assured' (*The Dawn, 8, Islamabad, Pakistan,* June 2015) <https://www.dawn.com/news/1186880/environmental-and-economic-sustainability-of-cpec-assured> accessed 4 November 2019.
[110] Umbreen Javaid, 'Assessing CPEC: Potential Threats and Prospects' (2016) 53 Journal of the Research Society of Pakistan.
[111] Obortunity Info, 'Chinese Company Grants $1.2bn for Gwadar Port's Development' (*Obortunity*, 21 September 2019) <https://obortunity.org/2019/09/21/chinese-company-grants-1-2bn-for-gwadar-ports-development/> accessed 24 October 2019.
[112] Muhammad Awais and others, 'The Sustainable Development of the China Pakistan Economic Corridor: Synergy among Economic, Social, and Environmental Sustainability' (2019) 11 Sustainability 7044.

financial and investment matters. It is empowered to issue any further order to remove difficulties, including jurisdiction, environment, and other matters.[113]

GPA cannot move independently for any infrastructure, development or trade project; neither it can implement its rules and regulations (if framed) without the permission or approval of the central government.[114] Henceforth, the fiscal policy of the Gwadar port is not completely complying with the trade liberalisation policies. The PPP agreement for infrastructure development is not accommodating other investors besides COPHCL. GPA, as it is responsible for preparing a master plan and the programme for Gwadar port development, it allocates port zones, lands, water, power, and natural resources. The environmental protection policy is also the sole responsibility of the GPA and is framed with the port master plan preparation. It is unnecessary to consult with any local authority or environmental authority to conduct a framing of the environmental policy and port master plan.[115] This policy framework is adopted through parent legislation entitled 'Ports Act,' capitalising ports as a federal/central subject.[116] Therefore, the environmental impact assessment of infrastructure development is conducted solely by the Gwadar Port Authority.

However, environmental impact assessment is the mandate of the Pakistan Environmental Protection Agency under the Pakistan Environmental Protection Act (PEPA).[117] Another environmental authority at the provincial level mandated for impact assessment is the Baluchistan Environmental Protection Agency under the Baluchistan Environmental

[113] Gwadar Port Authority Ordinance, 2002 (F No 2(1)/2002-pub (Ordinance no LXXVII of 2002), Enforced by Pakistan Government, 2002, http://www.pljlawsite.com/Statuteview.asp?ID=2391&offset=-1).
[114] ibid.
[115] ibid.
[116] Ports Act 1908 (Act XV of 1908, Enforced by Pakistan Government, 1947, Available at: https://pljlawsite.com/Statuteview.asp?ID=4462&section=).
[117] ‘Evaluation of Environmental Impact Assessment System in Pakistan’ (2008) 28 Environmental Impact Assessment Review 562; Pakistan Environmental Protection Act 1997 (Act No XXXIV of 1997/No F 9(46)/97-Legis, Enforced by Pakistan Government, 1997).

Protection Act (BEPA).[118] The uncertainty is due to the jurisdiction of central authorities over the ports, including the provincial and local interests, emerging as a significant jurisdictional overlap.[119]

Incrementally, PEPA and BEPA are itself ambiguous on port development and operations, which has led the Gwadar without a comprehensive impact assessment. The environmental impact assessment under both the PEPA and BEPA is substantiated for any industrial activity causing environmental damage.[120] Although port development and operations can be covered under the definition of the 'industrial activity,' as it states that 'operation or process for making, formulating, synthesising, altering, repairing, or otherwise treating any article or substance with a view to its use, sale, transport, delivery or disposal, or for mining, for oil and gas exploration and development, for any other industrial or commercial purpose.' Despite that, there is a lack of clarity in carrying impact assessment regarding industrial activity concerning port development and operations.

Hence, both the BEPA and PEPA contain imprecise provisions for the protection of the marine environment. For instance, in PEPA, the only marine environmental protection provision is inculcated in the biodiversity clause. Similarly, the BEPA only imposes an obligation to protect the marine environment from ship breaking and dismantling waste. Therefore, the port environmental protection policy of the Gwadar has ignored the obligations under the UNCLOS, London Convention and its Protocol. Furthermore, air quality regulation is also placed under both the PEPA and BEPA, establishing the emissions standards through specific regulations.

[118] Irum Ahsan and Saima Amin Khawaja, *Development of Environmental Laws and Jurisprudence in Pakistan* (Asian Development Bank https://www.adb.org/sites/default/files/publication/31140/environmental-law-jurisprudence-pakistan.pdf 2013) <https://www.adb.org/sites/default/files/publication/31140/environmental-law-jurisprudence-pakistan.pdf>.
[119] Iftikhar and others (n 104).
[120] Pakistan Environmental Protection Act; The Baluchistan Environment Protection Act 2013 (Act no VIII of 2012 (No PAB/Legis: V (9)/ Baluchistan Assembly, Came into force, 2013, Available at: https://elaw.org/system/files/balochistan_environment_protection_act_2012-1.pdf).

Pakistan Environmental Protection Motor Vehicle Regulations prohibit excessive emissions from vehicles and the Pollution Charge for Industry (Calculation and Collection) Rules that introduce the pollution trading schemes.[121] However, their shipping and port operations application requires a significant tantamount of regulations as per the UNEP Global Clean Port Hub Programme, the UNFCCC and the Kyoto Protocol.

PEPA empowering Pakistan Environmental Protection Agency necessitates, and BEPA re-endorse the conduct of environmental impact assessment and environmental protection. Beyond that, BEPA's specific implementation for Coastal Zone covers the environmental concerns due to the development of new ports or expansion of old ports as it calls 'to monitor strictly the environmental degradation caused by the ports and shipping.'[122] However, it is unclear on the preservation of the 'land spaces' as natural resources than the SPDA. The cultural heritage preservation concerns are not included in any investment, development or operational framework of the Gwadar port. The authorities responsible for cultural protection and preservation were not involved in any consultation or policymaking process. The general policy framework has not encompassed any such provisions to involve them in developmental projects.[123]

Although, the environmental policy framework generally endorses the obligations of the international treaty law. The foremost dispute in implementing international treaty law is the jurisdictional overlaps between the port authorities, local authorities, and the provincial and central environmental authorities. Disintegration among the authorities responsible for

[121] National Environmental Quality Standards (NEQS) to the Pakistan Environmental Protection Act, 1997 2010 (SRO 1062/2010 - Act XXXIV of 1997 Available at: http://environment.gov.pk/images/PDF/NEQS-Air-IndustrlGas.pdf); Pakistan Environmental Protection Motor Vehicle Regulations 2016 (SRO (1)/2015/ under Pakistan Environmental Protection Act, 1997 (XXXIV of 1997), Enforced by Pakistan Environmental Protection Agency, 2016, Available at: http://www.environment.gov.pk/images/regulations/20160201DraftMVR2016.pdf).
[122] The Baluchistan Environment Protection Act.
[123] Pakistan and Cabinet Division, *Rules of Business (As Amended up to 3rd March 2017)* (Government of Pakistan, http://cabinet.gov.pk/cabinet/userfiles1/file/ROB-amended-03-03-2017.pdf) <http://cabinet.gov.pk/cabinet/userfiles1/file/ROB-amended-03-03-2017.pdf>.

developing city and port, environmental protection, preservation of natural resources and cultural heritage is among other issues. Additionally, the GPAO and the Ports Act are unclear on protecting the environment, natural resources, and cultural heritage.

5 Sustainable Port Policy – The Future of Gwadar Port

As illustrated in the form of WBPRT, PMS and UNEP's programmes, the applicability of international law is a way forward in the harmonisation of port policies for SDGs. Port liberalisation policies are critical to economic development under the State regulatory framework. UNEP's 'Key Principles for Port and Harbour Development' and 'Global Clean Port Hub Programme' are a better form of integration. The threats to the environment, including air and marine, are considerably addressed under these UNEP's programme and principles. A specific application of both these UNEP's programme and principles with the international environmental law supports harmonising environmental policies. The disintegration among the PMS, WBPRT and UNEP's guidelines and programmes serves as a barrier to harmonising policies for the development of sustainable ports at the global level.

EMS as a system is problematic, although internationally recognised, in developing States, the involvement of the environmental authorities at each stage is laborious.[124] Additionally, the EMS system stems from an environmental policy of a State, and weak environmental legislation is symbolic in developing States.[125] The authorities in the process of environmental policy development are not usually involved primarily in developing States. In developed States although, joint conduct of monitoring and reporting of the environmental authorities and the port authorities seems effective. However, the environmental hazards due to intermodal transportation networks and the shipping embark aligning questions on the jurisdiction of the

[124] Lam and Notteboom (n 77).
[125] Clapp (n 80).

port, transportation and environmental authorities. Road, rail and shipping transportation, and port operations lacks an integrated policy in most of the States.

The vulnerability to the environment at ports is quite technical; its consecutive interactions with the air and oceans ecosystems seek stringent regulations.[126] A generic application and operationalisation of international environmental treaty law, including UNFCCC, Kyoto Protocol, UNCLOS, London Convention, and London Protocol, is technically avoided from the operations at ports. Better management of port operations for SDGs requires horizontal and vertical integration of the port, local and State regulatory authorities for a policy formation.[127]

The environmental challenges at ports call for adopting new and more inclusive perspectives with effective and comprehensive objectives to respond to the various issues.[128] An overall, IMO's coherent and integrated approach in developing and implementing shipping policy is compelling.[129] The IMO's regulatory practices in the implementation of international environmental treaty law to control shipping pollution have remarkably contributed to protecting the marine environment. Comparable guidelines amalgamating the international environmental treaty law is prospective to address the alarming environmental harms at ports.

In port development and expansion, the disaster is more significant, while accommodating invasion of trade due to immense increasing monetary demands of the States.[130] Degradation of land and oceans, destruction of fisheries and species, and contamination of soil and water

[126] Cheng-Hsien Hsieh, 'Disaster Risk Assessment of Ports Based on the Perspective of Vulnerability' (2014) 74 Natural hazards 851.
[127] Harry Barnes-Dabban, CSA van Koppen and Jan PM van Tatenhove, 'Regional Convergence in Environmental Policy Arrangements : A Transformation towards Regional Environmental Governance for West and Central African Ports?' (2018) 163 Ocean & Coastal Management 151.
[128] SangHyun Cheon, Arnold Maltz and Kevin Dooley, 'The Link Between Economic and Environmental Performance of the Top 10 U.S. Ports' (2017) 44 Maritime Policy & Management 227.
[129] Lawrence Sciberras and Joaquim Ramos Silva, 'Establishing an Institutional Conceptual Framework for Effective Delivery of the United Nations SDGs: An Application of Grounded Theory to Assist IMO Stakeholders' (2019) 18 WMU Journal of Maritime Affairs 379.
[130] Wei Yim Yap and Jasmine Siu Lee Lam, '80 Million-Twenty-Foot-Equivalent-Unit Container Port? Sustainability Issues in Port and Coastal Development' (2013) 71 Ocean & Coastal Management 13.

due to dredging with a limited prescription is supported through the generic impact assessment mechanism in the Convention on Biological Diversity. Nonetheless, the exigency is to cogitate way-beyond beyond a simplistic application of the impact assessment mechanisms as provided under the existing international treaty law.[131]

Applicability of the RIO Declaration, Stockholm Declaration and World Heritage Convention supports harmonisation of policies for port development and resource and cultural preservation. Most imperative is the Marrakesh Agreement urging to balance international trade with environmental protection. Hence, the application of the Marrakesh agreement is imperious and straight on ports as they are nodes of international trade. Fragmentation of international treaty law for intergenerational sustainability serves as an obstacle for sustainable port policy development. A distant approach is unclear, as there is no precise treaty, rule or policy on the port to affirm intergenerational sustainability.[132] Such an ambiguous position of international treaty law is problematic, which may coerce the global ports community to make specific assertions about land spaces, waterfronts, heritage sites, and energy utilised for port development and operations.

A positive prescription of international treaty law implementation aligning economic growth and environmental protection is observed in CMA.[133] The international trade liberalisation policies through the CMA mandates the port authorities to work independently. Therefore, the port authorities of Canada are significantly contributing to provincial/state level and national economies in terms of industrialisation, an influx of employment, business and

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[131] Schipper, Vreugdenhil and de Jong (n 43).

[132] Marco Casagrande, 'The Lack of Interest for Seaports in International Law and Doctrine', *Seaports in International Law* (Springer International Publishing 2017).

[133] Environment and Climate Change Canada, 'Participation in International Environmental Agreements and Instruments' (*aem*, 9 January 2007) <https://www.canada.ca/en/environment-climate-change/corporate/international-affairs/partnerships-organizations/participation-international-environmental-agreements.html> accessed 23 November 2019.

entrepreneurship opportunities.[134] The purpose of the CMA is to originate a system for efficient and competitive ports by establishing the port authorities to contribute to the Canadian economy.

CMA has integrated legislation on ports addressing widespread issues of the environment. Congruently, the policy impediments at ports in CMA are removed effectually. It establishes the applicable laws on the segmented issues the compliance and monitoring procedures resolve the wide-ranging issues.[135] Therefore, the diverse environmental protection under international environmental treaty law is the hallmark of the CMA. SPDA, although specify the protection of the Great Barrier Reef but is considered concerning balancing the intergenerational interests attached to ports' development. SPDA has promulgated intergenerational concerns at a large scale, protecting culture, environment and natural resources.[136]

The above debate and analysis suggest that integrating international treaty law supports harmonising the sustainable port policies for SDGs. Global ports' community and the international community generally had never recognised the importance of geo-strategic, environmentally divergent, culturally diverse, and economically multidimensional ports. The ports stayed behind the national legislations except for the Geneva Convention and few international regulations on other port-ship interfaces.[137] The Geneva Convention prompts the principles of equity, conferring to international treaty law amount of clarity and coherence, howbeit, limiting the domain of ports as only for treating the ships is challenging.[138] The

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[134] Jeremy Hainsworth, 'Updated: Port Automation Could Cost Thousands of Jobs, Tax Income: Union | Vancouver Courier' *Glacier Media, Available at: https://www.vancourier.com/updated-port-automation-could-cost-thousands-of-jobs-tax-income-union-1.23928888* (Vancouver, Canada, 28 July 2019) <https://www.vancourier.com/updated-port-automation-could-cost-thousands-of-jobs-tax-income-union-1.23928888> accessed 4 November 2019.
[135] Gaudreau and others (n 11).
[136] Nicolls, Lamb and Rayner (n 11).
[137] Casagrande (n 132).
[138] Marco Casagrande, 'A Contribution from Private International Law and Some Municipal Legal Orders' in Marco Casagrande (ed), *Seaports in International Law* (Springer International Publishing 2017) <https://doi.org/10.1007/978-3-319-60396-4_19> accessed 19 November 2019.

Geneva Convention lacks applicability in terms of harmonisation of port policies. Nevertheless, the Geneva Convention recognises its limitation and remains open-ended in the form of protocols.[139]

Therefore, the future of port policies and its harmonisation under international treaty law in the form of the protocol to the Geneva Convention, if established, then for SDGs shall considerably follow:

1) Sustainable development of new ports or sustainable expansion of old ports under the Marrakesh Agreement, RIO Declaration and Stockholm Declaration for the preservation of natural resources, cultural heritage and ecosystems;
2) Sustainable Operations of ports under the UNFCCC, Kyoto Protocol, UNCLOS, London Convention and London Protocol for environmental protection (UNEP's Guidelines, Principles and Programmes shall be deliberated in case if further clarity is required);
3) State economic development through better management of ports under the PPP model specified by WBPRT and UNCTAD PMS).

The future policy of Gwadar port to remove difficulties for better management of port operations shall follow the PPP model inclusively by opening the framework to embrace more private investment. The limitation of the PPP model to a specific corporation is hindering competition and is not beneficial for future trade and infrastructural development of Gwadar port. WBPRT and UNCTAD PMS financial models are quite resounding for remodelling the Gwadar port fiscal model.

[139] Convention and Statute on the International Régime of Maritime Ports.

A comprehensive environmental compliance framework to be developed with central and provincial environmental regulatory authorities, local authorities and stakeholders. The framework shall be constituted under the international standards as provided by the international environmental treaty law and followed by CMA, integrating air and marine environment issues.

Policy for expansion of Gwadar port shall be subject to the interests of the residents of Gwadar city, including the preservation of the water spaces and heritage sites. Provisions of the RIO Declaration, Stockholm Declaration, Marrakesh Agreement, and World Heritage Convention and SPDA are pretty accommodating for such policy development. The heritage sites around Gwadar are of national identity and cultural concern. Similarly, there is a potential for tourism as the Gwadar front Arabian Sea is aesthetically scenic.

6 Conclusion

The existing situation appears unsustainable in this era of globalisation towards the ports, vital financial and security hubs. The development and operation of ports are quite vulnerable to the environment, natural resources, trade and economic development. Promulgation of normative international law by tailoring it for ports generally appears efficient. The scholarly pavement is grossing; other good policies and guidelines support harmonising the diverse policies. Enhanced efforts of the UNCTAD and World Bank to develop specific guidelines to tool the financial strategies at ports are beneficial. UNEP's Global Clean Ports programme for emission prevention and guidelines, including the 'Key Principles for Port and Harbour Development,' are quite resounding.

An integrated mechanism noting the international treaty law is valuable to underpin the suggestion of Secretary-General IMO to 'harmonise port policies.' Distant thinking and dialogue among the international community to remove the barriers are required to achieve inclusive sustainability at and through ports. Port cities, communities, and other stakeholders are looking forth towards international communities for a positive response. For these purposes, a further specific guideline from the United Nations Educational and Scientific Cooperation Organisation is thoughtful for protecting heritage. The United Nations Development Programme emerging programmes ought to comprise ports as one of the tools in development. Moreover, the United Nations and IMO shall consider guidelines for the community resilience and social welfare of ports' employees and emerging communities.

The existing policy mechanism of Gwadar port gives an unsustainable impression, as it lacks harmonisation and coherency of the regulatory frameworks. The investment policy framework of Gwadar is also ambiguous and vague because its mechanism to involve stakeholders is not clear. The ignorance of the local community at any level of policy preparation, implementation and the environmental protection framework is alarming. The environmental and scholarly organisations had already addressed several concerns, and the social development of the Gwadar port city is questionable. Considering the international treaty law obligation, it is the State's responsibility to get the public on board for decision-making. The government of Pakistan shall involve the local community for their concerns and adopt a transparent policy framework.

Social development and protection policies appear to be future research concerning the sustainable port. The health and safety of the labourers employed, interests of the social actors, including non-governmental and environmental organisations, will be significant to harmonise port sustainability agendas further.

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Proceedings

Renewable Energy Resources Alternatives in Maritime Industry

A triboelectric-electromagnetic hybrid generator for wave energy harvesting

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1 Abstract

Wave energy is one of the most promising renewable energy sources in the ocean, which comes with high energy density, water depth independence and 24-hour availability, collecting low-frequency wave energy by triboelectric nanogenerators (TENGs) is still a considerable challenge. In this study, a hybrid wave energy harvester (H-WEH) is proposed. Herein, the H-WEH composes coupled TENG and electromagnetic generator (EMG). This design exhibits better output performance in harvesting wave energy compared with individual components. Moreover, the electricity generation unit makes no direct contact with the water surface, which enhances the durability of the generator. Additionally, the output characteristics of TENG can be complementary to the performance of EMG to achieve satisfactory power production. The device can work in the frequency range of 0.1-1Hz, which provides a simple, reliable, and durable alternative for large-scale and low-frequency wave energy harvesting.

Keywords: Hybrid Wave Energy Harvester, Triboelectric Nanogenerator, Electromagnetic Generator

2 Introduction

Electricity generation provides 18,000 terawatt-hours of energy a year, around 40% of humanity's total energy use[1]. Therefore, developing renewable energy is the one of the top priorities in the future. Utilizing renewable energy to generate electricity is not a new concept. With the boosting requirement for energy, the extensive use of blue ocean energy is an inevitable choice. Seawater covers 71% of the earth's surface, with a total area of approximately

360 million km^2, which contains abundant wave energy[2,3]. According to the researcher's statistics, the wave energy reserves in the oceans worldwide is about 80,000 TWh, which is enough to fulfill the world's total electricity demand[4–7].

Though the cnventional electromagnetic generators (EMG) have been applied in harvesting the wave energy[8,9], they usually don’t function well (directly) with low-frequency wave inputs. Triboelectric nanogenerator (TENG) was invented by Wang’s group in 2012[10]. The TENG exhibits many advantages including low costs, manufacturing easiness and lightweights. In particular, the TENG is superior to the EMG in harvesting low-frequency mechanical energy[11]. This feature has inspired many researchers to develop triboelectric-electromagnetic hybrid generators to harvest wave energy more efficiently[12,13].

In this work, a triboelectric-nanogenerator hybrid wave energy harvester (H-WEH) has been proposed to harvest wave energy. H-WEH is connected to a floating sphere. Under the excitations of the waves, the floating sphere drives the generator reciprocally, transforming mechanical energy into electrical energy. This structure can largely avoid the risks of water leakage into the power generation unit. What’s more, combining two generators (EMG and TENG) increases the output of H-WEH and enhance the practicality of wave energy conversion. After systematical design optimization, this H-WEH can effectively collect wave energy in the frequency range of 0.1 to 1Hz. Besides, one of its applications in charging capacitors is also demonstrated. This work may give rise to new insights in harvesting wave energy.

2 Experimental Section

2.1 Fabrication of mover

The mover, a cylinder with a radius of 3cm and a height of 2cm, was made using photocurable 3D printing technology. Four holes with a radius of 1mm and a depth of 3cm were dug on the bottom of the circular surface to place the bolts. A breakthrough hole with a depth of 2cm and a diameter of 1cm was dug along the axis on the side of the curved surface. A 40mm*20mm*10mm rubidium iron boron magnet is placed inside the mover, and a layer of copper foil with Polytetra fluoroethylene (ptfe) film is attached to the curved side of the mover.

2.2 Fabrication of stator

The stator is a circular structure with an outer diameter of 8cm and an inner diameter of 6.5cm following the same manufacturing process. A copper foil electrode with a width of 1cm and a thickness of 50 μm is affixed to the inner surface of the stator. An 8cm outside diameter and 7cm inside diameter circular arc is used to place the coil (0.02mm wire diameter, 100 in turns). Four fixtures are arranged to fix the stator to the optical plate, and connecting structures are designed to connect the other stators.

2.3 Electrical Measurement

The output signals of H-WEH were measured via a programmable electrometer (Keithley 6514 System Electrometer). The software platform was built based on LabVIEW, which was capable of realizing real-time data acquisition and analyzing the wave simulation system. An adjustable speed motor (US-52) equipped with a reduction gearbox (5GU-5-K MAILI) was conducted to simulate the water wave motion. Finally, for measuring the charging and discharging performance of the H-WEH, a capacitor (4.7μF, 50V) was used.

3 Results and Discussion

3.1 Structural Design and Working Mechanism

The H-WEH is composed by multiple power generation units. As shown in Figure 1a, the power generation unit is connected to a floating sphere that ocsilates under the excitation of waves. The structure of the H-WEH is depicted in **Figure 1(b)**, which mainly consists of two parts: Mover and Stator. The number of mover and stator in H-WEH can be adjusted flexibly according to various working conditions. As can be seen, a contact-sliding mode TENG is established between the outer ring of the actuator and the inner ring of the stator. To enhance the contact electrification effect, 2000 mesh sandpaper was used to grind the PTFE and copper foil before spraying with the hydrophobic coating (Rust Oleum 274232 Never Wet Multi Purpose Kit) to improve H-WEH flexibility under the marine environments. At the same time, the magnet inside the mover and the coil outside the stator constitute an EMG.

Under the excitations of waves, the actuator moves back and forth in the pool of the stator. Based on the coupling effect of triboelectrification and electrostatic induction[14], the working mechanism can be illustrated in five steps in a cycle as shown in **Figure 1(c)**. Due to the electronegativity difference between the nylon and PTFE, positive and negative triboelectric charges are generated on the surfaces of the nylon and PTFE respectively. The charge will not

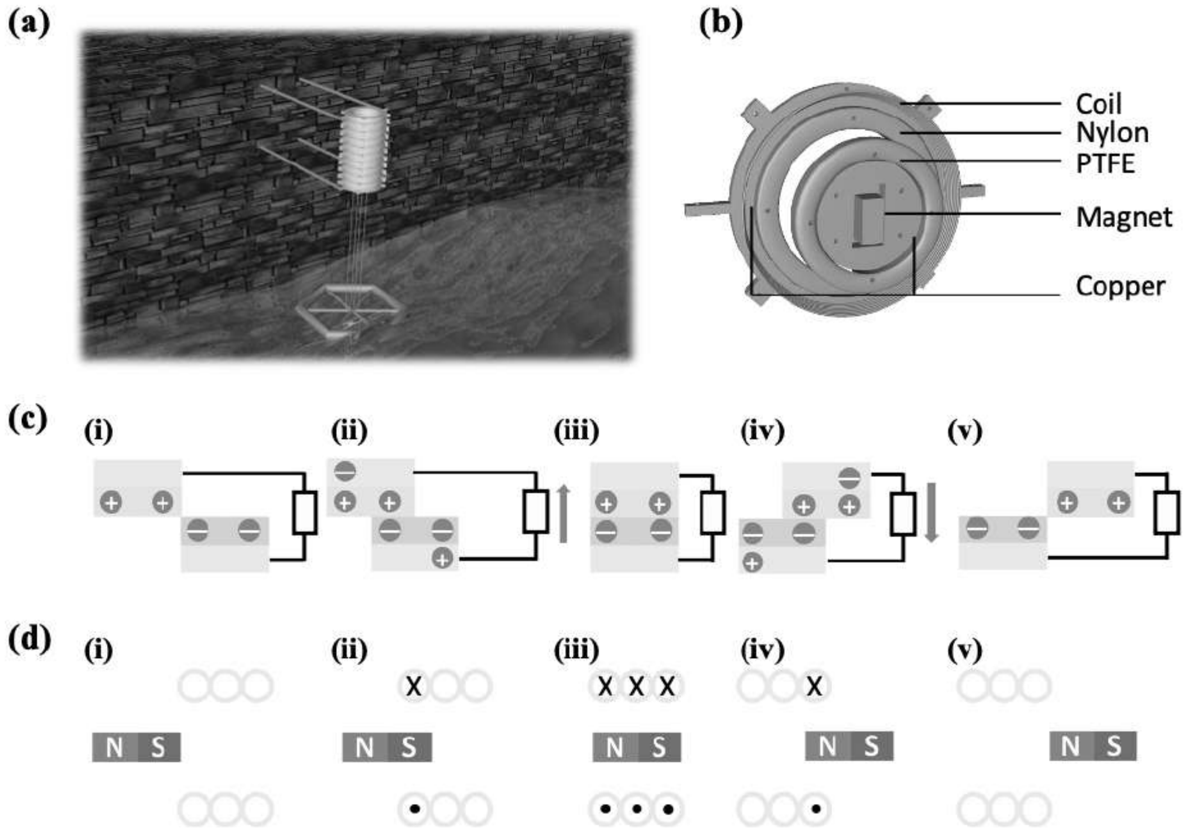

Figure 1. Structural design and working principles of the T-TENG. (a) Schematic diagram of the designed H-WEH consisting of multiple units. (b) Exploded view of the H-WEH's structure. (c) The working principle of the TENG component. (d) The working principle of the EMG component.

leak in one cycle because the triboelectric charge is only distributed on the surface layer of the polymer and the polymer has excellent insulationperformance. In the initial position, Nylon and PTFE carrying equal charges of opposite signs, and there is almost no potential difference between the two electrodes as shown in **Figure 1c(i)**, once the positively charged mover starts to slide to the right, the contact area of the two materials will increase, leading to charge separation. As shown in **Figure 1c(ii)**, due to the insulator nature of the polymer material, as the contact area increases, the excess transferred charge on the electrode flows from the upper electrode to the lower electrode through the external load. As shown in **Figure 1c(iii)**, when the surfaces of the two polymers are completely overlapped, there is no potential difference between the two poles, and no electron transfer occurs. As shown in **Figure 1c(IV)**, the separated charge causes the upper plate to have a higher potential. Driven by the potential difference, electrons will flow from the lower electrode to the upper electrode to offset the

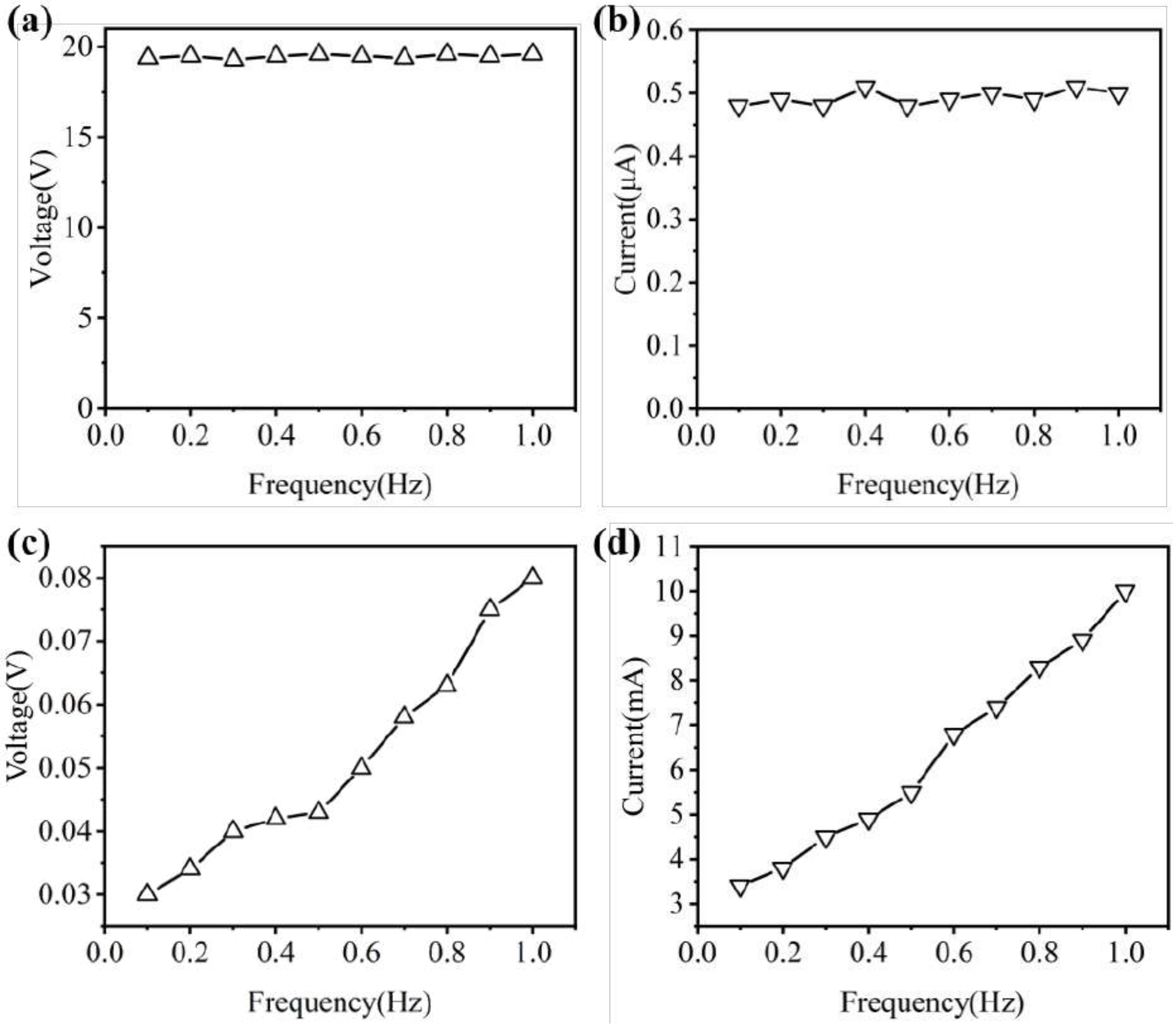

Figure 2. H-WEH output characteristics at different frequencies. (a) The voltage of the TENG component at different frequencies. (b) The Current of the TENG component at different frequencies. (c) The voltage of the EMG component at different frequencies. (d) The current of the EMG component at different frequencies.

potential difference generated by the frictional charge. Finally, the mover moves right to the position shown in **Figure 1c(V)**, the upper and lower plates have the same potential, and there is no electron transfer. Meantime, based on electromagnetic induction, the EMG component can generate alternating current due to the periodic change of the magnetic flux caused by the periodic displacement change between the magnet and the copper coil, as shown in **Figure 1(d).**

3.2 Electrical output performance of the H-WEH

To further study the performance of the H-WEH the stator is fixed on the optical plate and a linear motor is used to exert a forced motion to the mover. The output of the TENG and the EMG was tested under a fixed amplitude of 40mm and various frequencies from 0.1 to 1Hz. As

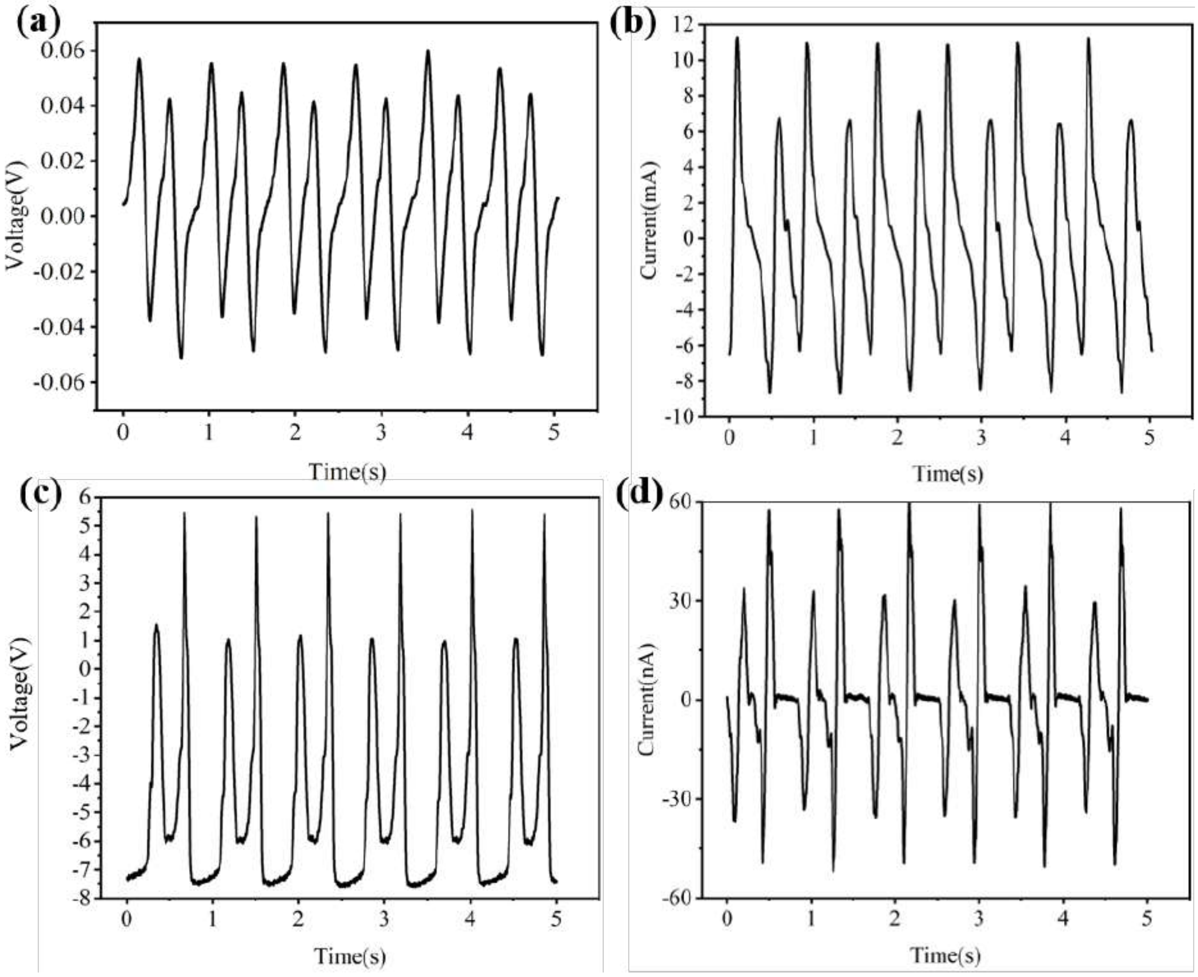

Figure 3. The output characteristics of H-WEH under the excitation of waves with a frequency of 1HZ and a height of 5CM. (a) TENG's voltage curve. (b) TENG's current curve. (c) EMG's voltage curve. (d) EMG's current curve.

shown in **Figure 2a, b,** the voltage and the current of TENG hardly change as the frequency increases. The maximum voltage and the current is 20V and 0.5μA, respectively. As shown in **Figure 2c, d,** the voltage and current of EMG improve with increasing frequency. Under the fixed frequency of 1Hz, the voltage is 0.08V and the current is 10mA. This also reflects that TENG is more stable than EMG under the low-frequency excitation.

3.3 Practical Applications

For the purpose of practical applications, we link the H-WEH with the floating sphere and place it in an experimental water tank. Linear motors are used as the wave maker. Under the excitation of waves with the frequency of 1Hz and the height of 5cm, the output performances of the H-WEH are shown in **Figure 3.** The output of the H-WEH decreased compared with its output under the driving of a linear motor because in the process of energy transfer between the wave

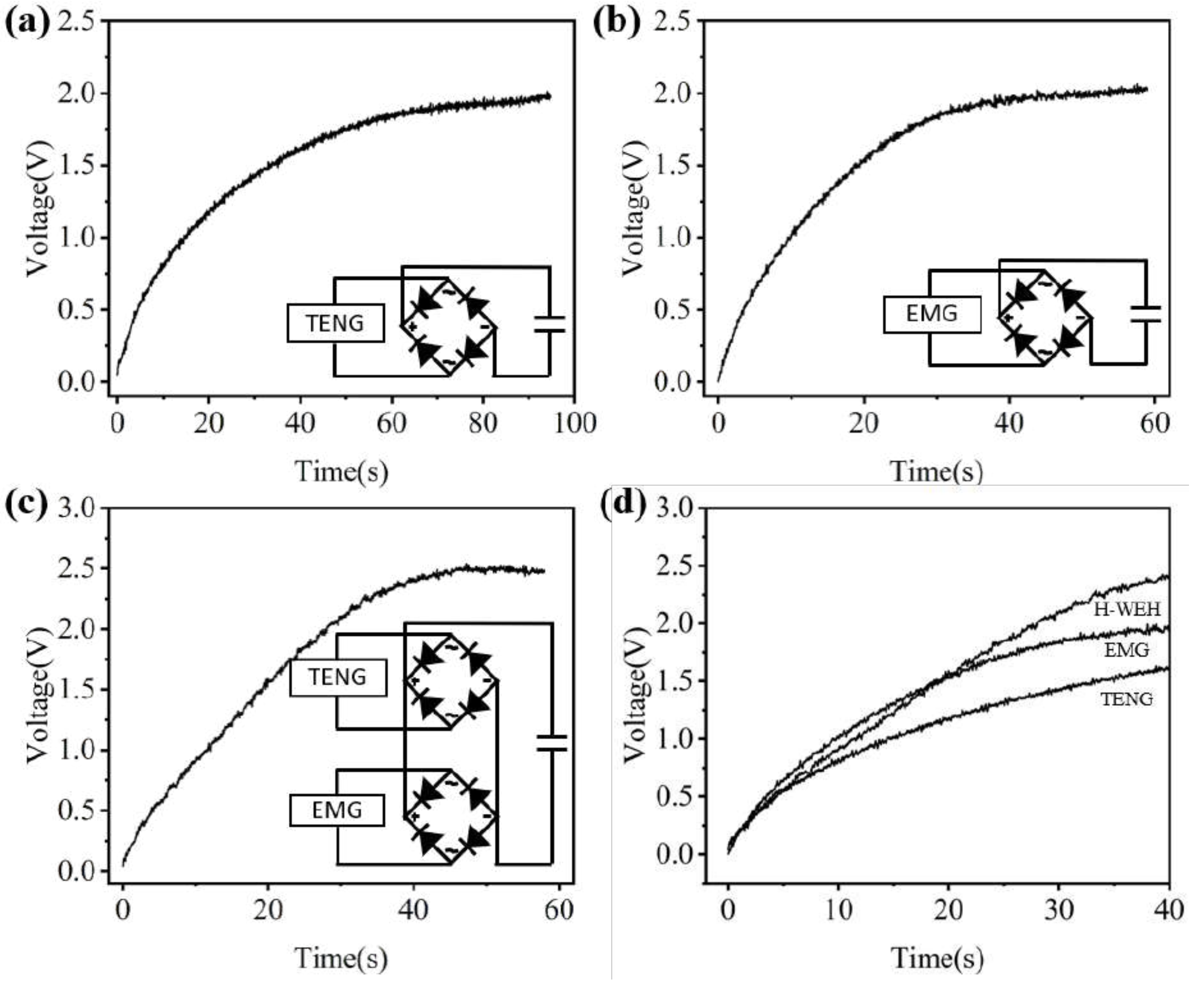

Figure 4. (a) Voltage curves of a capacitor charged by the TENG component. (b) Voltage curves of a capacitor charged by the EMG component. (c) Voltage curves of a capacitor charged by H-WEH. (d) Charging curves of a capacitor using TENG only, EMGs, and the H-WEH.

and the float, part of the energy will be dissipated due to the fluid viscocity .As the power generation unit in the H-WEH makes no direct contact with water, the probability of water leaking into the generator is greatly reduced. A 4.7μF capacitor is connected to the H-WEH and its charging characteristic curve is shown in **Figure 4**. The TENG can charge the capacitor from 0V to 2V in 95 seconds. For the EMG, it only takes 58 seconds. When TENG and EMG charge the capacitor together, the capacitor can be charged from 0V to 2.5V in 51 seconds. As shown in **Figure 4(d)**, the charging capability of the H-WEH was compared with that of the TENG and the EMG when they work independently. Apparently, the EMG has a faster charging speed than that of theTENG at the beginning due to the larger current output. In contrast, the H-WEH has a faster charging speed than the TENG and can charge the capacitor to a higher voltage at the same time.

3 Conclusion

In summary, we have designed a hybrid generator by combining TENG and EMG together to harvest wave energy. Benefiting from the design of the float and the power generation unit, the H-WEH can be used for low-frequency wave energy collection. The power generation performance of H-WEH under different frequencies has been studied systematically. Under the excitation of 1Hz frequency and 5cm wave height, the TENG component can output a voltage of 20V and a current of 0.5μA, while the EMG component can output a voltage of 0.08V and a current of 10mA. For the demonstration, a capacitor was charged successfully through the H-WEH in the water tank, which is superior in maximum charging value and speed compared with individual EMG and TENG components. Because of its small size and easy materials availability, the H-WEH could become a novel way to capture ocean energy.

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Limitations and Opportunities for Wave Energy Utilization in the Baltic Sea: the case-study of Estonia

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Abstract

The EU plans to achieve climate neutrality by 2050, which requires it to be prepared to reduce emissions on its territory by 80% compared to 1990 levels. In Estonia renewable energy potential is primarily reflected in bioenergy-based cogeneration, wind energy, and in the production of green gas/biomethane, while solar energy only became widely promoted throughout the region in recent years. The target percentage of renewable energy use in Estonia for 2020 was 17.6%, with the current average in Estonia at 24%, with 30% planned by 2030. The intent of the Authors is to show limitations and opportunities of the application of wave energy in the Baltic Sea Region alongside with such widely adopted renewable energy sources as wind generation and photovoltaics as an alternative to fossil fuels.

This is a case-study on limitations and opportunities for wave energy potential in the Baltic Sea on the example of the Estonian territorial waters. A survey is conducted with industry experts in Estonia in order to understand possible and desired usage of wave energy in offshore and coastal applications including seafaring, ports, maritime traffic services, maritime rescue, sea tourism and marine planning. Other relevant studies on the subject in the region and in other areas are analyzed in order to take account the aspects that did not arise in the survey conducted. Mapping of limitations, including natural barriers, such as NATURA2000 reserves, salinity, depth, and their impact on wave energy prospects as well as political and legislative burdens is carried out and then tested against the expectations of the industry experts and other possible usage of wave energy in the region.

The quantitative value of the study lies primarily in mapping the marine environment. Locations where sea wave energy could be an appropriate means of providing electricity will be discussed. Areas where wave energy production is limited will be discussed in order to determine the reasons for the limitations and provide proposals for mitigating the obstacles, if possible. For instance, in practice this can translate to the installation of wave energy converters in nature reserves, provided that it does not disturb protected wildlife, e.g., if the unit is installed underwater or in a secluded location, and necessary environmental impact assessments are carried out.

Expected Results: 1) By taking limitations and potential into account and proposing an optimal theoretical model of wave energy converter (WEC) based on that, the paper contributes to the rising awareness and real application of wave energy conversion in environments with low wave intensity such as the Baltic Sea; 2) the article can also be used by the Estonian and similarly placed public administrations as a background research for energy-policy related decision making processes; 3) the case-study of how limitations and opportunities in applying wave energy in the Baltic Sea region can be used as a showcase for other regions that face similar issues.

Keywords: Wave energy, Renewable electricity supply, Marine resources, Wave energy converters, Baltic Sea

Introduction

Currently, every member state of the European Union is trying to achieve the target goals of the Paris Agreement (UNFCCC, 12 December 2015) plans for preventing climate change. The conventional means of achieving this goal were the diversification of energy sources with the addition of renewables to the more commonplace fossil fuel sources, modernization, and optimization of power grids, as well as the search for anthropogenic activities that harm the environment and their subsequent restriction, particularly concerning air quality.

Landlocked countries are increasingly concerned with the role of oceans in climate change as well. The sea stores everything that enters it as a massive accumulator, but besides life-giving solar energy it also accumulates the refuse and waste produced by inhabited areas and other anthropogenic activities. (Lesley & Christopher, 2020).

We cannot accurately estimate nor anticipate where and when a source of a new harmful substance or activity will emerge. While exploring our habitat we often stumble upon opportunities for correcting and preventing the harm that anthropogenic activities cause to the environment. We also try to assess risks and prevent new potential harmful sources from emerging by limiting anthropogenic activities at sea. (Mark, et al., 2021)

If we were to address the crux of the problem and attempt to inspect the process of the emergence of new technologies (both in energy and mechanics), we could surmise that the fact of an innovation's existence alone is not sufficient for the adoption of its technological principle. For this to happen the sector in which such a technology was to emerge should be ready for its practical adoption. To do this, it is necessary to regulate and adjust the innovations' point of origin, namely the legal systems of participating countries, on a daily basis.

Several Baltic nations have already included ocean energy in their government strategies in order to promote the development and adoption of wave energy, most notably Sweden, Denmark, and Finland. Government strategies in these three states are to promote ocean energy development with favorable taxation, research subsidies, and development programs, in order to increase the share of renewables in total energy production to reach carbon neutrality. (Pierre Ingmarsson, 2019)

In this article the impact of various types of restrictions and the emergence of new energy sources will be assessed. For this purpose, article will handle the study area, as a territory of the European Union, and carry out a qualitative analysis of the possibility of the emergence of marine energy in addition to already established renewable energy sources. Following that we will assess the types of restrictions that prevent or contribute to the emergence of new energy sources in the given state's energy market. And in conclusion, we will analyze which mechanisms are necessary to facilitate the emergence of innovative approaches to power generation in the European Union and to achieving climate neutrality.

1. Current state

If we try to assess the state of the wave energy industry in the Baltic region on the basis of existing scientific literature, we will come to the conclusion that it is at the very beginning of its journey: and several attempts have been made to study and describe the potential of energy from the sea wave in the Baltic region. (Bernhoff, et al., 2006) (Jakimavičius, et al., 2018) (Kasiulis, et al., 2015) (Soomere & Eelsalu, 2014) (Henfridsson, et al., 2007).

2. Main parameters of the studied area:

2.1. First limitation – Size and resource

It is an established fact that in order to convert sea waves into electricity they must fulfil the necessary criteria of height and mass, which produce waves capable of transmitting potential and kinetic energy in the form of heat or electricity. But in the Baltic Sea such high waves are exceedingly rare - the largest recorded wave in the Baltics had a height of 8.2 meters (Tuomi, et al., 2011), and the path that a single wave can travel in a straight line without obstacles reaches a maximum of 800 km (STREET, et al., 2014). The average significant wave height for the Baltic Sea is 0.5 m (Björkqvist, et al., 2018). Based on this, we can identify the first serious limitation - the limited surface area, depth, and longitude of the Baltic Sea, which reduces wave propagation and intensity and therefore limits the total wave energy resource (Figure 1).

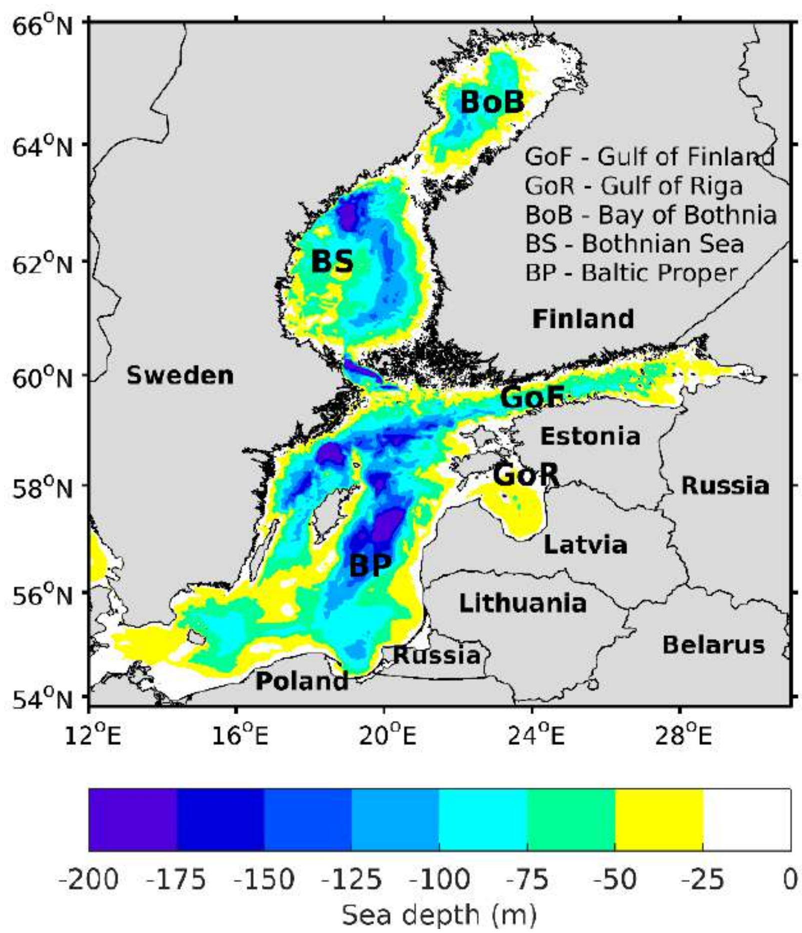

Figure 1. Study area with sea depths. (Author's figure 2021)

Several attempts have been made to estimate the wave energy resource contained in the Baltic Sea. As our article concerns the eastern coast of the Baltic Sea, namely Estonian territorial waters, we will rely on the studies of these locations during this study. (Jakimavičius, et al., 2018) (Soomere & Eelsalu, 2014). Based on the conducted simulations, it can be concluded that the energy resource of Estonian territorial waters is 611 MW of which approximately 73% can be industrially utilized (Soomere & Eelsalu, 2014).

2.2. Second limitation - Ice

The second limitation which serves as an obstacle to the adoption of wave energy in the Baltic region, is the ice formation during winter months, which at large part results from low salinity of the Baltic Sea. It is possible for a significant portion of the Baltic Sea to be covered with ice (Vihma & Haapala, 2009), which should be taken into account when designing a viable wave converter for local conditions. An ice cover strongly diminishes the propagation of sea waves, (Squire, 2018) making it an important factor to consider, as winter months are the most energy productive period in the Baltics. With regional ice formation patterns in mind, sufficiently durable materials must be used in the design of sea wave converters. The primary parameter of such a material should be its resistance to the mechanical effects of ice. Inertia-carrying ice fragments contacting the surface of the equipment can cause irreparable damage sufficient to put a wave energy converting device out of order.

Based on annual observations of ice coverage in regions of the Baltic Sea over the period 1971-2000, the following pattern can be observed within the regions of the study area: the annual average number of days of ice coverage has been 147 in the Bay of Bothnia (BOB), 101 in the Bothnian Sea (BS), 74 in the Gulf of Finland (GoF), and 0 in the Baltic Proper (BP) (Mats Granskog, 2006). As such, wave energy applications in the Baltic Sea are best applied south of the Bothnian Sea, which is consistent with more populated coastal regions of the Baltic.

2.3. Third limitation - Marine protected areas

When describing available resources, we must first assess their actual availability. In addition to the restrictions imposed by natural conditions, there are also restrictions imposed by public regulation. The largest network of restrictions in the Baltic region is connected to the NATURA2000 network (European Commission, 2021) (Figure 2).

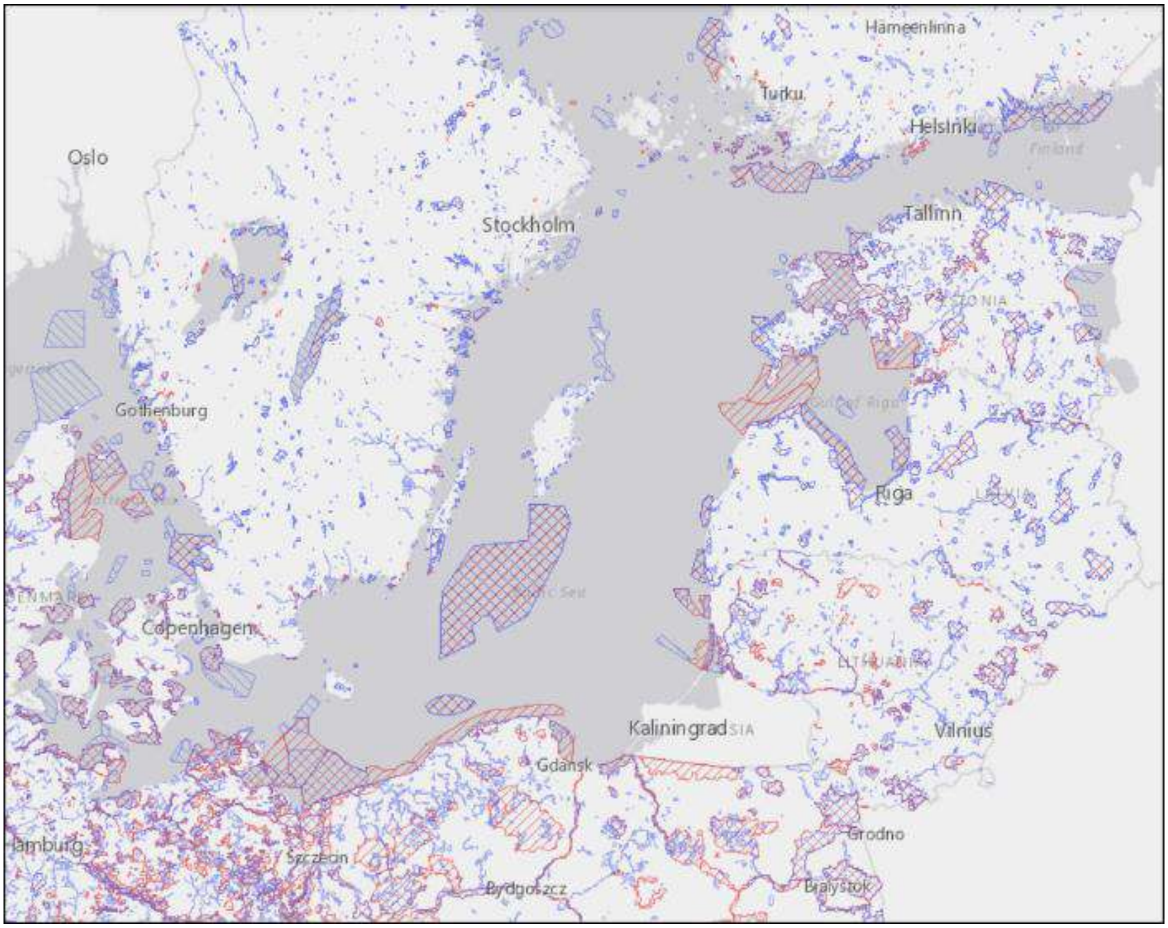

Figure 2. Protected nature areas in the Baltic Sea. (Natura 2000, 2021)

This network establishes protected areas in regions endangered by anthropogenic activities as a home and habitat for endangered flora and fauna. In addition to protected areas, public regulation mandates environmental impact assessments for any wave energy related installations in the sea, to determine their impact on local environments and wildlife, and prevent potential damage.

2.4. Fourth limitation - Energy conversion issues

Each energy converter possesses its own level of efficiency. At sea, this parameter is the lowest among renewable energy sources, as technological solutions to increase efficiency have so far been economically inefficient. If we assume that a wave energy converter can extract approximately 80% of the available resource immediately on-site, following subsequent transformations only 50% of the theoretically available energy would reach the coast. (Bernhoff, et al., 2006) Other limitations would be of temporary nature and caused by a specific locale's inherent features.

As the number of existing wave energy converter tests conducted on-site in the Baltic Sea is limited, we have exhausted the selection of existing sources on the topic during the writing of this paper, with primary sources mentioned above in the "Current state" section. This circumstance complicates the process of determining the suitability of WEC technologies for local environments and conditions – a factor that plays a larger role in a technology's operational efficiency than the base efficiency of the conversion system itself. Therefore, a greater number of physical tests in the marine environment of the Baltic Sea is necessary for proper evidence-based analysis of WEC technological compatibility with Baltic Sea conditions. Future research on the topic should focus on identifying WEC technologies that are most suitable for the Baltic Sea environment, with local marine conditions accounted for.

2.5. Fifth limitation – Awareness of wave energy

While conducting initial conversations with sector stakeholders we came to the conclusion that the limited awareness of ocean wave energy may be another obstacle for the adoption of wave energy in the Baltic Sea region. In order to test this hypothesis, in May 2021 a questionnaire was developed and distributed among 48 stakeholders within the energy and maritime industry, of which 9 submitted an answer (Table 1).

1. Which marine sector do you come from?	Research and education	Industry	Navigation markings	Ports	Energy
	3	2	2	1	1
2. Are you aware of wave energy applications in your sector?	Yes	No			
	7	2			
3. Please name possible uses of wave energy in your field of activities.	Electricity generation on land	Electricity generation at floating facilities			
	5	4			
4. In what time frame could you see wave energy becoming an alternative to the current energy sources you use?	2025-2030	2030-2035	2035+		
	4	3	2		
5. Would it be possible to use wave energy in a field other than your own	Yes	No			
	8	1			

Table 1. Energy and maritime industry stakeholder questionnaire results. (Authors' table, 2021)

The questionnaire consisted of six questions. Answers to the first question reveal that the respondents came from five sectors related to maritime – research and education (3 respondents), industry (2), navigation markings (2), ports (1) and energy (1). Secondly, 7 out of 9 respondents had heard of the usage of wave energy in their field of activity. Thirdly, all 9 respondents named possible usages of wave energy in their field of activities, namely as converted into electricity (5 respondents) or for electricity generation also at floating facilities (4 respondents). Fourthly, to the question in what time frame could they see wave energy becoming an alternative to the current energy sources they use, four respondents indicated years 2025-2030, three 2030-2035, and two 2035 and later. Fifthly, only one respondent answered negatively to the question, if it would be possible to use wave energy in a field other than their own. Sixthly, eight respondents indicated other possible uses of wave energy apart from their own field. In addition, although the questionnaire was anonymous, six respondents (67%) left their contacts indicating that they wish to receive information about the possibilities of using wave energy and the development of a wave energy converter in Estonia in the future.

Conclusion

There are approximately a hundred proposed wave energy converter concepts, and over 50 implemented projects. (Clemente, 2021) Accounting for the abovementioned limitations we can approximate the general parameters of a device that could be effectively utilized in the Baltic Sea waters. However, the goal of this paper is not to elevate any specific type of wave energy converter, but to determine the hypothetical scale and boundaries of an initially applicable wave energy converter for Baltic conditions, and we have demonstrated the limitations of implementing an innovative energy source, in the context of Estonian conditions. We can conclude that the approach proposed at the start of this article is optimal, with the sole addition to the possibility of connecting wave energy converters into parks or grids being their possible automation based on real-time forecasts. Such a system would rely on the installation of data-collecting buoys around wave energy converters, which would transmit live wave data to a converter in order for it to optimize its power output in real-time.

Accounting for the second limitation, we can assume that the energy flow in winter is at its highest at sites where the sea surface is not covered with ice, and absent at sites where the sea surface is frozen. Additionally, the ice can cause damage to a device, meaning that avoiding contact with ice should be prioritized when picking a location. With this in mind, it is necessary to create the conditions for relocating installed devices or removing wave energy converters entirely for low-production winter months. Additionally, the option of sinking the mechanism for the winter period should be considered.

Accounting for the third limitation, we can conclude that the availability of wave energy resources is often constrained by public regulation, which is a fact that should be respected in these circumstances. However, it is necessary to consider that the installation of wave energy converters can in some cases not only to cause harm to the surrounding environments, but also benefit the growth of artificial reef ecosystems, which can serve as a viable justification for the installation of wave energy converters in otherwise protected areas, provided that environmental assessments confirm the low impact of such installations.

And finally, accounting for the fourth limitation, we recommend that existing marine infrastructure be used for the installation of sea wave converters. Despite the fact that ports normally operate as territories where wave power is diminished through active means, such as the construction of breakwaters in order to avoid damaging the vessels moored on the premises, there are normally plenty of locations with sufficiently deep waters around ports, which can be used to install smaller scale wave energy converters. This would also serve the benefit of allowing potential developers to narrow down their choice of WEC technologies for such applications.

Contrary to the initial hypothesis on awareness of wave energy being a limitation to the usage of wave energy in the Baltic Sea area, the results of the questionnaire show support and interest for applying wave energy in various sectors and a general expectation of wave energy's imminent emergence.

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MATHEMATICAL MODELING AND DESIGN OF A BARREL CAM BASED TRANSMISSION MECHANISM FOR UNINTERRUPTED ENERGY HARNESSING FROM VORTICES

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Mathematical modeling and design of a unique transmission system for converting linear oscillatory motion of variable frequency and amplitude to uniform rotation is discussed in this paper. The transmission system discussed here derives its constructional and working principle from a candle holder which is further modified to suit a barrel cam mechanism. Any longitudinal motion with in the helical grooves produces rotation of the entire body about its vertical axis. This principle was adopted to convert the variable linear oscillations of the bluff body due to vortex shedding to bi-directional rotations of the barrel cam. A ratchet integrated gear mechanism is incorporated to convert the bi-directional rotations to uni-directional. The system forms an integral part of a renewable energy generator named Hydro Vortex Power Generator, which is capable of generating electricity from slow moving currents. The vertical oscillatory motion is transmitted to the slider and the same is transmitted to the barrel cam through the cam follower. A complete mathematical model of the transmission system is presented in this paper, through which the transmission efficiency is estimated to be 78.7 %. A computer aided design model with design specifications of each component of the transmission device is also presented. Based on the CAD model, transmission system is fabricated and is tested for its efficiency on a standalone HVPG module. The overall efficiency of the power generator with the novel transmission system was observed to be 60.2 % for an output power of 19. 8 W

1. Introduction

The earth's water bodies constitute a huge portion of the planet and their slow and steady motion represents a vast, but yet untapped energy resource. Hydroelectric power generation is of course a clean source of energy but considering the capital investment and the effects of dams on natural ecosystem the need for a much cleaner and safer energy source becomes more important [1,2]. Vortex power and studies on its efficacy to produce electric power has always been a matter of research. Devices have been developed and deployed on ocean beds for harnessing the power of vortices shed in the wake of bluff bodies due to ocean currents [3]. The elastically mounted bluff body oscillates due to the induced lift force from the vortices. The oscillations are then tapped to useful electric power. This process entails the incorporation of an efficient power transmission system. There have been many mechanical power transmission systems reported in various literature that convert the hydro mechanical energy of the bluff body available as oscillations to useful electrical power output [4, 5, 6]. However, the transmission modes considered were conventional employing piezoelectric conversion or a simple mechanical conversion such as a slider-crank mechanism. The efficiency of transmission systems directly affects the power output. This paper presents a novel transmission system inspired from a spiral grooved candle holder developed into a barrel cam mechanism. The transmission efficiency is found to be satisfactory establishing the system's suitability in the design of power harnessing devices.

1.1. The Concept of Hydro Vortex Power Generator (HVPG)

The HVPG is a device used to tap the hydro mechanical power of vortices and then harness the same in the form of useful electrical output. When a cylindrical body is placed with its longitudinal axis perpendicular to the direction of a flow, the body starts oscillating in mutually perpendicular directions. The oscillations in the direction of flow are called in-line (IL) oscillations and those in the direction perpendicular to the flow are known as cross-flow (CF) oscillations. The CF oscillations are more predominant and contribute to the power harnessing [7]. When the frequency of vortex shredding matches the natural frequency of that of the bluff body, the body undergoes harmonic oscillations of large amplitude. This phenomenon is known as 'lock-in' [8]. During lock-in, frequency of shed vortex shifts to natural frequency of the bluff body, leading to oscillations of greater amplitude.

Vortex shedding occurs at a discrete frequency and is a function of Reynolds number ($\boldsymbol{Re}$), given as in Equation (1) [9].

$$Re = \frac{\rho V D}{\mu} \tag{1}$$

When vortices are shed from the cylinder, uneven pressure distribution happens to develop around the upper and the lower part of the cylinder, giving rise to an oscillating hydrodynamic lift force on the cylinder. The lift force is given in Equation (2).

$$F_L = \frac{1}{2} C_L \rho A V^2 \tag{2}$$

where, F_L is the lift force, C_L is the coefficient of lift, ρ is the density of water, A the projected area in the direction of flow and V is the velocity of flowing water. The cylinder also experiences a net force along flow (IL) direction and is called the drag force. The drag force is given in Equation (3)

$$F_D = \frac{1}{2} C_D \rho A V^2 \tag{3}$$

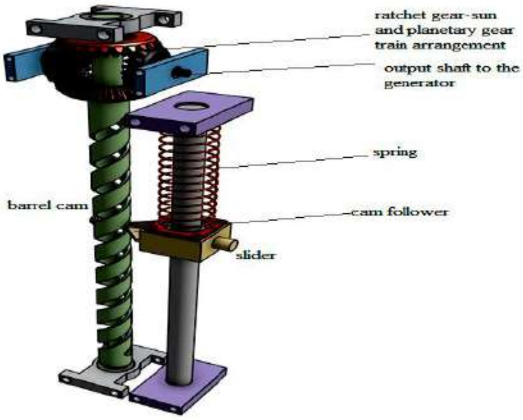
where, F_D is the drag force and C_D is the drag coefficient.

For the device HVPG to materialize for the intended purpose, a cylindrical bluff body has been mounted elastically, enabling the entire module to be considered as a spring-mass system undergoing harmonic oscillations. When the natural frequency of the spring-mass system matches the vortex shedding frequency, the system encounters resonance condition and the cylinder oscillate with large amplitudes [10]. The linear motion of the mass is then converted to rotary motions through an appropriate transmission mechanism. This paper discusses a novel transmission system for the device in detail.

2. Working Principle - Novel Transmission System

The transmission system discussed here derives its constructional and working principle from a candle holder show in Figure 1 (a) which could convert any linear motion with in the helical grooves to rotary. The system is further modified to suit a barrel cam mechanism. A ratchet integrated gear mechanism is incorporated to convert the bi-directional rotations to uni-directional.

The vertical oscillatory motion of the bluff body is transmitted to the slider and the same is transmitted to the barrel cam through the cam follower. The elements of transmission system are shown in Figure 1 (b). The follower reciprocates and the barrel cam rotates in clockwise direction during the upward motion and in the anticlockwise direction during the downward motion of the bluff body. The top end of the barrel cam is equipped with ratchet integrated differential gear system. One set consists of gears having ratchet drives attached to the axis coupled directly to the axis of barrel cam. As the cam rotates in clockwise direction the ratchet gear on one side attains the drive and the other undergoes free rotation.



(a) (b)

Fig. 1. Transmission mechanicsm (a) inspirational candle stand (b) CAD model

In case of anti-clockwise rotation, the drive and free rotation are reversed. The other set of gears, known as output gears, facing each other are meshed at 90° to the ratchet gears. The output gears are placed face to face forming a differential gear arrangement. The bi-directional rotation of the barrel cam is converted to unidirectional rotation, and the rotation is obtained from the output gears. The output gears is coupled to the output shaft and further to a generator for extracting output DC power. The process of hydromechanical power transmission to generate useful electrical power output is demonstrated using a flow chart as in Figure 2.

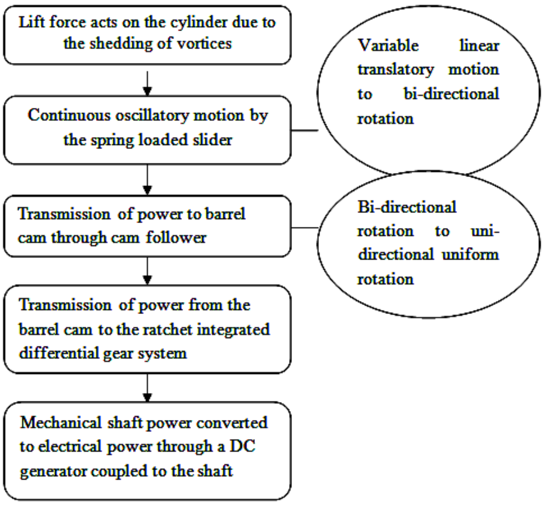


Fig.2. Flow diagram of power transmission system

3. Transmission Mechanism

The load acting on the slider in the direction of its motion is F_L. A slider bearing of 25 mm inner diameter for load carrying capacity of 980N is selected [11]. Details of the bluff body and the slider, spring specifications , details of barrel cam and the ratchet arrangement are listed in Table 1[12, 13].The barrel cam in the present design is used to convert linear motion into rotary motion, i.e. back driving. The main factor responsible for providing the back drive is the lead or helix angle [13, 14]. The barrel cam is provided with screw thread with double start thread groove. It has already been proved that thread angle greater than 20° shows the tendency to back drive [15]. On further increasing the thread or the lead angle, the back drive efficiency increases.

In the ratchet gear arrangement the larger gears rotate clockwise and anti-clockwise giving unidirectional rotation as output. Here maximum angular speed is obtained when the number of teeth on the planetary gear is reduced to that of the sun gears. On further reduction, the module of the gears changes resulting in backlash [16]. The net output is unidirectional rotary motion at the output shaft which in turn is coupled to a DC generator to produce power.

4. Theoretical Power Calculations

According to previously published work from the authors [11] lock-in vibration occurs at reduced velocity, U_r= 5 and frequency ratio, η = 1. The resonance or lock-in condition can be represented by Equation (4), where f_s is the vortex shedding frequency,

$$f_n = f_s = \frac{V}{DU^*} \tag{4}$$

Table 1 Specifications of the transmission system

Bluff body and slider		**Spring**		**Barrel cam**		**Ratchet gear arrangement**	
Parameters	**Specification**	**Parameters**	**Specification**	**Parameters**	**Specification**	**Parameters**	**Specification**
Cylinder Diameter	76.2 mm	Material	SS 134a	Material	SS	Material	PLA
Cylinder Length	800 mm	Type	Square	Thread	Double start	Sun gear: No.of teeth	24

						(t_1)	
Oscillating Mass	6.2 kg	Free length	300 mm	OD	40mm	Planetary gear: No. of teeth (t_2)	18
C_A	0.7	OD	34 mm	ID	32mm	Module (m)	1mm
Slider rod OD	25mm	ID	30 mm		50mm	Shaft angle	90°
Slider bearing ID	25mm	Wire thickness	2 mm	Helix angle	50.19°	Teeth width	5.08mm
Slider Capacity	980 N	Coils (Active)	8	Length of cam	680mm		
		Coils (Total)	10				

4.1. Mass Ratio

Mass ratio (m^*) of the oscillating system is an important parameter that influences the amplitude of response and is given by Equation (5), where m ,virtual mass of the system is taken as $m_a + m_b$, $\boldsymbol{m_a}$ is the added mass and $\boldsymbol{m_b}$ is the mass of the bluff body. m_{dis} is the mass of fluid displaced by the body.

$$m^* = \frac{m}{m_{dis}} \tag{5}$$

4.2. Stiffness of the spring (k)

Spring stiffness is a very important parameter in the design [17]. The body oscillations depends on the restoring forces and the spring should have enough stiffness to sustain the oscillations. The spring stiffness is calculated from the circular natural frequency value, ω_n corresponding to $U_r = 5$ using Equation (6).

$$\omega_n = \sqrt{\frac{k}{m}} \tag{6}$$

The device uses a pair of springs connected in parallel and stiffness of each spring (*k/2)*

4.3. Amplitude of Oscillation (y)

The amplitude of oscillation ymax during resonance is given as in Equation (7)

$$y_{max} = \frac{F_L}{2k\xi} \tag{7}$$

where ξ is the damping ratio.Various design parameters and the calculated values using Equations (1) through (7) used in the design of HVPG is shown in Table 2.C_L value is taken from the previously published work of the authors for the same Re and m^*[11].

Table 2 Design parameters

Parameters (HVPG)	**Specifications**	**Parameters (DC Generator)**	**Specifications**

Design velocity (V)	1.2 m/s	Output speed(N_{gen})	120 rpm
Density of water (ρ)	998.3 kg/m^3	Supply Voltage	4.5 – 15 V DC
Reynold's number (Re)	1.02 x 10^5	DC motor type	Brushed
Coefficient of lift (C_L)	0.75	Shaft diameter ($d_{genshaft}$)	6 mm
Lift force (F_L)	32.86 N	Gearhead type	Spur
Strouhal number (St)	0.2	Length (L_{gen})	78 mm
Mass ratio (m*)	2.89	Width (B_{gen})	37 mm
Natural frequency (f_n)	3.15 Hz	Current Rating (I)	2.81 A
Stiffness (k)	4124 N/m	Core	Iron
Maximum amplitude – theoretical (Y_{max})	0.1327 m		
Damping ratio (ξ)	0.03		

4.4. Mechanical Efficiency

The hydro-mechanical efficiency, η_{hymech} of the system is defined as the ratio of power available at the bluff body to the power available at the slider, and is shown in Equation (8).

$$\eta_{hymec\,h} = \frac{P_{slider}}{P_{bluff}} \tag{8}$$

where P_{slider} is estimated considering the actual amplitude of oscillation obtained from field test conducted at Palissery irrigation canal which is presented in Table 3.P_{bluff} is estimated considering the maximum velocity and the corresponding amplitude $Y_{max.}$, estimated theoretically from the value of lift force calculated from Equation (2). C_L has been assumed based on the numerical simulation carried out in the previously published work by the authors. Lift and drag coefficients of a horizontal cylinder were also estimated from a wind tunnel experiment conducted at the same Re in the published work [11].

4.5. Transmission Efficiency

The transmission efficiency, of the system is given as in Equation (9)

$$\eta_{trans} = \frac{P_{shaft}}{P_{slider}} \tag{9}$$

The output power of the transmission system is given as in Equation (10)

$$P_{shaft} = \frac{4\pi N_{shaft} T_{shaft}}{60} \tag{10}$$

$$\boldsymbol{T_{shaft}} = T_b \left(\frac{t_2}{t_1}\right) \eta_{gear} \tag{11}$$

Torque on the barrel cam T_b presented in Equation (11) can be estimated from the force acting on the barrel cam. Estimated values of the output parameters are presented in Table 4.

5. Electric Power Generation

Two direct current (DC) generators with specifications as given in Table 2 are connected to the shaft of the linear transmission system to covert the mechanical power into electricity. The efficiency of the generator, η_{gen} can be obtained from Equation (12) [18,19].

$$\eta_{gen} = \frac{P_{gen}}{P_{shaft}} \tag{12}$$

Using a suitable compound gear the speed is reduced from 550 rpm at the shaft to 120 rpm at the generator shaft. Corresponding torque at the generator shaft will be 0.59 N m. Torque at the generator shaft, T_{gen} and the efficiency of the generator, η_{elec} are given in Table 4.

6. Overall Efficiency of Hydro Vortex Power Generator (HVPG)

Overall efficiency of the HVPG module developed is obtained from Equation (13).

$$\eta_{overall} = \eta_{hymec\,h} \times \eta_{trans} \times \eta_{gen} \tag{13}$$

7. Experimental Validation

The design calculations presented in this paper are based on the amplitude of the slider measured from a field test carried out in Palissery[1] irrigation canal. The measurements were carried out using a pantograph with a pencil attached to the mechanism.The pencil was permitted to move against a paper and the readings were recorded on a linear scale. The calculated value of N_{barrel} is verified using a digital tachometer and is obtained as 400 rpm instead of 500 rpm. This change when reflected in the rest of the calculation indicate an over prediction of 3% in the overall efficiency, $\boldsymbol{\eta_{overall}}$.

The HVPG module with specifications as in Table 2 has been tested for response and output power at the Palissery irrigation canal. The module was tested for a range of natural frequencies to validate the argument that lock –in vibration with highest amplitude occurs not only at the discrete frequency when η =1, but over a range of frequency ratios, thus widening the efficient regime of operation. Actual value of Y_{max} observed during the field test is used for calculating mechanical efficiency of the module. The observations are presented in Table 3. A photograph during the test is presented in Figure 3.

Table 3 Output parameters from the field test of HVPG Phase III

Frequency Ratio (η)	**Spring Stiffness (k) (N-m)**	**Maximum Amplitude (Y_{max}) (m)**
1.13	1020	0.098
1.05	2314	0.105
1.0	4124	0.11
0.93	1784	0.107
0.9	1363	0.102
0.86	1156	0.102

[1]Palissery is a country side place in the Ernakulam District, the state of Kerala, India.

Fig. 3. Field test of HVPG Module Phase III at Palissery irrigation canal

7.1 Uncertainty Analysis of Measurements

The experimental results show a non linear relationship with k, which is comparable to previously published results. In view of the results the uncertainty for measurement is well within the acceptable range.

8. Results and Discussions

From the calculations carried out the performance parameters of the device in discussion are arrived at and are shown in Table 4. The measurable output of the device is terms of various efficiencies are also presented in the table.

With the overall efficiency of 60%, and output power approximately 21 kW, the module is a promising source of renewable and clean hydrokinetic energy.

Hydro Vortex Power Generator with the efficient transmission system developed through this research possess high scalability and is capable of harnessing energy from vortices shed by ocean currents. Research can be taken ahead with a vision of tapping green energy of vortices from the vast costal line of India. HVPG modules can be design improvised and installed in array, of which further numerical analysis is required, to produce green and sustainable energy.

Table 4 Performance parameters for the HVPG module

Design Parameter	Value	Design Parameter	Value
Power of bluff body (P_{bluff})	86W	Speed of planetary gear in rpm ($N_{planetary.}$)	550.4 rpm
Maximum amplitude – actual (Y_{act})	0.11m	Gear efficiency (η_{gear})	95%
Power at slider (P_{slider})	71.5W	Torque transmitted to shaft (T_{shaft})	0.364 Nm
Hydro-Mechanical efficiency (η_{hymech})	83.14%	Power available at the shaft (P_{shaft})	20.98 W
Velocity ratio (V_r)	1.13	Transmission efficiency (η_{trans})	78.7%
Coefficient of friction (f)	0.3	Torque transmitted to the generator (T_{gen})	0.59 Nm
Efficiency of barrel cam (η_{bcam})	71.2 %	Motor Power	19.8 W
Force on barrel cam (F_b)	28.401 N	Generator efficiency (η_{gen})	94.4 %
Torque on barrel cam	0.5112	Number of individual	2

(T_{barrel})	N/m	threads (n)	
Slider displacement during field tests (y_{act})	110 mm	Hydromechanical efficiency (η_{hymech})	83.14%
Actual velocity ($V_{barrel.act}$)	0.688 m/s	Transmission efficiency (η_{trans})	78.7 %
Speed of barrel cam in rpm (N_{barrel})	412.8 rpm	Electrical efficiency (η_{elec})	94.4 %
Power at barrel cam (P_{barrel})	22.098 W	Overall efficiency ($\eta_{overall}$)	60.2%

8. Conclusions

A new concept for generation of clean and renewable energy from ocean/river currents from an Indian perspective has been introduced in this paper.The standalone module of HVPG developed in this work has considerable efficiency and output power, which can be used to light up tribal areas of the nation in an absolutely green way. During the course of the project three models I, II and III have been built and tested in the Palissery irrigation canal which is a low-turbulence free surface water channel. HVPG allows efficient extraction of energy with minor and slow adjustment of basic design parameters such as the spring stiffness and induced damping. It is capable of generating energy with high power conversion ratio at speeds as slow as 0.5m/s, and as high as 5 m/s. Finally, HVPG's scalability, modularity, and design flexibility allow for a broad range of applications. The proposed design of the transmission mechanism can be used as a universal transmission device where it can convert non uniform oscillations into rotation. The ratchet integrated differential gear mechanism alone can be used in high speed switching in the direction of rotation. Hydro Vortex Power Generator with the efficient transmission system developed through this research possess high scalability and is capable of harnessing energy from vortices shed by ocean currents.Research can be taken ahead with a vision of tapping green energy of vortices from the vast costal line of India. HVPG modules can be design improvised and installed in array, of which further numerical analysis is required, to produce green and sustainable energy.

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Zero Emissions Ferries Utilizing PV/ Shore Connection Hybrid Power System

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Keywords: RES, GHG, PV, hybrid power system, Suez Canal ferry.

Abstract

The use of non-clean energy sources such as fossil fuels is a major threat to the environment and the general climate change. The quick economic development has increased the energy demand and conventional fuel consumption, thus increasing the pollution and environmental impacts. The societies and most countries are now turning to renewable sources like: solar, wind, hydroelectric, biomass, and geothermal energy to produce clean energy and to reduce emissions. The need to search for renewable sources of energy in Egypt is important in terms of economic and environmental impacts, due to Egypt's geographical location and the vital role of the Suez Canal. The present study aims to present renewable energy sources for ship propulsion. Renewable solar energy and electric storage systems are the beneficial solution to achieve the major target of the present research. A conversion of 35 Suez Canal car/passenger ferries to use photovoltaic (PV) solar panels combined with a battery bank instead of conventional propulsion system. The ferries are operating between Port Fouad and Port Said. The proposed propulsion system of the case study cars/ passengers ferry consists of electric output power from PV solar panels in conjunction with an appropriate battery bank system combined with charge shore connection. The results of the study indicate that the ship power generation using PV system is appropriate for long term investments. In addition, solar energy utilization reduced the output emissions by 38.76 tons of NOx, 1421.15 tons of CO_2 and 2.92 tons of particular matter (PM) annually. The financial calculations show that the conversion costs per ferry will be recovered after three years, and the annual operation costs saves more than 262,000 $ each year when compared to traditional operation. Finally, it is noted that the installation of photovoltaic solar panels on the board ferry does not affect its stability.

1) Introduction

Over the past 50 years, the average global temperature has rapidly increased. The public societies are focusing on climate change, one of the major contributions to global warming is the marine industry [1]. The number of emissions emitted into the atmosphere increases day by day due to rising fuel consumption. Recent studies of greenhouse gases (GHG) estimation conducted by International maritime organization (IMO) in the maritime field in 2009 indicated that about 870 million tons of carbon dioxide is released into the atmosphere by maritime transportation sectors. The ratio of CO_2 emitted to the atmosphere is expected to increase by 5% in 2050 [2]. The International Convention for the Prevention of Pollution from Ships (MARPOL), specifically, Annex VI of MARPOL addresses air pollution emitted from ships. The international air pollution requirements of Annex VI establish restrictions on nitrogen oxides (NOx) and Sulphur oxides (SOx) emissions and require the use of fuel with lower sulfur content. The requirements apply to vessels operating in the United States of America and within 200 nautical miles of the coast of North America, it is known as the Emission Control Area (ECA) [3]. In order to reduce GHG and air pollution from domestic and international shipping alternative sources of energy are used [4].

The United Nations developed a navigational safety system, which can help respond to growing demands for optimization of port and shipping performance, monitoring of emission data and trade forecasts called “Automatic identification system”. A ship’s emissions depend on numerous factors, including vessel size, engine type, speed, fuel used and route. Automatic identification system data combined with information on the ship’s engine and fuel can help assign carbon dioxide emissions to the country of the vessel's flag or the country’s waters where the carbon dioxide is being emitted [5]. The private sector leads an initiative called “Getting to Zero Coalition” which suggests that shipping’s de-carbonization can be the engine that drives green development across the world [6].

Green shipping is one of the major topics across the world with an adverse anticipation that the reserves of fossil fuels would be used up in the future. Member states of IMO agreed in 2018 to reduce the total annual greenhouse gas emissions by at least 50 per cent by 2050 [7]. To achieve this objective, the international chamber of shipping and other maritime industry associations proposes the establishment of a research and development fund to help cut emissions [8].

Renewable energy can transform the global shipping fleet at all levels and in varying magnitudes. Renewable power applications in ships of all sizes include options for fully electric or hybrid, as well as onboard and shore-side energy use. Potential renewable energy sources for shipping applications include wind, solar photovoltaic, Bio-fuels, wave energy and the use of super capacitors charged with renewable sources [9]. A great development of battery technologies has been leading a greener future in the maritime industry, with hybrid and electrical vessels. The electrification of marine vessels has been evolving over several decades, to move toward zero-emission sea transportation. However, large marine vessels are still facing challenges due to the high cost of batteries and low-energy density. Thus, most vessels with purely electrical operations are currently short-distance ferries or local coastal transportation [10].

1.1 Scope of work

35 car/passenger ferries connect the two banks of the Suez Canal at Port Said Governorate and hold individuals and vehicles with no charge, the ferries transport nearly 20 million people and more than 5 million vehicles per year. The Suez Canal Authority (SCA) is responsible for the execution of orders, the maintenance and repair processes for these ferries. It takes these ferries 10 minutes to travel from one bank to the other. The scope of the present paper aims to evaluate the contribution of solar energy as a proposed propulsion power source for a selected ferry; the retrofit process is compared to the conventional diesel engine propulsion system. The modification, outfitting, and installation requirements for the PV solar panels / electric batteries storage technology and onshore electric connections were discussed and explained. This proposed design could be applied to the rest of the ferries.

1.2 Literature review

Alternative energy sources are the twenty-first century trend. They reduce fuel consumption and gas emission that increase ocean acidification, oil spills, NO_x, and SO_x. Therefore, clean and environmental energy sources such as solar, wind, wave energy and fuel cell are used on marine vessels in both hybrid and individual systems. There are two different kinds of operation models in the solar photovoltaic system that are integrated in the ship power system, the off-grid and grid connected mode. The optimization of energy management of the photovoltaic-ship power systems

(PSPS) and the optimization of the operation control strategy of multiple inverter equipment under grid connected mode are investigated [11]. A comprehensive study tests a configuration model of a hybrid power generation system between diesel generators and renewable energy as a solution to meet the electricity needs for 24 hours. The simulation results provide a configuration model of the first optimal hybrid power plant of PV (50%) and Diesel (50%) configuration to reduce fuel consumption per year by 47.1%. The second configuration model is PV (70%) and Diesel (30%) configuration to reduce fuel consumption per year by 64.3% [12]. The solar boat will be powered by energy processed from the solar energy to minimize environmental pollution and costs of fuel. Solar energy extracted from the panel was optimized by using quadratic maximization maximum power point tracking (MPPT) with KY converter to generate high output power which is found to be more reliable, efficient and economic. In case of any hazardous condition a backup power system that is integrated with photovoltaic cells would continue to operate the vessel [13]. In 2020 a novel approach was demonstrated for the layout of solar arrays within a Ro-Ro type marine vessel navigating between Pendik /Turkey and Trieste/Italy, the performance of the designed system was theoretically evaluated. The system indicated that a 334.6 MWh power could be supplied to the main grid of the vessel at the end of year and the ship output emissions reduced by 0.312, 3.942, 232.393 tons of SO_x, NO_x and CO_2 respectively [14]. Many experimental and computational fluid dynamics (CFD) numerical results were simulated and predicted the application of solar power onboard ships [14, 15]. A life cycle analysis (LCA) was applied on a short route ferry operating in turkey and the costs of changing from conventional ferry into hybrid solar ferry were illustrated from cradle to grave. These results indicated a reduction in GHG emission around 3 x 10^6 kg during the 25 years of its lifespan, as the payback time period of the solar panels system was estimated at three years. The fuel cost saved after 25 years of operation could reach approximately 300,000$ and about 130,000$ in present value [16].

2) Methodology

The objective of the present study is to convert the existing diesel propulsion machinery of Suez Canal car/passenger ferries to a fully electric propulsion operation. A ferry operating between Port Said east bank to Port Fouad west bank is chosen as a case study.

The conventional propulsion of the existing ferry is illustrated with all the main principal dimensions and particulars, the ferry operating scenario and fuel consumption with emissions are discussed, the weather and Meteorological ferry operating site data is considered to know the sunshine hours and intensity. Finally, the technical, environmental and economical concepts of photovoltaic solar panels/ rechargeable batteries system are discussed and analyzed.

2.1 Existing car/ Passengers ferry

The case study ferry is certified by Lloyd's Register as an inland waterway vehicle. The technical specifications of the ferry are given in Table 1 [17, 18]. The ferry steel hull is subdivided into different watertight compartments by 6 transverse and two longitudinal bulkheads. The propulsion and auxiliary machinery with the propeller's mechanism are located in four compartments after the fore and aft peak. The general arrangement and machinery installation is shown in figure 1.

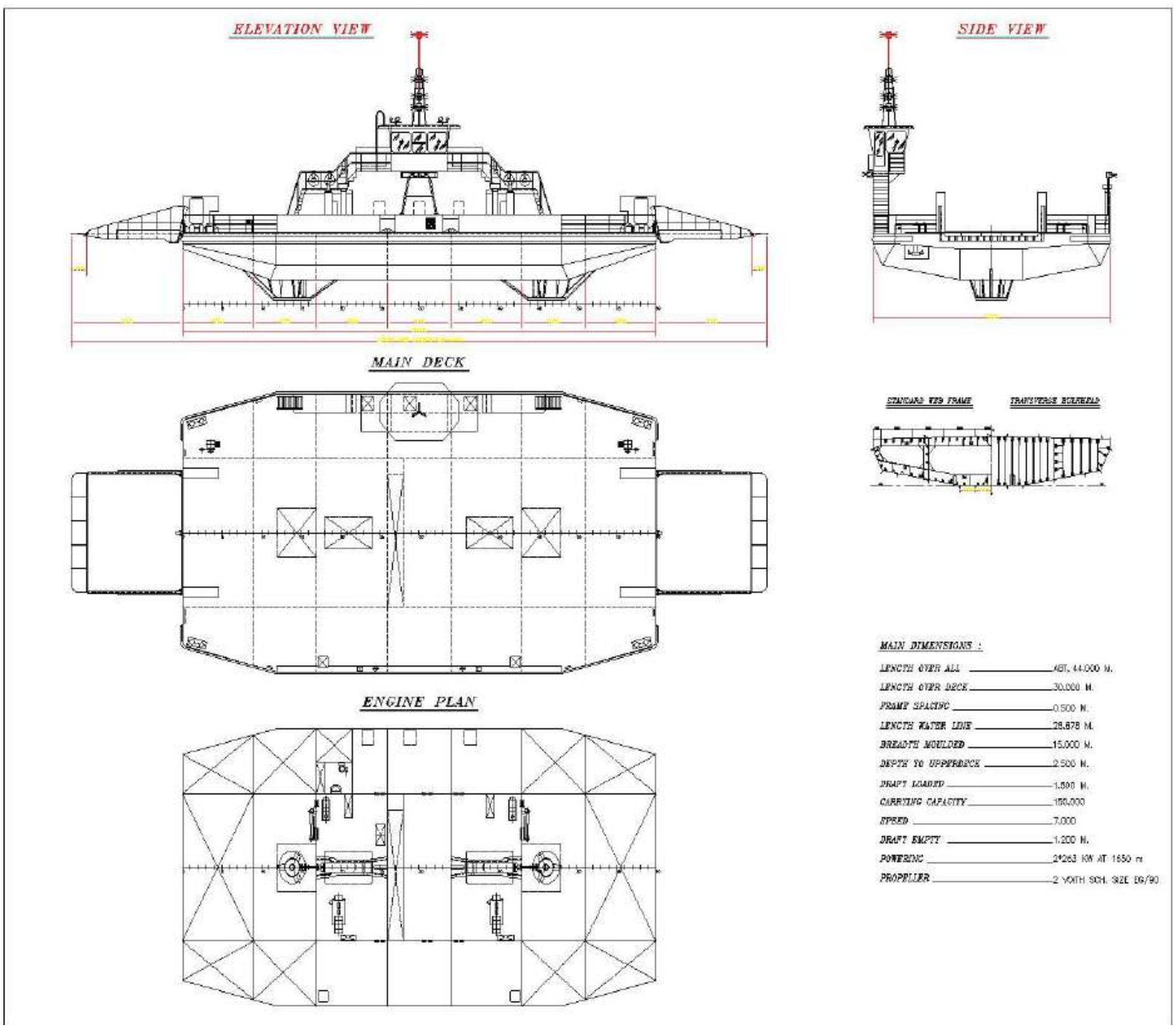

Figure 1 General arrangement of the car/passenger ferry

The total weight of the main engines and diesel generators are about five tons. The propulsion engines are connected with a pair of Voith Schneider Propellers (VSP).

Table 1 the principal dimensions and main particulars of the existing ferry

Length over deck (m)	30
Depth Mold (m)	2.50
Deadweight (Ton)	150
Breadth L.O.A. (m)	15.34
Draught light (m)	1.50
Service speed (Knot)	7
Main Engines	2 x Deutz model SBA 6M 816,340 HP, 253.5 KW
Diesel AC Generators	2 x MWM D226-6, 65 HP, 49 KW

2.2 The ferry sailing route

The sisters Suez Canal ferries are shown in figure 2, each ferry can load 21 cars, 60 cyclists, in addition to 100 individuals. The ferry takes approximately 30 minutes per trip including the loading and unloading of vehicles and individuals [18]. The trip itself alone takes around 10 minutes as shown in Table 2.

Table 2 The envisaged scenario of ferry operation

Operating scenario of Suez Canal car/passenger ferries	
Item's description	Time in Minutes
Loading passengers and vehicles	5.0
Departure and maneuver	2.5
Route between both banks of channel	10.0
Arrival and maneuver	2.5
Unloading passengers and vehicles	5.0
Allowance for heavy traffic in the channel	5.0
Total duration	30.0

Figure 2 Suez Canal Car/Passenger Ferries

2.3 Fuel consumption

Based on the tabulated scenario of the ferry operation in Table 2, the daily total turning time of main engines and generators are 12.5 and 13.5 hours respectively to perform an annual running of about 3750 hours for main engines and 4050 hours for generators. The annual fuel consumption was calculated for the two main engines and one of the two diesel generators which is 465 ton per year.

2.4 Emission and Environmental pollution

The overall amount of the emission released to the environment is calculated using the environmental protection Agency (EPA) formula. In the EPA method, Equation (1) is used to estimate the emission amount (E) of certain pollutants from the ship's engines [19, 20].

$$E = P \times L_f \times T_a \times E_f \quad (1)$$

Where, E is the engine emission (gm), P is the engine power (kW), L_f is the load factor for main and auxiliary engines, T_a is the activity duration (h) and E_f is the emission factor (g/Kwh). Emission factor (E_f) may be estimated by using Equation (2). Where a, b and x are the coefficient specific to each air contaminant and are tabulated as shown in Table 4 [21].

$$E_f = a(L_f)^{-x} \times b \qquad (2)$$

Table 4 Marine engine Emission Factor Coefficients

Pollutant	x	a	b
PM	1.5	0.0059	0.2551
NO_x	1.5	0.1255	10.4496
HC	1.5	0.0667	Not significant
CO_2	1	44.1	648.6
CO	1	0.8378	Not significant

The ferry annual emission parameters are tabulated in table 5.

Table 5 Ferry annual emission parameters

Air pollutant	CO_2	NO_x	PM	HC	CO
Amount of Emission Ton	1421.15	38.76	2.92	1.56	7.71

2.5 Meteorological Data of ferry operating site

According to the solar atlas of Egypt, in winter the sun shines an average of 10.31 hours (hrs). In spring the sun shines for a period of 12.53hrs, in summer it shines an average of 13.48 hrs. On the other hand, in fall it shines for an average of 11.27 hrs. To simplify the solar power calculation, eight solar hours per day are taken as an average to be used at all seasons,[22]. Egypt receives annually 2,400 hrs of solar operation with high intensity of solar radiation equivalent to 2,600 KWh/m^2 [23]. PVsyst is a photovoltaic simulation software that uses a meteo database to visualize a virtual model used to calculate the global horizontal irradiance values shown in Figure 3.

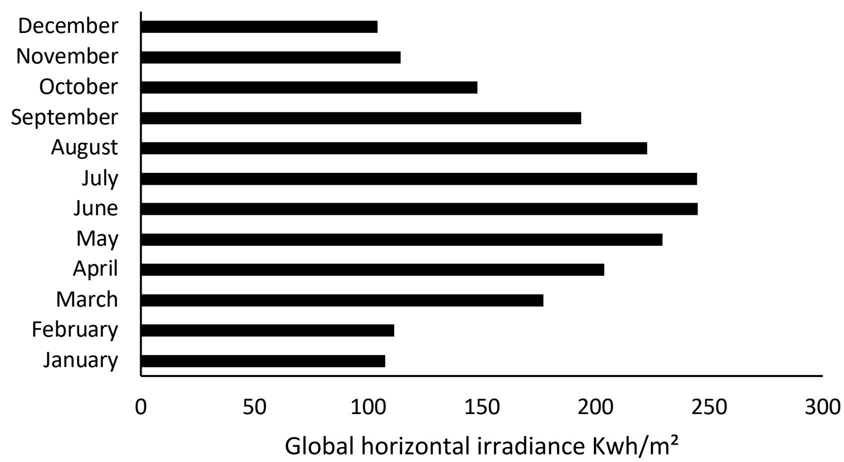

Figure 3 Global horizontal irradiance values predicted by Photovoltaic simulation software

2.6 Photovoltaic solar system

Photovoltaic solar (PV) system consists mainly of four components, PV solar panels, charging controllers / solar regulators, storage batteries and solar inverters as shown in Figure4. The components are set out as follows: Solar Photovoltaic Panels, Charge Controllers / Solar Regulators, Storage Batteries, and Solar Inverters.

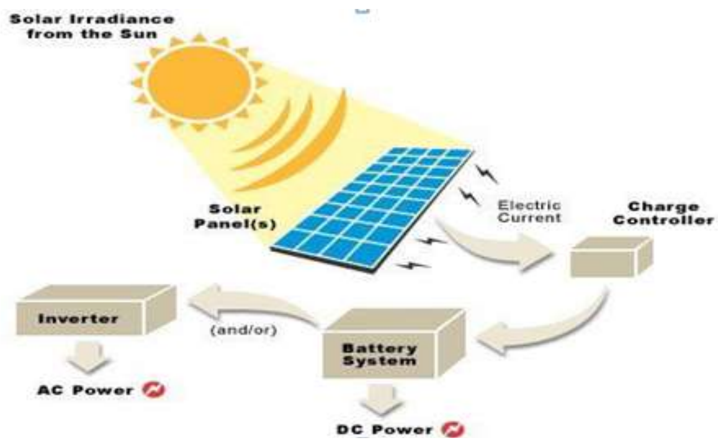

Figure 4 photovoltaic solar power arrangements

3) Design of Proposed Electric Propulsion System of the Case study

The Suez Canal Car/ Passenger ferry operates for two rounds, each round concludes in half an hour. It needs approximately 122.17 KWh to operate per round table 6 illustrates the electric motor as well as the electric load.

Table 6 Vessel Operating conditions (One Round)

Operating Mode	Time (Hr)	Electric Propulsion Load (kw)	Electric appliance Load (kw)	Total Electric Loads (kw)	Power demand (kwh)
Cruising	0.1667	511.2	10	521.2	86.88
Berthing	0.1667	127.8	10	137.8	22.97
Maneuvering	0.1667	63.9	10	73.9	12.319
Total	0.5	702.9	30	732.9	122.17

3.1 Praxis Electric Propulsion Motor (EPM 230)

The modified ferry uses two Voith Schneider propeller shafts connected to two individual mega-guard electric propulsion motors which is an efficient permanent magnet motor producing 255.6 KW instead of the existing diesel propulsion engines. The specifications of electric motors are given in Table 7. The motors are connected to an Electric Energy Storage (ESS) through a central inverter. An average motor's efficiency of 98% is taken for calculations as recommended by the manufacturer and approved by classification societies [24].

Table 7 Electric motor Specification (EPM 230)

Motor Length (mm)	MotorØ (mm)	Torque (NM)	RPM=3600 Power(kw)	RPM=1800 Power(kw)	RPM=900 Power(kw)	RPM=450 Power(kw)	Weight (kg)
540	276	678	255.6	127.8	63.9	31.95	125

3.2 Batteries

The vessel would use LFP-CB by Victron energy, these batteries are chosen due to several factors; they save 70% of space and weight, long life expectancy, and safe li-ion battery type [25]. Lithium iron phosphate batteries are illustrated in Table 8 which produces a maximum charging current of 400 A, 200 Ah nominal voltage.

Table 8 Specification of Victron Energy Batteries

Manufacturer	Victron Energy	Storage temperature	-45°C to +70°C
Model	LFP-CB 12.8v / 200ah	Cycle life discharge 80% 70% 50%	--- 2500 3000 5000
Nominal Voltage	12.8v	Dimensions (L*H*W)	237 * 321 * 152
Nominal Capacity	200 Ah	Weight	20 Kg
Maximum charging current	400 A	Maximum Discharging Current	400 A

3.3 Solar Panel

It is proposed to partly charge the batteries with LG 395N2T-A5 bifacial panel which is described in Table 9, manufactured by LG electronics, mono-crystalline type of cells in the solar panels, 2064 mm of length, 1024 mm of width, 40 mm of thickness and 22.0 kg of weight. It produces 395 W with 18.5% efficiency. The solar panels will be installed on the ferry roof, they would take up 370 m^2 from the total area of 460 m^2. They would be placed as five modules each containing 35 strings;175 solar panels could be fitted in the stated area, which generate 120,181 kWh per annum translated to an average of daily electrical power 264 kW [26]. The technical specification of the solar panel is given in Table 9.

Table 9 Specifications of a 395W N2T-A5 Solar panel at STC

Manufacturer	LG Electronics	Dimensions (L * W * H) mm	(2064 * 1024 * 40) mm
Model	LG395N2T-A5	Product warranty	25 YEARS
Maximum Power (Pmax)	390	Open Circuit Voltage (Voc)	49.2
MPP Voltage (Vmpp)	41.4	Short Circuit Current (Isc)	10.15
MPP Current (Impp)	9.43	Module Efficiency	18.5

3.4 Charge Controllers

A maximum power point tracker (MPPT) is an electronic DC to DC converter that optimizes the match between the solar array, and the battery bank or utility grid. They convert a higher voltage DC output from solar panels down to the lower voltage needed to charge batteries. The charge controller should be able to control the I-short circuit of the panels [27]. A proper MPPT charge controller shown in Table 10.

Table 10 JINGE MPPT Controller

Manufacturer	JINGE	PV max. input power	24 kW
Model	JN-HV Series	Dimension	453*300*132 mm
Battery voltage	265 V	Weight	8.2 kg
Battery voltage range	180 V – 320 V	Maximum input current	100 A
Number of controllers = 2 Controllers			

3.5 Inverters

The inverter is chosen according to the total produced power from the PV array and the total power stored in the battery bank systems. The battery bank stores low voltage direct current, typically around 10 to 15 volts. Furthermore, the onboard ship's loads are powered by alternative current. Inverters should be bigger than the electric power of the ferry by 20-25%, it needs to have the same nominal voltage of the battery chosen. According to the ferry's electric balance power sheet the current appliance's total power equals 122 kWh for one round. The specification of the inverter is given in Table 11. [28]

Table 11 Specification of ABB central Inverter PVS800-57-0500 kW-A

Type designation	PVS800-57-0500 kW-A	Nominal output Voltage	300 V
Maximum input power	600 kW_p	Output frequency	50/60 Hz
Maximum Dc voltage	900 V (1000 V*)	Dimensions W/H/D	3030 / 2130 / 644
Maximum Dc current	1145 A	Weight	1800 kg
Nominal output power AC	500 kW	Number of inverters	1
Nominal AC current	965 A		

3.6 Shore to Ship Charger

E-ferry charging Power Adapt provides a fast connection and disconnection for e-ferries to maximize the charging capacity during off and on- loading of the ferry. Power Adapt uses Cavotec APS (automatic plug-in system) technology. The system is formed by two main sub-systems, one installed on the ship side, the other on the shore side. The vessel installation is featured by a fixed funnel for power connection and its shipboard control equipment. The shore installation is featured by a fixed structure, holding cablings, control equipment and counterweight system and by a mobile unit: the APS Box. This system is sufficient to charge the batteries, it takes around 10 minutes which is enough for one round. In addition, the connection and disconnection cycle take less than 60s [29].

4) Result and Discussion

4.1 Ferry New Design

The fully electric system contains two battery banks Port and STB, each bank room contains 3 packs in parallel and each pack contains 20 Lithium iron phosphate batteries to maintain the package volt of 256 and a total capacity of 606 Ah. The 3 pack produces 140 KWH (80% DOD), these batteries are connected to a ship automation system that automatically discharges when fully charged and simultaneously charge the other storage room, separately each storage room will be responsible for navigating one round. Ferry new design illustrated in Table 12.

Table 12 Modifications of the vessel

Removed Items	Location	Weight (kg)	Added Items	Location	Weight (kg)
Main engine	Aft E/R	2000	Elec. Propulsion motor	Aft E/R	160
Main engine	Forward E/R	2000	Elec. Propulsion motor	Forward E/R	160
Diesel Generator	Aft E/R	372	Inverter	Center	1800
Diesel Generator	Forward E/R	372	2 Controller	STBD / P	16
Fuel Tank	STBD	4560	60 Batteries	STBD	1200
Fuel Tank	P	4560	60 Batteries	P	1200
Total (STBD + P)		9120	Total		4536
Total (Aft + Forward)		4744	175 Solar panels	Roof Top	3500
Total removed items		13864	44 Pillars		2500
Reclaimed Weight		3328	**Total Weight Added**		10536

Monthly power generation is calculated based on the ship's voyage in the relevant months shown in Figure 4. The results show that the most beneficial time for the PV system is from May to August, while it is observed that the lowest production time is between November and February.

The most efficient month generates about 13457 kwh power in June, while 5976 kwh of power is generated in December which is the lowest efficiency.

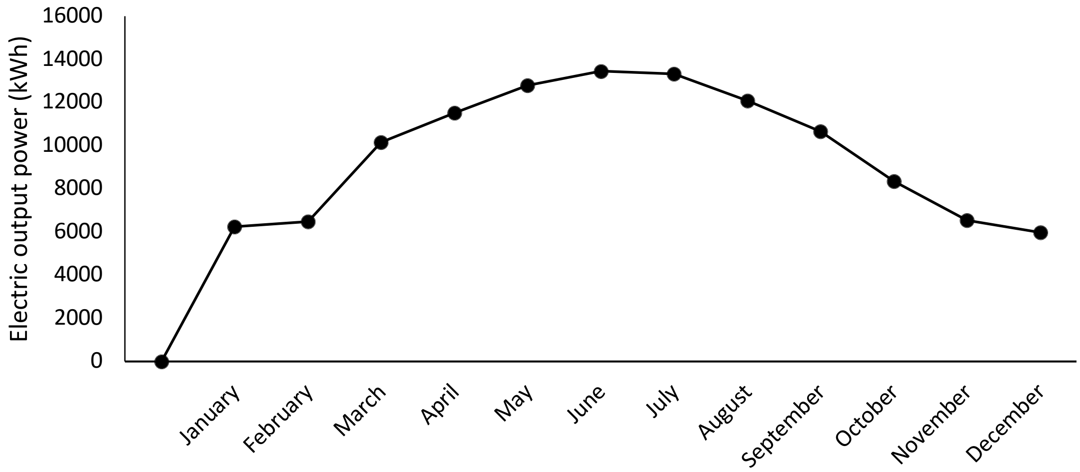

Figure 2 Monthly Electric Output Power

4.2 Operating scenario with proposed green system

The ferry works for 24 rounds and it needs 122 kwh to work for one round, solar panel present in the ferry provide approximately 263 kw/day, which will be provided by:

- The first method, which is the main source of energy for the batteries, is the shore connection. It takes around 10 minutes to fully charge one storage room which is approximately the time passengers ascend and descend from the ferry. The power in storage room P is enough to work up for one round.
- The second method, the alternate source of energy, comes from the solar panels which produce 263 kw during the day and the remaining power needed will be used from the shore charge.
- It should be noted that the main source of energy for the ferry is the dual battery bank, which is charged from the shore charge connection, while the solar panels are the secondary source of energy which is used to decrease the electricity usage of the government which will save costs in the long run.

4.3 Financial feasibility study

The capital cost of the conventional ferry was 21,000$ including: two main diesel engines and two diesel generators. On the other hand, the capital cost of the proposed ferry is about 288,000$, inclusive of the two electric motors, solar panels (0.75 $ x 395w x 175 panel), batteries module, inverters, charge controllers, battery management system, and ship automation system. The running cost per year of the conventional system of the ferry was 262,000$ including: diesel fuel, maintenance, lubricant oil, while the running cost of the proposed system would be 1% of the capital cost 2,880$ per year [30]. The capital cost of the modified model would require a large start up investment; however, the running costs are decreased significantly in the proposed model which will amount to a large amount of savings due to the reduction of diesel fuel and other maintenance costs required in the conventional model. According to these numbers the net present value (NPV) is 363,555 $ after 3 years, the discounted payback period is 1.2 years and the cash flow return rate 22.67% per year [14].

5) Conclusion

The ferry conversion results in cleaner operation and zero emissions. The Solar energy/Electric propulsion system promises to not only minimize emissions, but also to extend the ferry's life. However, the proposed design provides a cost effective alternative focusing on the long run compared to the relative costs of diesel fuel.

The conversion of existing conventional car/passenger ferry into electric propulsion operation has a positive effect on environmental emissions. The solar energy utilization reduced the annual output emissions by 38.76 tons of NOx, 1421.15 tons of CO_2 and 2.92 tons of PM.

In addition, the results of the study indicate that the power generation using photovoltaic systems is useful for long term investments, nevertheless it requires a sizable investment. The financial calculations show that the ferry conversion cost will be recovered within 1.2 years, and the annual operation saving due to diesel fuel, lubricating oil and other diesel related services is more than 262,000$ per year. Meanwhile, the study found that the installation of photovoltaic solar systems on board of the ferry does not affect its stability.

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Marine Pollution and Climate Change New Challenges

ANALYSIS OF MARINE DIESEL ENGINE EMISSION CHARACTERISTICS UNDER BENCH TEST CONDITIONS IN CHINA

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Abstract

In order to accurately evaluate air pollution caused by ships, two main methods are usually used for calculation, such as, the method based on ship fuel consumption (top-down approach) and the method based on ship activities (bottom-up approach). Both of the methods require accurate diesel engine emission factors. If the underlying data is not accurate, the assess results will significantly depart from actual conditions and mislead policy decisions. In this paper, the emission characteristics of NOx, CO, CO_2 and THC from 198 domestic marine diesel engines were investigated under bench test conditions by standard emission measurement system which conformed to the requirements of the International Maritime Organization (IMO). The emission factors of marine diesel main engine (ME) and auxiliary engine (AE) were analyzed statistically. The ME's and AE's fuel-based emission factors and energy-based emission factors are given in detail and compared with the reference data given by IMO. The energy-based emission factors for different types of diesel engines are closely related to the diesel engine load, and the relationship between them can be expressed by quadratic polynomial or power function. In addition, the emission factors for marine high-speed engines are illustrated in detail. The results of this paper can provide valuable data for the estimation of waterway transportation exhaust emissions, emission regulation revise and comprehensive understanding of the emission characteristics of marine diesel engines.

Keywords: Fuel-based emission factor; Energy-based emission factor; Ship emissions; Specific emission

1. Introduction

Shipping not only brings great economic benefits to the global development, however, it also emits harmful substances into the atmosphere, which causes environment problems that have aroused widespread concern [1-3]. The ship emissions have always been considered as one of the important air pollution sources in port cities and inland river areas, which have brought serious negative effects on global climate and human health [4-6]. Therefore, more and more people pay attention to the ship emissions in recent years [7-9], and study the ship emission characteristics. At present, there are two main research methods for estimation ship exhaust emission: top-down approach based on ship fuel consumption and bottom-up approach based on ship automatic identification system (AIS) [10]. Both methods need to obtain effective emission factors. Currently, some international organizations or research institutions have provided emission factors for reference, such as the IMO, IPCC, USEPA and LR and so on. In addition, some researchers have also done more in-depth research on emission factors. Cooper et al. [11] tested the emission factors of 22 marine auxiliary engines from 6 ships at berth, and obtained the emission factors of NO_X, CO, THC, CO_2, SO_2 and PM. Chu-van et al. [12] tested a cargo ship exhaust emission, and gave the emission factors under different sailing conditions. Fu et al. [13] and Yin et al. [14], respectively took the freight ships in the Grand Canal as the research object and carried out a shipboard test on the emission factors of inland river transport ships in China, and preliminarily formed the emission factors of inland river ships under different operating conditions with the power under 300kW. Peng et al. [9] and Huang et al. [15] used portable equipment to measure the emission factors of the marine diesel engines, and gave the emission factors under different sailing conditions. In terms of the research status in China, although the research on the emission characteristics of Marine diesel engines is more in-depth, the emission test data is generally less, and it is difficult to provide sufficient data support for the establishment of emission inventory in China. Many scholars generally adopted foreign emission factors when studying the emission inventory of ships in coastal areas of China [16-19].

In this paper, 198 marine diesel engines manufactured in China were tested under bench test conditions. The fuel-based emission factors and energy-based emission factors were analyzed statistically, aiming to reveal and master the emission characteristics of ocean-going and inland river ship diesel engines.

2. Methodology

2.1 Emission measurement system and test bench

The HORIBA MEXA 1600DSEGR exhaust analyzer is mainly used for emission testing, which can obtain the contents of NO_X, CO_2, CO, THC and O_2 in exhaust. The measurement equipment is mainly composed of the following detection modules: Chemiluminescent detector (CLD) for NO_X, Non-dispersive infrared analyzer (NDIR) for CO_2 and CO, Heated flame ionization detector (HFID) for THC, and Paramagnetic detector (PMD) for O_2. In order to ensure the test results' accuracy, the test is usually carried out on a standard test bench, as shown in Figure 1.

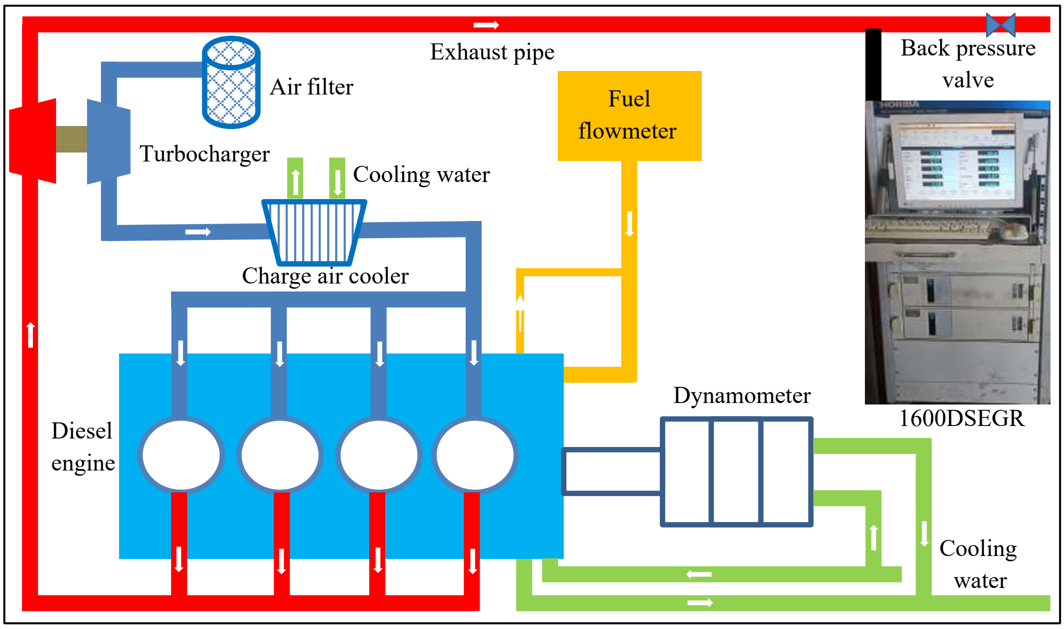

Figure 1. Schematic diagram of diesel engine bench emission test

2.2 Test engines

In this paper, a total of 198 marine diesel engines were tested under bench test conditions and analyzed statistically. According to the statistical results, the slow-speed diesel (SSD) power range was between 4320 kW and 26000kW, and the speed range was between 67.6 rpm and 120rpm. The medium-speed diesel (MSD) power range was between 330 kW and 4500kW, and the speed range was between 600rpm and 1000rpm. The high-speed diesel (HSD) power range was between 130 kW and 1816kW, and the speed range was between 1000rpm and 2425rpm. All tested diesel engines were completely able to meet the IMO NOx Tier II emission standard, which was executed since January 2011, and more stringent rule of Tier III in ECAs was executed from January 2016.

2.3 Emission factor calculation method

The fuel mass flow rate and engine power can be measured during the diesel engine emission bench test. The mass flow rate of individual exhaust gas component can be calculated according to carbon balance method [20,21]. The fuel-based emission factor and energy-based emission factor and can be calculated based on the above conditions. The calculation method is as follows:

$$EF^f = \sum_{i=1}^{n} Q_{mags,i} \cdot W_{F,i} / Q_{mf,i} \tag{1}$$

$$EF^e = \left(\sum_{i=1}^{n} Q_{mags,i} \cdot W_{F,i}\right) / \left(\sum_{i=1}^{n} P_i \cdot W_{F,i}\right) \cdot 10^3 \tag{2}$$

where: EF^f: fuel-based emission factor(kg/t-fuel); Q_{mags}: emission mass flow rate of individual gas (kg/h); Q_{mf}: fuel flow rate(t/h); W_F: weighting factor; i: test power point; EF^e: energy-based emission factor (g/kW•h); P: power of each test load point (kW).

2.4 Fuel information

The fuel used in all the bench tests was diesoline. According IMO NO_X technical code, the fuel was sampled and sent to a special testing institution for elemental analysis after each test. Elemental analysis included carbon(C), hydrogen(H), oxygen(O), nitrogen(N), sulfur(S). According to the analysis report, C, 85.22~86.83%; H, 12.47~14.12%; N, 0.01~0.41%; O, 0.02~0.77% and S, 0.00~0.19%.

3. Results and discussion

3.1 Fuel-based emission factors

The fuel-based emission factor of NO_X, CO, CO_2 and THC of each type of diesel engine can be calculated according to formula (1), as shown in Table 1. As it can be seen from Table 1 that the NO_X fuel-based emission factors are all smaller than baselines given in the IMO research report. The slow-speed and middle-speed ME NOx fuel-based emission factors are 5.79% and 7.86% lower than the baseline values respectively. And the medium-speed and high-speed AE NOx fuel-based emission factors are 19.34% and 18.09% lower than the baseline values respectively. The CO fuel-based emission factors are all higher than baselines. For the ME, the

CO fuel-based emission factors are 55.23% and 11.95% higher than baselines. And for the AE, the CO fuel-based emission factors are 29.53 and 105.88% higher than baselines. The CO_2 fuel-based emission factors are all lower than baselines. In this paper, the carbon conversion rate is between 97.27% and 98.65%. The THC fuel-based emission factors are either higher or lower than baselines, without obvious rule.

Table 1 Fuel-based emission factor (kg/t-fuel)

Eng speed/ type	EF^f_{NOx}			EF^f_{CO}			EF^f_{CO2}			EF^f_{THC}		
	x±s 1)	n 2)	Base-line [10]	x±s	n	Base-line	x±s	n	Base-line	x±s	n	Base-line 3)
SSD-ME	69.48± 8.17	27	73.75	4.30± 2.49	27	2.77	3163±30	27	3206	1.23± 0.44	26	3.08+ 0.06
MSD-ME	45.11± 2.82	22	48.96	2.81± 1.23	22	2.51	3119±21	21	3206	2.25± 0.86	22	2.33+ 0.05
HSD-ME	35.40± 4.03	46	na	3.98± 2.79	49	na	3140±21	47	na	1.23± 0.90	46	na
MSD-AE	37.41± 4.09	35	46.38	3.09± 1.14	33	2.38	3118±24	35	3206	2.87± 1.17	34	1.76+ 0.04
HSD-AE	27.81± 5.91	59	33.95	4.90± 2.91	59	2.38	3142±21	55	3206	1.31± 0.90	56	1.76+ 0.04

1) x represents the mean, and s represents the standard deviation; 2) n represents the number of samples; 3) EF^f baseline including: NMVOC baseline before + and CH_4 baseline after +.

In addition, the emission characteristics of different diesel engines under different loads are studied. It can be seen from Figure 2 and 3 that the CO_2 fuel-based emission factors depend on the fuel carbon content and are independent of diesel type and load. Therefore, if the shipping industry continues to use petroleum fuels, it will be difficult to achieve the ambitions of the initial IMO strategy, which are to reduce the carbon intensity of international shipping by 70% and the total annual GHG emissions by at least 50% by 2050, compared to 2008 [22].

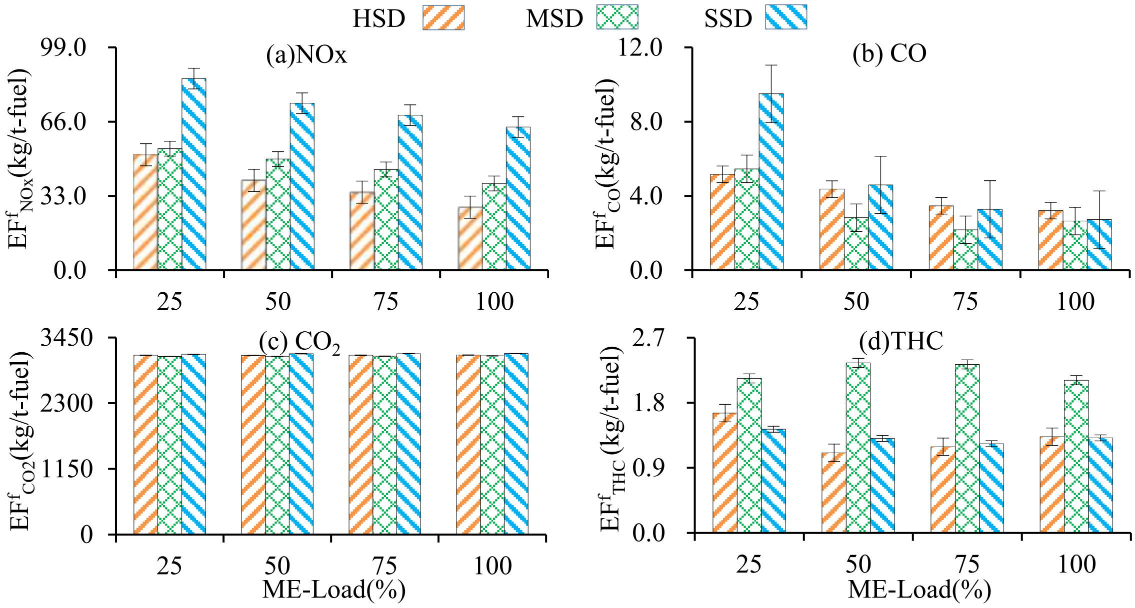

Figure 2. ME's fuel-based emission factors under different load

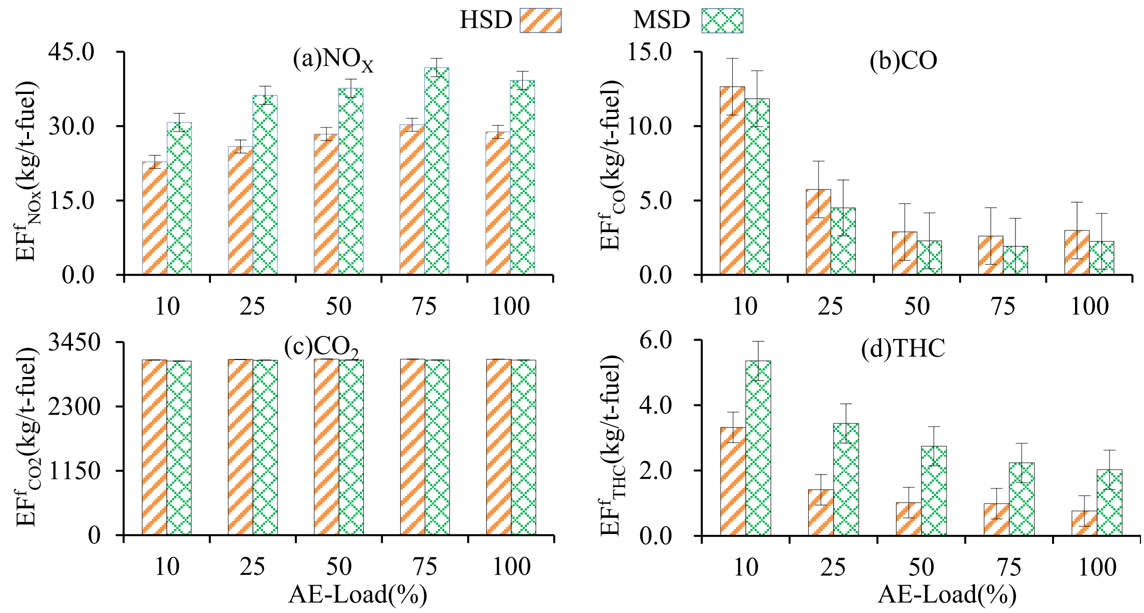

Figure 3. AE's fuel-based emission factors under different load

3.2 Energy-based emission factors

Based on individual exhaust gas mass flow rate and each test load point power of marine diesel engine, the energy-based emission factors of NOX, CO, CO_2 and THC can be calculated according to formula (2), as shown in Table 2.

Table 2 Energy-based emission factor (g/kW•h)

Eng speed/ type	EF^e_{NOx}			EF^e_{CO}			EF^e_{CO2}			EF^e_{THC}		
	x±s 1)	n 2)	Base-line	x±s	n	Base-line	x±s	n	Base-line	x±s	n	Base-line3)
SSD-ME	11.38 ±1.22	27	14.38	0.61± 0.30	27	0.54	532.90 ±11.89	27	607	0.22± 0.05	24	0.60+ 0.01
MSD-ME	8.91± 0.53	21	10.53	0.55± 0.32	23	0.54	636.69 ±12.79	20	670	0.46± 0.18	22	0.50+ 0.01
HSD-ME	6.96± 0.87	47	na	0.78± 0.57	49	na	659.20 ±24.76	50	na	0.25± 0.18	46	na
MSD-AE	8.17± 0.80	35	10.53	0.55± 0.23	34	0.54	662.31 ±19.36	35	707	0.56± 0.22	34	0.40+ 0.01
HSD-AE	6.31± 0.91	56	7.71	0.76± 0.37	56	0.54	687.28 ±40.40	59	707	0.22± 0.13	54	0.40+ 0.01

1) x represents the mean, and s represents the standard deviation; 2) n represents the number of samples; 3) EF^e_{THC} baseline consists of two parts: NMVOC baseline before + and CH_4 baseline after +.

Table 2 shows that the NOX energy-based emission factors are all within the IMO Tier II limit and lower than the baselines [10]. The ME NOX energy-based emission factors are 15.38% to 20.86% less than the baselines, and the AE NOX energy-based emission factors are 18.16% to 22.41% less than the baselines. The CO energy-based emission factors are 1.85% and 40.74% higher than the baselines. The CO_2 energy-based emission factors are between 87.79% and 97.21% of the baselines. The THC energy-based emission factors are either higher or lower than baselines, without obvious rule. For different type of diesel engines, the energy-based emission factors at each test load point are calculated and averaged. The relationship between engine load and energy-based emission factors is shown in Figure 4 and 5.

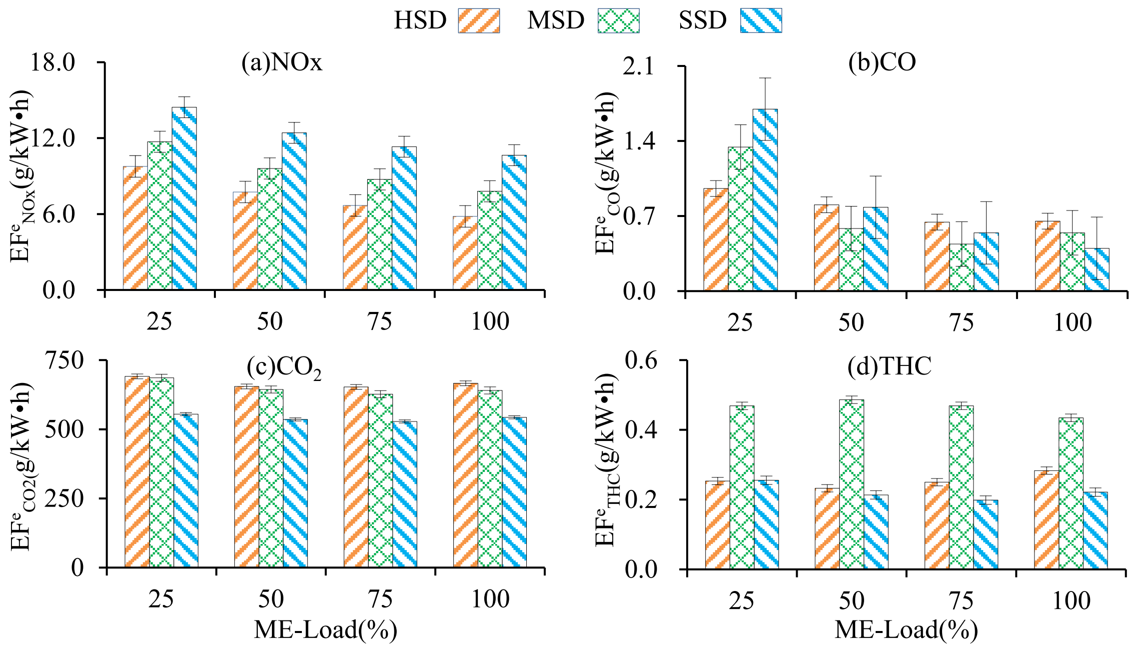

Figure 4. ME's energy-based emission factors under different load

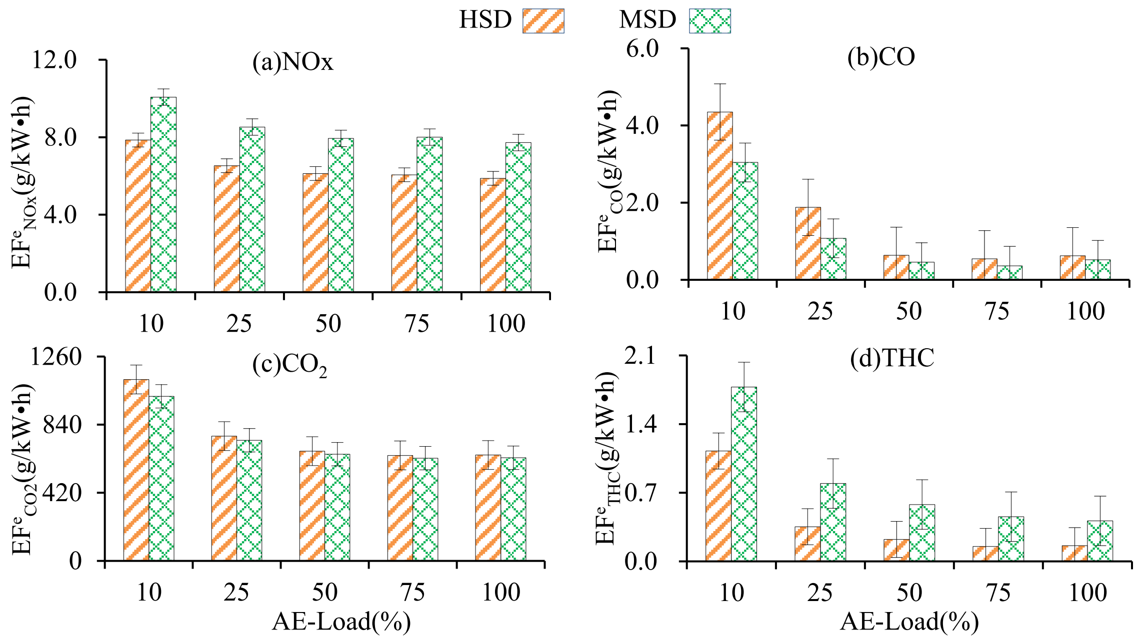

Figure 5. AE's energy-based emission factors under different load

Figure 4 and 5 show that the energy-based emission factors are closely related to the diesel engine type and load. The diesel engine operated under low load will lead to a higher NOx energy-based emission factor. This is because when the diesel engine works at low load, the amount of fuel injection per cycle is reduced, but the oxygen content in the cylinder is increased, thus promoting the generation of NOx. Similarly, under 10% load, the AE CO and THC energy-based emission factors are obviously higher than other loads. It shows that when the AE operates under low load, the oxygen content in the cylinder increases and the fuel gas is diluted, which promotes the THC formation. At the same time, the temperature in the local area of the cylinder is too low, the CO lost the temperature condition and can't be oxidized to CO_2.

3.3 Energy-based emission factors regression analysis

In addition, a regression analysis of the relationship between diesel engine load and energy-based emission factors was carried out. Under the maximum coefficient of determination (R^2), the relationship between diesel engine load and energy-based emission factors can be fitted by quadratic polynomial and power function, as follows:

$$EF^r = a \cdot LP^2 + b \cdot LP + c \quad (3)$$

$$EF^r = a \cdot LP^{-b} \quad (4)$$

Where, EF^r: regression analysis energy-based emission factor (g/kW•h); *LP*: load percentage; *a, b* and *c*: equation coefficient.

The obtained equation coefficients are shown in Table 3. It should be noted that the fitting of the relationship between diesel engine load and energy-based emission factors in this paper is only a statistical result. As can be seen from Table 3, for the ME, there is a power function relationship between NO_X energy-based emission factor and engine load, and there is a quadratic polynomial relationship between CO, CO_2 and THC energy-based emission factor and engine load. For the AE, the relationship between the energy-based emission factor and engine load is a power function.

Table 3 Coefficients of fitting formulas for energy-based emission factors

Coefficients / Eng. type	EF^r_{NOx}				EF^r_{CO}				EF^r_{CO2}				EF^r_{THC}			
	a	b	c	R^2	a	b	c	R^2	a	b	c	R^2	a	b	c	R^2
SSD-ME	10.6	0.22	-	0.99	3.08	-5.51	2.85	0.98	136	-187	593	0.99	0.26	-0.37	0.33	0.99
MSD-ME	7.9	0.29	-	0.99	3.46	-5.34	2.45	0.99	223	-341	758	0.99	-0.21	0.21	0.43	0.99
HSD-ME	5.92	0.37	-	0.99	0.64	-1.24	1.23	0.98	198	-278	747	0.98	0.22	-0.23	0.30	0.98
MSD-AE	7.59	0.11	-	0.91	0.34	0.88	-	0.89	598	0.21	-	0.92	0.38	0.63	-	0.98
HSD-AE	5.76	0.12	-	0.93	0.46	0.95	-	0.93	607	0.24	-	0.90	0.13	0.87	-	0.96

4. Conclusions

In this paper, emission bench tests of 198 diesel engines were carried out on the bench, including NO_X, CO, CO_2 and THC. The ME's and AE's fuel-based emission factors and energy-based emission factors are analyzed statistically and the research results can provide benchmark data for the ship emission inventory in China's coastal areas.

ME is a major source of ship emissions leading to air pollution. If the IMO's reference value is adopted, the estimation result of NOX will be high and the estimation result of CO will be low. Therefore, reasonable emission factors should be selected during the establishment of China's ship exhaust emission inventory.

The energy-based emission factors under different loads are analyzed. The energy-based emission factors are closely related to the diesel engine type and load. The oxygen enrichment in the cylinder is an important reason leading to a higher energy-based emission factor when diesel engine works at low load. However, the CO_2 fuel-based emission factor is independent of engine load and type, but closely related to the fuel carbon content.

Based on the regression analysis of the relationship between the diesel engine load and the energy-based emission factors, the results show that the relationship between the emission factors and the diesel engine load can be fitted by the quadratic polynomial or power function, used for predicting diesel engine emissions under different loads.

Acknowledgements

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Design of structure and control system of an underwater vehicle for marine environment perception

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Abstract

With the increasingly severity of marine pollution and climate change, the protection of marine ecosystem is particularly important. In order to realize ship inspection, ocean cleanup and marine pollution detection, this work introduces an underwater vehicle for marine environment protection. An underwater vehicle for marine environment perception is comprised of land-based console, a zero buoyancy cable and an underwater vehicle motion platform. In particular, the video and sensor data collected by underwater vehicle system are displayed in real time through zero buoyancy cable back to the land-based console. This paper proposes a multi-stage PID cascade controller, aiming at the shortcomings of traditional proportional integral derivative (PID) algorithm. Underwater vehicle designed in this paper was tested in real environments such as ports and polluted sea areas, which were successfully completed.

Keywords: posture control, underwater vehicle system, marine environment perception

1. INTRODUCTION

Shipping is the main activity of the ocean. More than 80% of international trade goods are transported by freighter and cruise ships transport millions of tourists to their destinations. Every year, more than 50,000 ocean ships sail on the five oceans of the world, carry tens of billions of important commodities, including fuels, raw material and consumer goods [1, 2].

At the same time, the International Mathematical Organization (IMO) has established a legal and technical framework through its 172 member states, making shipping relatively sustainable [3]. Over the past ten years, the shipping industry implemented many measures such as new regulations and new forms of team training, aimed at improving shipping safety. Despite this change, transportation accidents especially collisions are still major problems. Recently, some statistical studies have identified human error as a major factor in most accidents at sea [4, 5]. Although innovations in marine technology and automation systems have contributed to improving shipping safety, but incidence rates of shipping accidents has increased and continued to have a negative impact on marine environment [4]. These accidents have a great impact in the marine environment, causing serious damage to the ecosystem.

An underwater vehicle is a device that can move through the water, it has a vision and perception system. It uses the manipulator remote control autonomous operation to assist people to complete certain tasks, such as underwater hull inspection, marine pollution detection and marine garbage cleaning. Application of marine environment perception underwater vehicle system and architecture are shown in figure 1.

Underwater vehicle is a challenging research field, whose expansion and replacement capabilities are valuable because they can be deployed in dangerous environments without endangering divers [6,7]. In general, underwater vehicles can be divided into two types: Remotely Operated Vehicle (ROV) and Autonomous Underwater Vehicle (AUV). ROV is a diving device that is controlled and monitored by operators. The vehicle receives signals and power from the land-based console through a cable. It is comprised of console, cable winch, power supply system and underwater equipment like thruster, repeater and vehicle body [8-13].

AUV is a diving device that has autonomous decision-making and control capabilities. The vehicle can realize autonomous decision making without real time operation. AUV can process the observed information, establish an environmental state model and transmit it to the land-based console [14-19]. With the console, operators can monitor the working process of the vehicle according to the environmental state model.

In this article, our vehicle uses NVIDIA JETSON TX2 as onboard computer because it is cheap and multi-processing capabilities. The onboard computer equipped with a GPU that can independently realize image processing functions. In addition, this paper designs a multi-stage PID controller, which can achieve precise depth control, allow more refined operations and capture better quality underwater images. Finally, we carry out the experiment, and the results show that the vehicle can overcome the complex underwater environment under challenging operational circumstances.

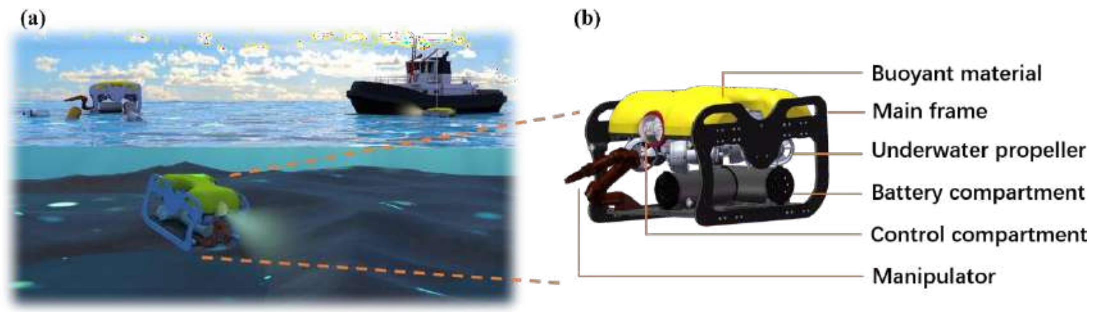

Figure 1. Application of marine environment perception underwater vehicle system and architecture. (a) Multiple application scenarios of marine environmental perception underwater vehicle systems; (b) Underwater vehicle architecture.

2. Technical parameters and sensors

This work introduces an underwater vehicle, for needs of underwater hull inspection, marine pollution detection and marine garbage cleaning tasks. The technical parameters of the final product are shown in Table 1.

Table 1. Technical parameters for underwater vehicle

Basic parameter		Forward thrust	14kgf
Length	457mm	Vertical thrust	9kgf
Height	338mm	Lateral thrust	14kgf
Net weight	9-10kg	**Cable indicators**	
Net buoyancy	0.2kg		
External diameter of seal cabin	110mm	Diameter	7.6mm
Floating body material	BR3318(200m) BF600（600m）	Length	25-30mm
Design index		Working strength	45kgf
Reachable depth	100m	Breaking strength	160kgf
Maximum speed	1m/s	Buoyancy	Positive buoyancy
Endurance time	2.5-3h	**Headlamp**	
Thruster	Single thruster of 5kgf	Luminance	1500 lumen water LED
Thruster configuration	Six thrusters	Degree of light beam	135 degrees

3. Structure design of underwater vehicle

The underwater vehicle is mainly comprised of three parts: land-based console, zero buoyancy floating cable and underwater vehicle motion platform.

3.1 Hull design

The underwater vehicle adopts a general open-shelf design, with control cabin, battery cabin, underwater thrusters and buoyancy materials. The open-shelf structure adopts High-density polyethylene（HDPE) mold to be pressed into plates, which are connected by 316 stainless steel connectors. Control cabin and battery cabin are arranged in the middle of the open-shelf structure. Both cabins are machined with aluminum alloy and anodized. The cabins are sealed with flanges, which opening at one end of the cabin used to install through bolts.

By analyzing the resistance characteristics of the open-shelf structure in underwater motion. We choose four horizontal thrusters with a thrust of 4kg are arranged in a parallelogram vector, the other two thrusters with a thrust of 6kg are placed in the vertical direction to realize floating and diving of the vehicle. The buoyancy material of underwater vehicle is made of hollow glass beads. By adjusting the number, size and position of buoyancy materials, the vehicle is made to have positive buoyancy.

3.2 Zero buoyancy cable design

Cable selection for the underwater observatory takes into account the need of release and communication. The cable will not only be able to communicate, but will also be able to pull underwater vehicle ashore in case of emergency. In the pool test, our vehicle was pulled back in still water at 1.4m/s, which required a pull of 12kgf. According to the above requirements this research contact the cable factory to customize the zero-buoyancy cable as shown in Figure 2.

The cable core is made of high-strength Kevlar fiber, with 4 pairs of twisted wires inside separated by polyester fiber and the outermost layer covered with polyethylene. The cable made of this fiber can maintain neutral buoyancy in sea water. The working strength of our cable is up to 35kgf and the breaking strength is up to 155kgf. One end of the cable is vulcanized and connected with a watertight connector to realize quick plug-in connection with underwater vehicle, the other end is connected to the cable to realize the release and recovery of the vehicle.

3.3 Land-based console design

The operation of underwater vehicle relies on land-based console for data processing and transmission. The land-based console adopts a computer architecture, including a motherboard, central processing unit, memory, hard disk, inverter, battery, power management circuit and display, which is convenient for operators to control and developers to carry out secondary development. The motherboard, central processing unit, memory and hard disk form a computer system, after installing the Linux operating system and underwater vehicle control program, operators can easily realize underwater vehicle's attitude control and sensor data collection. The battery and power management circuit transmit power to the components of land-based console, which uses 18650mAh rechargeable lithium batteries. At the same time, the inverter mounted on land-based console is used to output 220V 50Hz alternating current to supply power to display.

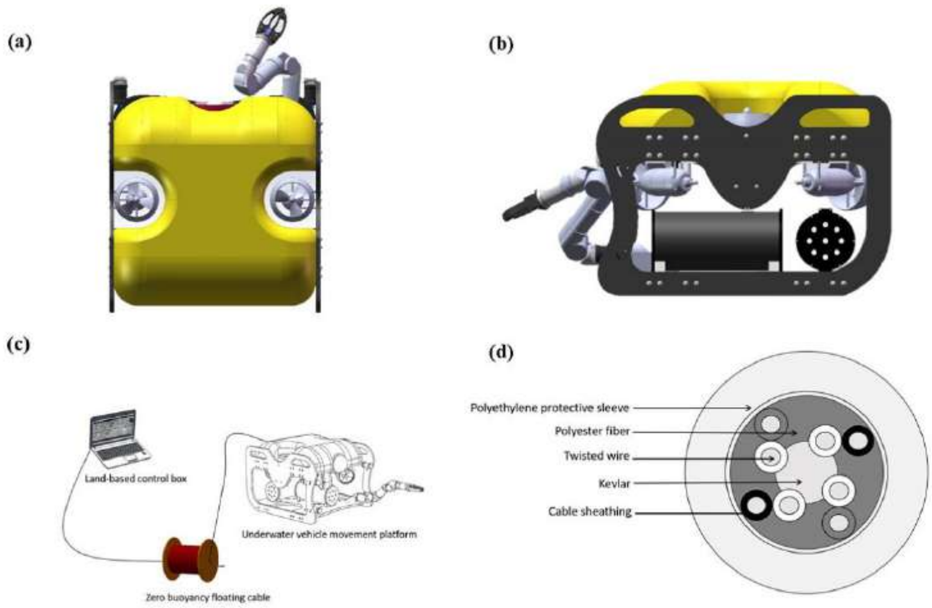

Figure 2. Underwater intelligent robot system architecture. (a) Top view of the underwater vehicle body motion platform; (b) Side view of the underwater vehicle body motion platform; (c) General framework of underwater intelligent vehicle system; (d) Zero buoyancy cable structure

4. Control system design

Design diagram of underwater vehicle control system is shown in Figure 3. The system is sealed in control cabin and its core modules are self-designed main control board and NAVIDIA JETSON TX2 embedded artificial intelligence computing device. The main control board processor is STM32F407 microcontroller, which contains ARM Cortex M4 kernel and main frequency 168MHz. It has the advantages of fast calculation speed and strong real-time performance.

Main control board integrates two independent Inertial Measurement Unit (IMU) systems. One adopts ICM-20602 6-axis motion tracking device, which combines a 3-axis gyroscope with a 3-axis accelerometer and uses an AK8975 3-axis magnetometer as an electronic compass. The other adopts a MPU6050 6-axis Micro Electro Mechanical System (MEMS) motion tracking device, which includes a gyroscope and an accelerometer. An IST8310 three-axis digital magnetometer is used as an electronic compass. This combined design greatly improves the stability of underwater vehicle control system. In addition, the main control board also integrates a micro-USB interface, an Analog to Digital (A/D) module, 2 serial ports and 8 Pulse Width Modulation (PWM) output interfaces.

The vehicle calculates its real-time attitude and depth information by IMU system and transmits it to the main control board by serial port interface. The STM32F407 encapsulates the above status information through the (Micro Air Vehicle Link) MAVLINK protocol and sends it to Jetson TX2 through the Micro-USB interface. At the same time, the Jetson TX2 receives control commands from the land-based console and transmits them to the main control board. After receiving the command, the board combines it with the vehicle attitude information, calculates the thrusters output in real time by using the motion control algorithm and drives the thrusters through the Electronic Speed Control (ESC) system at the PWM output port.

When underwater vehicle is working, it is necessary to monitor its safety status. Therefore, a water leakage sensor has been added to each sealed cabin. When sensors detect water leakage into one sealed cabin, vehicle invoke vertical thrusters to float above the surface of the ocean.

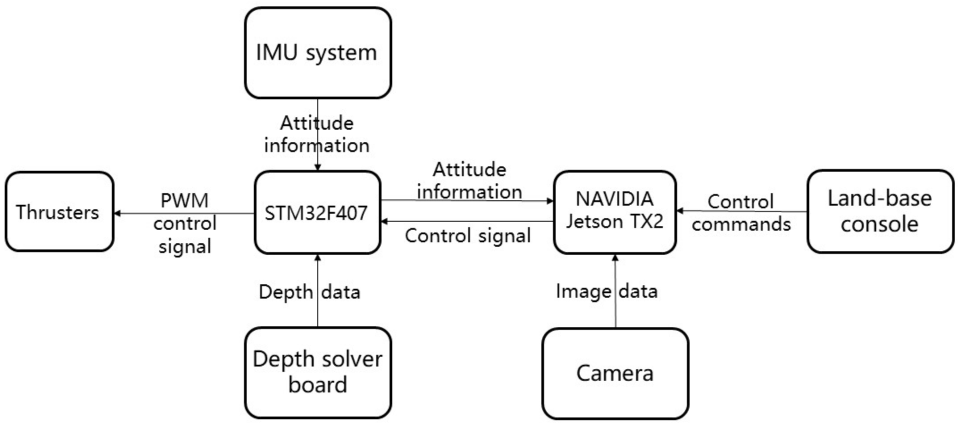

Figure 3. Underwater vehicle control system design block diagram

5. Control algorithm

5.1 Attitude and inertial navigation algorithm

The realization of the stable control of underwater vehicle is inseparable from the accurate perception of its own attitude. In this paper, the Butterworth filter and the moving average filter are used specifically to remove high-frequency noise in data collected by various sensors. The main control board reads these data and executes navigation algorithm to convert it into its own attitude information. The Attitude and inertial navigation algorithms, which can convert the filtered sensor data into real-time attitude angle, depth, velocity and acceleration information of underwater vehicle.

5.2 Heading control algorithm

In this paper, we designed a multi-stage PID algorithm, the heading control is divided into inner and outer loop multi-stage control, the structure diagram is shown in Figure 4. When land console does not send new control commands, our vehicle uses heading angular velocity and angle multi-stage control algorithm to maintain the heading angle.

In the angle loop control, expected angle is always set to 0 degrees to lock the heading angle of the underwater vehicle. The heading angle obtained by solution algorithm is used as the feedback of angle loop controller, aim to calculate the desired angular velocity of it. The angular velocity loop controller uses desired angular velocity and heading angular velocity calculated by the solution system for closed-loop control of angular velocity. At the output end, a hybrid controller distributes the output to four horizontal thrusters to realize the lock of heading angle of the underwater vehicle.

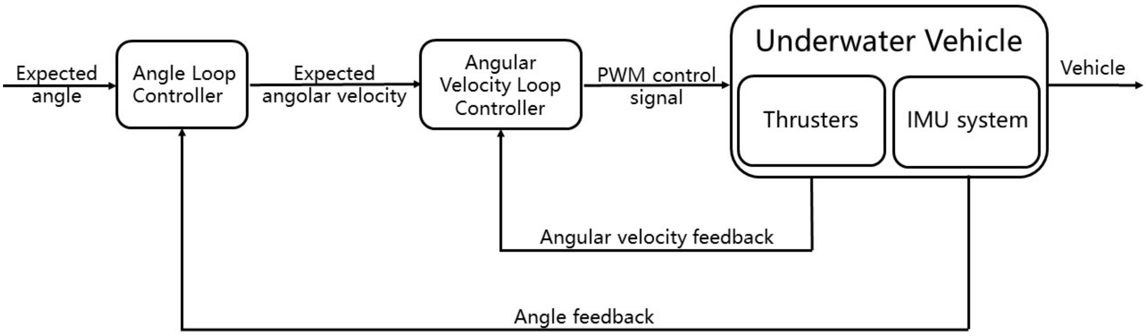

Figure 4. Structure of multi-stage angular PID controller

When the land console sends a heading control command to the underwater vehicle, the controller is switched from multi-stage PID controller to single-stage angular velocity PID controller. The structure diagram of the single-stage angular velocity controller is shown in Figure 5.

The operator sends a desired heading angular velocity to underwater vehicle through land console, then PID controller uses the heading angular velocity, which calculated by the controller as a feedback value. In the end, the controller use heading angular velocity feedback value and desired heading angular velocity to obtain the value of attitude error, as a result to perform real-time closed-loop control of the heading angular velocity to achieve the desired control effect.

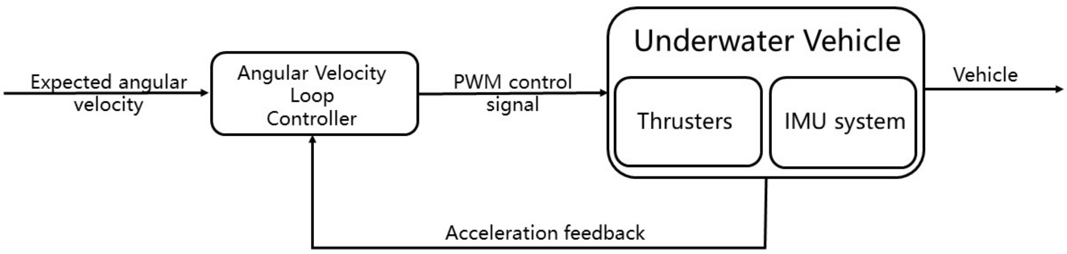

Figure 5. Structure of single-stage angular velocity PID controller

5.3 Depth Control Algorithm

There are difficulties in the depth control of underwater vehicles. Underwater thrusters have a certain hysteresis, there will be oscillation phenomenon during the depth control. In addition, the interference of ocean currents brings a lot of uncertainty to the control of vehicles in the real environment.

There are many studies on the depth control of underwater vehicles in the world, such as depth control method of underwater vehicle based on fuzzy control [20], terminal synovial controller was used to realize automatic depth determination control of ROV [21], uses PD control algorithm to realize ROV depth control [22]. The key to the performance of PD controller lies in the setting of PD parameters. Facing the complicated marine environment, simple PID control can no longer meet the needs of actual engineering. Aim at the shortcomings of traditional control algorithms, this paper proposes a PID multi-stage controller to achieve better depth control effects. The controller framework is shown in Figure 6.

Similar to the heading control, the depth control of underwater vehicle is also divided into two situations. One is when the operator does not send depth control commands, the vehicle realize the fixed depth control. The other is when operator sends depth control commands, at which time the vehicle obtains a desired speed of ascent or descent.

Underwater vehicle depth control is divided into three levels of PID multi-stage control. Depth loop PID controller based on the inertial navigation system, use the depth of underwater vehicle to calculate its expected speed and use the speed and its current speed to calculate the velocity error value. Then use speed loop controller for the vertical speed and calculate the expectation of underwater vehicle acceleration value. Finally, the error value of acceleration is calculated and the closed-loop control is carried out. The three-stage PID controller can be used to control the depth of the underwater vehicle well and can effectively resist the interference of the marine environment to achieve stable operation.

After sending the depth control commands to the vehicle from the land console, the vehicle will switch to speed control in the vertical direction. At this time, the depth loop controller will be abandoned and the velocity sent by land console will be taken as expected velocity of the vehicle. The closed-loop control of velocity and acceleration will be carried out to achieve the desired motion effect.

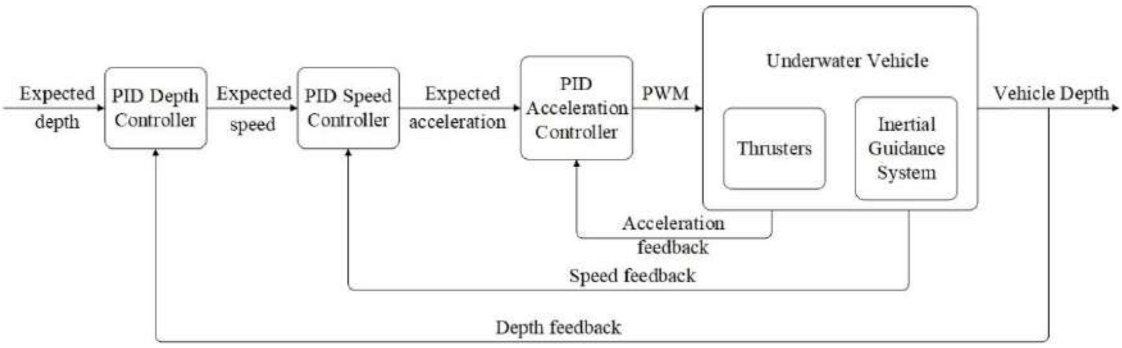

Figure 6. Structure of depth loop PID controller

6. Experiment

The underwater vehicle made in this paper is put into the real environment for testing. The hull inspection mainly involves three aspects: the underwater part of the hull, the main propeller and the lateral propeller. The underwater parts of the hull include the two sides under the draft, the bottom planks, rudder and rudder fins, the bottom door, the drain, the bilge keel, the half guide hood and the zinc on the outside planks. Inspection of main propeller, including propeller wing, propeller hub and propeller hub cap. The inspection of the side propeller is mainly to check its condition. The hull inspection needs to observe whether the parts involved in these three inspection aspects have peeled off the coating surface, rusted, stained and marine biological attachment. If there is any need to take photos and report the specific location, quantity and area.

During the test, the underwater vehicle first launched from the bow of the ship, turned around along the bilge keel of the hull, observed the condition of the hull and recorded the image. Then divide the captain into three equal parts, select three points from one side of the ship and cross across the other side of the ship. Figure 7 is the inspection of the training ship of Dalian Maritime University. Through the test, the body and control algorithm of the underwater robot designed in this paper can withstand the test of the ocean environment, run stably in the ocean and successfully complete the hull inspection task and obtain clear underwater images of different depths.

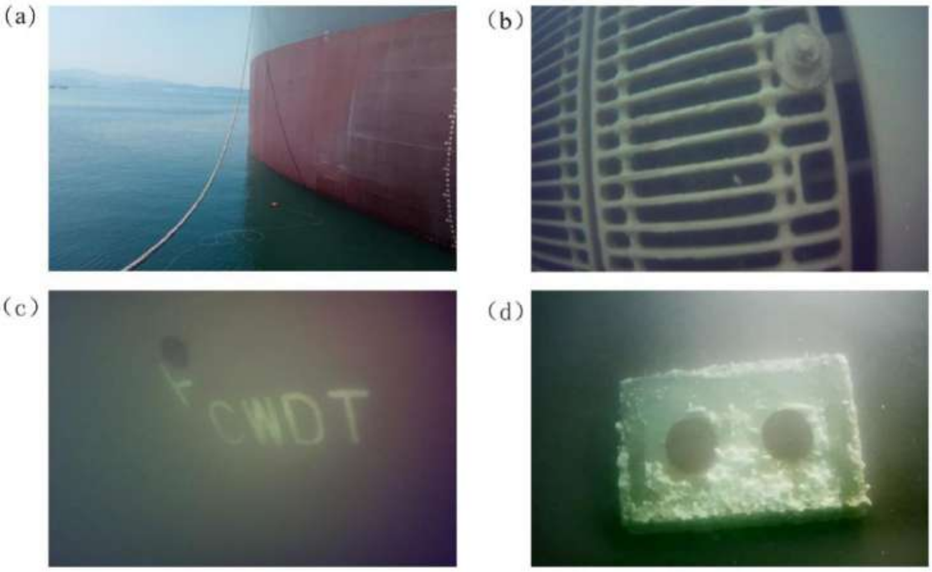

Figure 7. (a) At the time of testing, (b) Check the submarine gate, (c) Inspection of the hull surface, (d) Zinc block on rudder surface was detected

7. Conclusion

This paper describes the design of structure and control algorithm of underwater vehicle for ship safety, marine garbage collection and marine environment monitoring. This is a compact, high-performance underwater vehicle. The submergence depth index of the vehicle is 100 meters and it can work flexibly in this range.

At the same time, a multi-stage PID multi-stage controller is designed. It ensures that the underwater vehicle can run stably and achieve the function of fixed navigation and depth, so it can capture high-quality underwater images. The real environment test proves that the designed underwater vehicle can work reliably in the ocean environment. The vehicle body and control algorithm designed in this paper lay a foundation for the realization of automatic cruise monitoring of underwater vehicle in the future, which has valuable commercial and military value.

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Safe and Environment-friendly approach to recycling of Tanker ship

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ABSTRACT

Every drop counts because it is the little drops of water that make the mighty ocean. Every drop of oil that is prevented from polluting the Ocean will make the Blue Economy a truly Green Economy and every life saved from being lost in accidents, in the recycling yards will truly make every Ship-Recycling yard a safer workplace.

Alang (Gujarat-India), one of the world's biggest ship-breaking yards, recycles about 300 of the 1000 ships that are demolished per annum globally and with India ratifying the Hong Kong convention this number is bound to go up manifold soon.

The two most important aspects of the Hong Kong convention namely, environmentally friendly and labour safety, are directly related to making a scrap ship completely gas-free before being permitted to enter the recycling yard. Although recycling yards are claiming compliance with this convention, it appears that its implementation is not taking place as desired, thereby defeating the very purpose of this convention.

When a product tanker goes for a grade change, the amount of cleaning carried out and efforts made to ensure that cargo tanks are free from the residues of previous cargo, including all kinds of un-broachable oil that may remain in the pumps, pipe-lines or tank bottoms, is humongous. Depending on the size of the tanker, it may take up to a week to completely remove all the traces of residues. Since the commercial interest of the shipowner/charterer is involved, best efforts are made to do the job most professionally, but in the case of a ship that is being scrapped, since the deal has already been done, it is most unlikely that the shipowner would show similar enthusiasm or concern in making the ship gas-free and make it safe for carrying out hot work. Are the people inspecting the ship before permitting its entry into the recycling yard determined to ensure that the ship is absolutely Gas free, before issuing it a Gas Free certificate? Only the number of accidents and the marine pollution incidents will tell the tale. The data was collected through a survey of shipping companies operating tankers and through appropriate authorities at Alang Ship-recycling

yard. The extensive experience of the Author and his colleagues in Tanker operations (Over 20 Years) was utilized in the analysis of data.

Only the involvement of third-party experts from the field in Tank cleaning and gas freeing operations can pave the way to safe & environmental friendly Tanker recycling.

Keywords: - Tankers; Gas Free, Pollution; Safety, Hong Kong Convention, Ship-recycling

1. Introduction

The raison d'etre of this paper are the continuing instances of loss of life in shipbreaking yards especially due to tanker explosions/ fire and the after-effects of marine pollution caused by these ships. In this paper, a workable solution has been provided to ensure that no more lives are lost in tanker explosions/fires during the shipbreaking of end-of-life tankers and that the wastes generated from these ships are adequately disposed of.

The Ship-recycling industry has a universal reach. Shipowners from developed countries after sufficiently milking the ships commercially send their End-of-Life ships to Ship-Recycling Yards in South Asian countries to get the highest price for the scrapped vessel because of the existence of cheap labour and lax implementation of environmental and safety policies in these countries.

South Asian ship-breaking industry chiefly comprises of India's Alang, Bangladesh's Chattogram, and Pakistan's Gadani. A closer look at the economy of these three countries reveals that a significant population of these countries depends on the ship-breaking industry for its livelihood, thus making these countries in the South Asia region a favourite destination for ship-breaking.

In Bangladesh, the contribution of the ship recycling industry to the national economy is humungous, by way of supplying 90 to 95% of all its steel requirement for the building construction industry, thereby saving a considerable amount of foreign exchange for the country. Additionally, it generates employment for an estimated 30,000 people directly and 250,000 associated industries.[1]

As far as India is concerned, the ship-recycling sector employs up to 50,000 people directly and a couple of thousands more indirectly through re-rolling mills, scrap traders, oxygen gas facilities, transporters, the real estate market, and the money market.[2]

The Ship-recycling industry in India meets approximately 2% of domestic steel demand that amounts to about 28% of the country's total imported ferrous scrap.[3]

As regards Pakistan, the Gadani yard provides 30% of Pakistan's iron and steel needs. Gadani was the world's largest ship-breaking yard in the 1980s, with over 30,000 direct employees. Today it employs around 6000 workers.[4]

2. Principal regulations governing the Ship-recycling industry:

The contribution of various UN agencies, principally the IMO to ship recycling, to ensure workers' safety, sustainability and environmentally sound practices in the industry are as follows:

2.1 The UN Agencies [5]

- "Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal"
- Joint ILO/IMO/BC Working Group on Ship Scrapping
- Ship-breaking: a hazardous work (By ILO)

2.2 The IMO [5]

The Hong Kong International Convention for the Safe and Environmentally Sound Recycling of Ships, 2009 (the Hong Kong Convention).

2.3 IMO Resolutions (Guidelines)[5]: MEPC.196(62)–2011, MEPC.210(63)–2012, MEPC.211(63) – 2012, MEPC.222(64) – 2012, MEPC.223(64) – 2012, MEPC.269(68) – 2015

3. Development of shipbreaking Laws in India:

- 2007 Supreme Court ruling resulted in the formulation of shipbreaking code 2013.
- The revised Shipbreaking code, 2013 was promulgated in 2017 after factoring in pollution.
- On 9th December 2019, the Indian Parliament approved the "Recycling of Ships Bill 2019", thus ratifying the Hong Kong Convention.

Despite the advent of various conventions/rules/regulations/guidelines regulating ship-breaking at Local, National, Regional and International levels by various bodies, for Safer and Environmentally friendly Ship-Recycling, the efficacy of these efforts has not yielded results. This is evident from the examples listed below of Marine pollution caused by these shipbreaking yards and the numerous accidents/ deaths caused during the dismantling of ships.

4. Marine Pollution caused by the Ship-recycling Industry

4.1 A recent study conducted by the United Nations Environment Programme indicated that the leading shore-based cause of marine pollution is the ship-breaking activities in India, Pakistan and Bangladesh, in South Asia.[6]

4.1.1 According to one study conducted in Chittagong, Bangladesh, shipbreaking activities, as well as the consequential processing and treatment of materials, result in emissions of persistent organic pollutants (POPs).[7]

In the absence of a proper waste disposal facility, the marine environment near these shipyards continue to deteriorate unabatedly.

4.1.2 A Greenpeace study shows, shipowners get approximately **two million dollars** for every scrap ship sold to dismantling companies, while they remain absolved from the responsibility of proper recovery and disposal of hazardous wastes generated by these end-of-life ships.

4.1.3 The Gujarat Maritime Board, which oversees the shipbreaking business in Alang, tasked the Gujarat Ecology Commission in Vadodara with conducting a research on pollution levels in the city. Metallurgical and Engineering Consultants (India) Limited, Ranchi, was commissioned by the Union Ministry of Steel to conduct another research. Both investigations found that pollution at the shipbreaking yard had increased significantly.[8]

4.1.4 During an investigation into a related issue brought up in the Parliament of India, the Central Pollution Control Board (CPCB) discovered enormous volumes of oil in the area where the ships are demolished. This oil is washed away into the sea. According to CPCB, tests on seawater revealed oil and grease concentrations of 22 mg/litre, which is extremely high. Despite the fact that labourers claim to remove a substantial amount of oil from the ships before scrapping them, some oil remains in the lowest area of the hulls. The remaining oil is mixed with sand and tossed into the sea. Oil pollution has the potential to suffocate marine life.[8]

5. Major Accidents in Ship-recycling yards involving Tankers

Listed below are some of the major accidents that took place in the ship recycling yards in the South Asia region:

5.1 Gadani Shipyard, Pakistan

5.1.1 Aces fire in 2016: The explosion of the floating production storage and offloading oil tanker Aces on 1 November 2016, claimed the lives of 31 workers and seriously injured at least another 58 workers, causing a huge fire. According to the National Trade Union Federation of Pakistan (NTUF), the explosion was caused by the presence of combustible and hazardous gases inside the fuel tank during the dismantling procedure. No cleaning was carried out before the start of dismantling.[9]

5.1.2 According to World Maritime News, another tanker caught fire at the Gadani shipbreaking yard on October 11, 2018. No injuries, however, were reported.[10]

5.1.3 On 14 October 2018, seven people were injured, of which three suffered critical injuries after an oil tanker Kriti caught fire in Gadani ship-breaking yard's plot number 10. It was when the workers were cutting steel, the fire erupted inside the beached ship. The suspected cause of the fire was that the ships were not properly cleaned from residual oil.[10]

5.1.4 At an accident in yard number 66, five more workers were hurt while breaking the Greek ULCC (Tanker) Mistral. The fire took place on 2 November 2018.[11]

5.2 Chattogram Shipyard, Bangladesh.

5.2.1 On May 15, 2019, aboard MT BUNGA KELANA 4, which was beached at Chittagong's Mahinur Ship Breaking yard, an explosion and fire resulted in the death of one person and severe burn injuries to five others. The fire started in an abandoned waste oil tank near the engine room, where employees cutting steel components with a torch.[12]

5.2.2 On February 18, 2019, two workmen were killed after a fire broke out in the engine room of the tanker GREEK WARRIOR, which was beached in Chittagong.[13]

5.2.3 On the 24th March of 2020, while working in the engine room of MT West Energy at Kabir Steel's Khawja yard, two people died and two became ill from toxic gas inhalation.[14]

5.3 Alang-Sosiya Shipbreaking yard, Gujrat, India.

5.3.1 On the 22nd of April 1997, an explosion took place at plot number 48, onboard a beached oil tanker. As a result, it was reported that 16 deaths occurred but the unofficial figure of deaths stands at 30. A 700-tonne steel plate was ripped out of the ship's body due to the force of the crash. The reason for this was that the ship was not gas-free. When workers used gas cutters to cut the ship's body, it caught fire, blowing out the gas cylinders and causing a catastrophic explosion.[8]

5.3.2 On the 22nd of April 1999, 16 labourers were killed when an oil tanker beached at one of the plots exploded. The explosion was caused because when the workers began cutting the ship's body with gas cutters, which caused the explosion. The body caught fire, causing gas cylinders to explode, thereby resulting in a tremendous explosion.[15]

5.3.3 On May 19, 2003, an explosion ripped apart an oil tanker MT Ameena docked at plot number five, killing six persons and injuring five more in Alang. The vessel, MT Ameena, was said to be carrying a huge amount of oil, and the explosion occurred as workers were cutting steel with flame cutters.[16]

5.3.4 Pump room explosion and subsequent fire on board an oil tanker MT Union Brave beached at plot no 82 of the Alang ship-breaking yard resulted in the death of six workers and severe injury to one other on 06 Oct 2012.[17]

5.3.5 An explosion on June 28, 2014, onboard chemical tanker “Perin” during dismantling at plot number 140, inside the Alang ship-breaking yard, resulted in the deaths of five persons and injury to at least 10. The explosion was triggered by a suspected gas leak.[18]

It is common knowledge that, due to the lack of transparency in the industry, many accidents go unreported. The actual number of workers that have been either killed or maimed due to accidents in the ship-breaking yard is expected to be much higher. Besides, many more workers suffer from occupational diseases, including cancer and asbestosis, years after having been exposed to toxic fumes and substances at the shipbreaking yards.

It is pertinent to note that, of the three South Asian countries, India has made considerable efforts by putting in place appropriate rules and regulations to improve shipbreaking conditions at Alang, where up to six independent agencies inspect the ships before the beaching permission is granted. The certifying process that the vessel is gas-free is handled by agencies such as the Explosives Department, Gujarat Pollution Control Board and Industrial Safety. Yet the ground reality paints altogether a different picture regarding the number of accidents taking place and the frequency of their occurrence.

6. The Shipbreakers’ Woes

When the shipbreakers were contacted to elicit their views about the state of shipbreaking business particularly concerning workers safety and marine pollution issues, this is what they had to say:

- When a high-pressure flame comes in contact with hydrocarbons like fuel oil, furnace oil, or lubricating oil, shipbreakers concede that there indeed is a risk of a huge explosion taking place. Furthermore, the use of low-pressure gas cylinders to break the vessels raises the risk of explosions manifold.
- Sometimes cleaning of oil from the ship is not given its due importance or the time as the muqaddams (supervisors) are hard-pressed for time to cut up the vessel as soon as it is beached.
- The perils of cutting the ships are summarised by an Alang shipbreaker thus: " Around 300 low-pressure gas cylinders used for cutting the body of the ship, are kept indiscriminately at each yard.” A beached ship is usually loaded with about 100 gas cylinders. These ships carry hydrocarbons in the form of diesel, fuel oil, and lubricating oil that are required for the

operation of the ship until beaching. In the majority of cases, the cutting begins without first ensuring that all the traces of hydrocarbons are removed. A large blast results from the contact of high-pressure flame with hydrocarbon vapour.[8]

The above-stated facts indicate that there is an urgent need to find a solution to the above-mentioned problems to save precious lives and to prevent marine pollution.

7. Normal Tank Cleaning Practice & the Costs

Whenever an in-service tanker is to undergo major repairs, thorough cleaning of the ship is carried out and the ship is made gas-free before starting any kind of hot work. Preparing a tanker ship for hot work involves: - Tank Cleaning, Purging of Hydrocarbon Gas and Gas Freeing operation. Set procedures for the same are detailed in the International Safety Guide for Oil Tankers & Terminals.

Tank cleaning is a process in which leftover oil cargo, its residue and cargo vapours are removed from cargo tanks on board a tanker. Tank cleaning is usually undertaken: For carriage of clean ballast; To make tanks gas-free for man entry; To carry out repairs, or while preparing for dry dock; To remove cargo sludge from the tanks and; when loading a cargo grade which is not compatible with previous cargo. <u>As per the data obtained through survey of shipping companies operating tankers:-</u> The tank cleaning process for making an oil tanker Gas free requires on average six days. During these six days, the shipowner has to bear the running cost of the vessel, which involves the following expenses: Indirect Operating Expenses such as Victualling, Insurance, Wages, General Repairs /Stores, Standing Charges and Management Expense.

Following are the typical average operating cost per day for different types of tanker ships: - VLCC: 19-20 Thousand USD/day; SUEZMAX: 12000 USD/day; AFRAMAX / Large Range Tanker 2: 15000 USD/day; Large Range Tanker 1: 13000 USD/day; Thus, for Gas freeing a tanker the shipowner has to incur on an average additional cost ranging anywhere between 72,000 to 120,000 USD, depending on the size of the tanker. Therefore, a ship-owner who is selling his ship as scrap to earn the last bit of profit from an end-of-life ship would certainly not be keen to do a thorough job of gas freeing the tanker incurring additional expenses for the purpose. This is amply clear from the number of cases of explosions/ fire reported in paragraph 5 above.

It has been observed that the Shipbreaking yards in Pakistan and Bangladesh do not have strict regulatory control to ensure that the tanker is Gas free before being offered for beaching. At the

Alang shipbreaking yard in India, however, a tanker ship is permitted to beach for shipbreaking only after it has been declared Gas Free by the authorities.

8. The Regulatory Requirement and the Practice

Given below are a summary of the regulatory requirements and the current practices:

1) Regulation 8.3 – General requirements of Hong Kong convention warrant that, tankers destined to be recycled shall arrive at the Ship Recycling Facility with cargo tanks and pump room(s) ready for certification as Safe-for-entry, Safe-for-hot work, or both, in accordance with the Party whose authority the Ship Recycling Facility operates.

   This puts the onus of delivering a gas-free ship, on the shipowner or cash buyer.

2) Indian "Shipbreaking code (revised) 2013" at article 3.21 states that, "Any sweepings of cargo (leftover of last cargo) will be permitted to be cleared upon completion of proper import processes thereto if the sweeping/left out cargo has no commercial value or are not fit for consumption/use, such cargo shall be disposed of by the ship recycler as per appropriate statutes and rules framed thereunder". **This indicates that even the ship recycler is tasked with ensuring cleaning of oil from cargo tanks, pipelines, fuel oil tanks and lube oil tanks after beaching, before the commencement of shipbreaking.**

3) Ship Recycling Facilities must have management systems, procedures, and techniques that do not pose health risks to workers or the population in the vicinity of the Ship Recycling Facility and that prevent, reduce, minimise, and, to the extent practicable, eliminate adverse environmental effects caused by the Ship Recycling Facility, according to Regulations 17.1 and 19 of the Hong Kong Convention's annex. **Thus, it stipulates that the Ship-recycling facility is accountable to ensure that space is gas-free before commencing the shipbreaking and also ensure proper disposal of the hazardous wastes.**

4) At present most of the ship owners/ cash buyers clean the scrapped tanker at Fujairah or Singapore since no facility is available to clean the tanker through a professional agency at anchorages of shipbreaking yards. For example, in India, if a professional agency is appointed, then unclean tankers can also be called at Bhavnagar and the same can be cleaned by the professional agency and then inspected by the Petroleum and Explosives Safety Organization (PESO) and if found gas-free, may be permitted for beaching.

5) At Alang (India) the petroleum tankers are inspected by the representatives of the Petroleum & Safety Organization (PESO) for their cargo hold only, leaving out cargo pump room, bunker

tanks, lube oil tanks which constitute some of the potential areas for the presence of Hydrocarbon gas (explosive gas). Chemical tankers too are inspected by the competent authority (as approved by state maritime board/ Port authority) for its cargo holds only. PESO does not inspect Chemical and LPG tankers.

Thus, the requirement of the ship being completely gas-free before beaching, as per Shipbreaking code (Revised), 2013 of India and the general requirements (Regulation 8.3) of Hong Kong convention are not fully complied with. This is a major lapse in the system concerning pollution control and safety.

9. CONCLUSION:

For ensuring that tankers are made gas-free before beaching and remain so during the entire process of dismantling of the vessel as also for assisting the ship-recycler in proper waste-disposal, the following solution is suggested: -

1) A recognised third-party (RTP), competent to carry out tank cleaning of tankers and make it Gas free be appointed to carry out the job at anchorage before the vessel is cleared for beaching. The RTP should be a company or an agency comprising of a group of experts in the field of tank cleaning of tankers and also in the field of waste disposal.
2) This recognised third party should be made responsible for making the tanker gas-free and Safe-for-hot-work certification, inspection and testing as detailed in the Safe-for-hot-work procedures of Annex 4, Resolution MEPC.210(63), 2012 Guidelines For Safe And Environmentally Sound Ship Recycling.
3) The recognised third party should be made accountable in case of any accidents involving injuries to persons/ deaths/ damage to property resulting from tanker not being Gas free and should be made liable to pay penalty/compensation to the affected party, as decided by the competent authority.
4) The recognised third party should also be made responsible for the safe and environmentally sound disposal of hazardous wastes removed from the ship. Failure to do so by the recognised third party should attract a penalty as decided by the competent authority.
5) The responsibility of this recognised third party should commence at the anchorage before beaching and end after the ship is completely dismantled, that is on the issuance of the "Statement of Completion" certificate by the ship-recycling facility as per regulation 25 of the Hong Kong Convention.

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TOWARDS ZERO SHIP EMISSIONS II – PROJECT GREENSHIP

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Abstract

IMO's own International Shipping Facts and Figures report 2012 stated the number of vessels across the globe of 100 Gross Tonnage and over was 104,304, with cargo carrying vessels being 55,138 and expressed concern about the exponential increase of CO_2, NO_2, CH_4 and so forth in recent year. The EU responded by setting targets. The EU 2050 objectives set some intermediate targets for Eco-Efficient Vessel Emission Reduction for key pollutants: CO_2: >80% (-30% by 2020), NOx: 100% (-80% by 2020), SOx: 100% (-80% by 2020) and Noise Reduction: -3dB. A review of current research (Ziarati et al, 2018) clearly shows that the targets set for 2020 by both IMO and EU were not achieved and the 2050 goals are also unlikely to be achieved. The Industry is taking steps to reduce its air pollution and carbon footprint due to recent and upcoming IMO and EU regulations; IMO GHG study, Buhang et al (2009) reports that IMO has introduced some limits but has been unable to monitor ship emissions.

EMSA has tried the use of satellites and drones to monitor ships, which pollute the sea but has been unable to monitor ship emissions and waste discharge at sea effectively due to technical difficulties and also vastness of the oceans.

As the regulations and technologies governing energy efficiency on board ships becomes more complex it is realised by both the IMO and the shipping industry that seafarers need specific training to a much higher level in these fields. There needs to be a position specifically for managing, checking and controlling a ship's emissions for gases that are harmful to human health and the environment, an "Emissions Manager". As this is a brand new position, there are

neither defined competences for this role nor any specific knowledge, understanding or proficiency for it.
The paper gives full account of IMO efforts in recent years in setting legislation for key pollutants and reports on a new job specification for the Emissions Manager and proposes that an e-course being developed by several EU member states for the training of key ship officers and crew on how to minimise and monitor harmful emissions. The corresponding programme concerned with the current practice of managing emissions as well as the principle of making ships energy efficient. The new training programme targets both current cadets and existing seafarers in order to complement their skills.

1. Introduction

The global warming of planet Earth is well known by all concerned. This is mainly due to human action through the industries that use hydrocarbon fuels from crude oil. Fortunately, society in general is well aware of the impact on the environment and in particular by the maritime transport. Without being the biggest polluter of the planet, only 2.7% of the total CO_2 emitted, a reduction in greenhouse gases of 80% by 2050 is the aim of the IMO.
Reducing air pollution by focusing on greenhouse gases is a task that is not the only responsibility of national and international governments and government agencies, etc. Adoption of regulations that avoid and reduce air pollution also requires the collaboration of the industry. Without the support of the manufacturers of the energy systems used in the propulsion and auxiliary services of the ship, ship designers and shipbuilders and finally of the seafarers who have to operate these systems efficiently it would not be possible to help meet the goals of the IMO, as the representative of all maritime countries.
It is a well known that once the ship's hull is designed and built, few, if any, improvements can be made to reduce its drag and fuel consumption. The same also can be said of the propulsion and auxiliary machineries, since their effectiveness is and will be what the manufacturer has achieved when designing them.
Whilst it is true that once a ship is constructed little can be done to reduce fuel consumption or ship emissions nevertheless much can be done to keep its fuel consumption at an efficient level. For this reason, it is necessary to ensure that the crew has the necessary knowledge to operate the ship efficiently, including knowing when to slow steam or make use of wind, tide and currents. Therefore, the ‘Toward Zero Ship Emission’, the GreenShip project was initiated to ensure ships run efficiently and produce the minimum emissions.

2. IMO GHG Studies

IMO, has been mindful of the need to reduce GHG from ships, and has conducted four studies on air pollution by CO_2, NO_2 and CH_4 from ships. The First IMO GHG Study on GHG emissions, published in 2000, and estimated that ships engaged in international trade in 1996 contributed to about 1.8% of the world's total anthropogenic CO_2 emissions. The Second IMO GHG Study, published in 2009, estimated that international shipping emissions in 2007 were 880 million tonnes, 2.7% of the global total anthropogenic CO_2 emissions. The Third IMO GHG Study, published in 2014, estimated that international shipping emissions in 2012 were 796 million tonnes, 2.2% of the global total anthropogenic CO_2 emissions. The Study also updated the CO_2 estimates for 2007 to 885 million tonnes, or 2.8%.

The most recent estimates included in this Fourth IMO GHG Study 2020 show that GHG emissions of total shipping have increased from 977 million tonnes in 2012 to 1,076 million tonnes in 2018 (9.6% increase) mostly due to a continuous increase of global maritime trade. The share of shipping emissions in global anthropogenic GHG emissions has increased from 2.76% in 2012 to 2.89% in 2018.

It can be concluded that even with IMO's concern about reducing fuel consumption on board ships, its four studies only focus on the amount of fuel consumed by ships and not on the measures that should be taken to reduce it. However, it is of great interest and a great step forward, to be aware of the amount of CO_2 that shipping releases into the atmosphere. However, in line with IMO's concern to reduce pollution, this intergovernmental organisation has created a course called "Train the Trainers" in which the measures that should be applied on board ships are studied in order to achieve the 2050 target of reducing GHG by 80%.

3. The STCW Code

The minimum mandatory standards for seafarers' training are set in the Seafarers' Training, Certification and Watchkeeping (STCW) Code. A review of the minimum training requirements in STCW Code shows that both in chapter 2, corresponding to the deck department and chapter 3, corresponding to the engineering department, the knowledge and skills contained in them, at both operational and management levels, address the design, operation and maintenance of onboard equipment. Although there is a specific focus on good practices and their safe operation there is little on aspects relating to reducing emissions or fuel consumption. For this reason, the current and future seafarers must have specific training in the field of ship design and construction, efficient operation and maintenance of the ship, in brief, in the GHG reduction and greater awareness of fossil fuels impact on the environment.

In addition, as part of the battle to reduce GHG to a minimum, fuels other than fossil based must be considered such as hydrogen, ammonia and bio-fuels or electric provided emission elsewhere is not increased.

4. MARPOL Convention

The MARPOL Convention is entirely dedicated to the protection of the marine environment. Annex VI of this instrument establishes the measures to reduce air pollution including from GHG, CO_2, NOx and others such as PM and SOx. Regulation 20 and 21 of Annex VI of MARPOL: Energy Efficiency Design Index attained (EEDI attained) and EEDI required. As of January 1, 2013, every new ship must comply with an energy efficiency level according to the type of ship. This energy efficiency level is the Energy Efficiency Design Index (EEDI) and is has been gradually adjusted every five years. This has encouraged the use of more energy-efficient equipment and machinery, encouraging constant innovation and development of all the factors that affect fuel consumption and ship efficiency. The EEDI does not define a specific technology but focuses on a specific figure for a specific ship design, expressed in grams of CO_2 per ton of ship capacity and mile; the lower the EEDI, the higher the energy efficiency. By not restricting the technologies, ship designers and builders have some flexibility.

The equation for the EEDI is concerned with the basic amount of CO_2 produced by the main and auxiliary engines and elements of efficient energy generation such as shaft generators. Innovative energy efficient systems such as air lubrication systems, Flettner rotors or waste heat recovery systems could be considered for reducing fuel consumption hence engine emissions.

With the EEDI, an absolute value of the amount of CO_2 per ton mile of fuel burned is obtained. The ship will emit with the equipment and technologies with which the ship has been equipped for, but it does not tell how to maintain this Index, as poor operation and maintenance of the equipment can cause an increase in the index, which means consequentially an increase in fuel consumption.

In very simple terms, EEDI can be represented by:

$$EEDI \;=\; \frac{emissions\ of\ CO_2}{ship\ capacity}$$

Source: IMO MEPC.322(74)

Main engine | Auxiliary engines

$$EEDI = \frac{\left(\prod_{f=1}^{n} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)} \cdot C_{FME(i)} \cdot SFC_{ME(i)}\right) + \left(P_{AE} \cdot C_{FAE} \cdot SFC_{AE^*}\right)}{f_i \cdot f_c \cdot f_l \cdot Capacidad \cdot f_w \cdot V_{ref} \cdot f_m} +$$

Efficient and innovative energy for power generation

$$\frac{\left(\left(\prod_{f=1}^{n} f_j \cdot \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{AEeff(i)}\right) C_{FAE} \cdot SFC_{AE}\right)}{f_i \cdot f_c \cdot f_l \cdot Capacidad \cdot f_w \cdot V_{ref} \cdot f_m}$$

Efficient and innovative energy for propulsion

$$- \frac{\left(\sum_{i=1}^{neff} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME^{**}}\right)}{f_i \cdot f_c \cdot f_l \cdot Capacidad \cdot f_w \cdot V_{ref} \cdot f_m}$$

Source: IMO MEPC.322(74)

Regulation 22 of Annex VI of MARPOL: Ship Energy Efficiency Management Plan (SEEMP); as of January 1, 2013, states that it is a requirement for ships over 400 GT operating internationally. As for ships of 5,000 GT or more, no later than December 31, 2018, these must include in the SEEMP a description of the methodology that will be used to collect the data required under regulation 22A on Collection System of data on the fuel consumption of ships.

The purpose of the SEEMP is to establish a mechanism for the ship to improve efficiency during its operation, i.e. in its operational phase. In this way, it seeks to optimize the performance of the ship to consume less fuel and produce less CO_2 emissions. The SEEMP is an individualized plan that must be adapted to the characteristics of each ship.

The SEEMP consists of two parts: the first tries to provide guidelines to monitor the ship's efficiency over time; and for this, it uses four phases: planning, implementation, monitoring/self-evaluation and improvement. The second part deals with the methodology for collecting data.

The first part gives us the measures to improve energy efficiency. Greater energy efficiency means that the same amount of work is done by using less energy. As a result, less fuel is consumed hence emissions of all combustion exhaust gases are reduced.

Thanks to technology and engineering, there is a wide variety of options to increase the efficiency of ships and thus reduce CO_2 emissions. These measures can be divided into two groups. On one hand, the design measures would be part of the construction process of new ships or existing ships that go through a “refit” process. On the other hand, operational measures to optimise the ship such as trip planning, fleet management, energy management on board, speed optimisation, use of emerging alternative fuels, etc can be considered to any type of ship, either existing or new.

However, there are many more options besides these. The options shown do not result in the same efficiency in all ships, nor are they applicable to all ships.

While both the EEDI and the SEEMP are indicators of improvement of the ship's energy efficiency, providing the values that can be achieved by reducing fuel consumption and the steps that can be taken to do so; they do not explicitly provide the means to enable maintaining and lowering these indices. The above entails that the only way to maintain and lower these values is through adequate training of seafarers, in addition to creating the position of the manager for the efficiency of the equipment and other elements related to the fuel consumption on board ships. To this end, the core of the GreenShip project incorporates a specific training course on energy saving of ships that clearly and concisely explains to future ship managers the energy consumed by the ships throughout its life cycle. The course provides knowledge of all the applicable technology and its efficient use, measures taken in the design, redesign, operation and maintenance of the ship's energy equipment.

5. Emission and Energy Manager Training Programme

The GreenShip course addresses the need for:

a) Qualified personnel to implement regulations and technologies;

b) Emission control and energy efficiency of ships through cost savings and more efficient use of fuels;

c) The mobility and enhancement of employability in the global labour market for EU/worldwide seafarers and cadets who take the qualification either as part of their initial studies or as part of a continuing Vocational Education and Training (VET), for career development;

d) IMO SEEMP and related requirements of Maritime and Education and Training (MET providers to offer courses that are relevant and comply with latest regulations and requirements of the industry and address new skills gaps that are emerging with the latest technologies, requirements and practices for maritime emissions control and energy efficiency and

e) The integration and development of e-learning and digital skills into the EU's MET so that they can design and deliver e-learning materials as an online learning platform for the maritime officers who can truly benefit from online access to learning and training materials.

6. Teaching, Learning and Assessment Strategy

a) This is a standalone maritime emission and energy management training programme delivered using an e-learning platform that can be integrated into an existing maritime education training programme or delivered as a training module for seafarers and those involved in the shipping industry and maritime administration;

b) This training is competence based incorporating several learning outcomes;

c) The programme is in line with relevant IMO rules and regulations and compliant with European Credit Vocational Education and Training (ECVET), and with the Institution of Marine Engineering, Science and Technology (IMarEST) Continuous Professional Development (CPD) requirements;

d) It contains a set of assessment criteria based on the learning outcomes;

e) The assessment is part of the learning strategy and there is a provision for online self-assessment followed by several in class assignments supported by scenario based final assessment; and

f) The assessment has marking criteria awarding the trainee the grade of 'Competent' or 'Referral (not yet competent)'. The course is made up of the following components.

7. Ship Emission Manager Job Specifications

Ship emission manager is primarily responsible for managing all aspects of emissions management on board vessels. The manager is expected to:

i. Have knowledge, understanding and application of IMO emissions requirements/regulations;

ii. Be familiar with all emissions management systems on board and IMO and national regulations in place including Energy Efficiency Operation Index, EEOI, and Energy Efficiency Design Index, EEDI, with a specific knowledge of toxins produced by the ship engines as well as other machinery;

iii. Have skills in emission reduction and energy saving practices including engine propulsion, heating cooling and so forth;

iv. Be familiar with the ISM practices, and company specific measures including aspects relating to any quality standards which may relate to ISO 29000 or ship specific standards such as ISO 58000; and

v. Be aware of IMO's MARPOL, SOLAS, and related standards including aspects concerning maritime environment protection.

8. Ship Emission Manager Training Specifications

The aim is development of the training specifications are:

i. Provide specific education, awareness and training that is in line with national and international legislations;

ii. Enable effective and efficient management of emission control and monitoring processes energy transformation systems used on board ships and the reduction of consumption with a view to saving energy, reducing emissions and improving the overall quality of emission management practices;

iii. Facilitate the initial assessment on board ships and identify areas in order to improve effective and efficient emission control and monitoring processes as well as transformation of energy and its use, with regard to the key processes concerning SEEMP, and in particular EEOI and EEDI and Energy Efficiency Existing Ships Index, EEXI.

9. Chapters and Learning Outcomes - Summary Content

The online training manual will primarily include five chapters of the training programme and one of the chapters (introductory) will provide the IMO and EU rules and regulations regarding energy efficiency and emissions. The training programme produced will include a full curriculum, which takes into account the ECVET system, delivery guidance, as well as sample learning materials. The training programme will also include provision for web based assessment tools. The content of the training programme contains primarily information on the IMO EEDI, EEXI; EEOI, SEEMP and good practices in other industries such as automotive and aerospace. The course will be evaluated by a recognised professional body.

The project will also take into account IMO model course 1.38 – Marine Environmental Awareness (2011). This is to ensure there are no overlaps.

9.1. Chapter 1

This chapter describes the challenges faced in reducing global warming and reports on aspects concerning climate change. The focus is on IMO and EU efforts and rules/regulations. It describes all IMO and EU's measures and regulations and gives practical examples of each measure and/or rule, assess compliance with international legislations and requirements, monitor different indices such as EEDI, EEXI, EEOI and assess compliance with inspection, approval and accreditations.

9.2. Chapter 2

This chapter deals with the systems and sub-systems of emission production, dispersion and monitoring on board ships identifying the differences in each main type of ships. It focuses on the ability to:

i. Identify the emission measures of different types/sizes of ships and their designs;

ii. Assess safety concerns in different environmental conditions;

iii. Identify operational requirements at sea/in port and their environmental impact;

iv. Assess fuel emissions from vessels such as CO_2, NOx, SOx and PMs from the combustion of fuels and their compliance with legislations and

v. Identify different types of emissions generated from incinerated waste from cruise vessels and compliance with environmental requirements.

9.3. Chapter 3

This chapter focuses on the core part of the emission management programme namely, how emissions are reduced to a minimum while maximizing energy efficiency, by means of, mechanisms such as slow steaming, wind direction and strength monitoring as well as energy saving records for future management decisions. The competence developed are the ability to:

i. Implement ship's emission management, assess different ship emission management options;

ii. Assess fuel emissions management systems of ships regarding CO_2, NOx, SOx and PMs from the combustion of fuels and their compliance with relevant legislations;

iii. Identify different types of waste discharges generated from incinerated waste mainly from cruise vessels in compliance with environmental requirements, audit and inspection requirements including ISO 50001 and/or ISO 14001 as well as EU Monitoring, Reporting and Verification (MRV), Directive (EU) 2015/757, as well as the IMO fuel oil consumption data collection system and

iv. Develop the outline of company emission management plan in compliance with IMO SEEMP.

9.4. Chapter 4

This chapter describes the marine propulsion system and emission monitoring. The abilities developed are:

i. assessment of different ship

ii. evaluation emission generation and its use on board;

iii. assessment of the fuel emissions from ships regarding CO_2, NOx, SOx and PMs from the combustion of fuels and their compliance with legislations; communicate and manage conflicts with regards to effective and efficient use of engine energy usage and

iv. development of the outline of a company engine emission management sub-plan in compliance with IMO SEEMP

9.5. Chapter 5

This chapter concerns navigation and examples of savings emanating from the application of good practices. The competences developed are ability to:

i. Describe good practice in navigation that help to save energy and reduce emissions;

ii. Provide guidance to crew with regards to any changes at sea and weather conditions;

iii. Identify the navigation and operational requirements at sea/in port and their environmental impacts; and
iv. Communicate and manage conflicts with regards to effective and efficient use of overall use of energy.

9.6. Chapter 6

This chapter concerns port operations and air pollution. In port areas, air pollution is primarily due to ships. However, other equipment use energy hence contributes to air pollution in port areas. For example cargo loading devices, trucks and other transportation units, buildings and energy needed for these buildings and harbour crafts that provide additional services to port and shipping companies. The abilities develop are:

i. Ship times in port and just-in-time operations as well as improved cargo handling;
ii. Other measures for avoiding ship waiting times in port,
iii. Technologies for port air quality improvements and GHG emission reduction,
iv. Ship in port operational energy efficiency measures, 5) onshore power supply facilities; and
v. Green port initiatives and port environmental programmes.

10. Conclusion

The position of ship emission manager on board is very necessary as a specialist to reduce the consumption of fuel and the generation of GHG. Another conclusion is that all crew should receive training on the efficient use of fuels onboard. Finally, the use of EEDI, EEXI, EEOI and SEEMP is fundamental, but, it is necessary that the crew on board receives the most appropriate education and training on how to best operate and maintain all fuel consuming systems on board to achieve the maximum efficiency and optimum related indexes.

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USING ARTIFICIAL INTELLIGENCE (AI) METHODS TO COMBAT CLIMATE CHANGE at MARINE PORTS

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Abstract

Marine ports operations are often associated with a variety of externalities including air pollution, noise, accidents, vibration, land take and visual intrusion. Climate change is considered to be a crucial challenge that mankind has to confront nowadays Special attention has to be paid to the emissions of greenhouse gasses from freight transport. When berthing at a port a vessel needs considerably large amount of electric power to support its operations such as loading, unloading, lighting, cooling, etc. The power is usually supplied by auxiliary machinery and the fuel used causes several gasses emission that results in air pollution. Furthermore, this kind of engines produce noise pollution to a neighbourhood. The negative factors have an impact on the working environment and the quality of life of the citizens living in an area adjacent to a port.

A universal method of shore-to-ship electrification, also known as Cold Ironing, has been recently applied for connection between all the types of ships or on-land electrical systems with different frequencies – 50 and 60 Hz. Although the cold ironing is a way to reduce ships' emission and air pollution of a port and its neighboring areas consequently, the fact that the

ship is connected with a grid is a disadvantage. The disadvantage lies in its holistic approach to combat climate change. The electrical grid is powered by fossil fuels so the total contribution to air emission is limited. The zero emissions' port approach using a smart grid technology approach connected to renewable energy sources. The electrical grid is used only as a backup source in a situation where there is a deficit in power balance. The offered energy sources, found in nature, are wind, solar, geothermal, tidal and wave energy while there is also energy in biomass and earthquakes. Although there are so many of them, the challenge is the conversion to electricity and the efficiency of the converting systems. The use of such sources for commercial electrical supply is only possible with the new "Smart Grid" concept. The optimal control of such systems soon will require up-to-date algorithms with the use of artificial intelligence(AI).
In the paper, an overview of AI methods for smart grid energy management optimization are presented for ports discussing the potential application of each algorithm to zero-emission port concepts.

Keywords: artificial intelligence, climate change, cold ironing, smart grid, green port, zero-emission port

Introduction

In our days, all this cosmogonic change will significantly affect shipping not only in its mode of operation but also in the various support actions, as in our case with ports. The term artificial intelligence (AI) refers to the IT industry that deals with the design and implementation of computer systems that mimic elements of human behavior that imply even elementary intelligence: learning, adaptability, drawing conclusions, contextual understanding, problem-solving, etc. Artificial intelligence is a crossroads between multiple sciences, such as computer science, psychology, philosophy, neurology, linguistics, and engineering, to synthesize intelligent behavior, with elements of reasoning, learning, and adaptation to the environment while usually applied on specially designed machines or computers.

The new interesting approach is to use AI methods for the optimization of marine port operation with the zero-emissions criteria. Development of such algorithms will require first a review and analysis of existing AI approaches to provide the optimal one based on allotted tasks of ports sustainable and economical operation.

1. Basic classification of AI systems

AI is divided into symbolic artificial intelligence that attempts to simulate human intelligence algorithmically using high-level symbols and logical rules and into sub-symbolic artificial intelligence that seeks to reproduce human intelligence using elementary numerical models that synthesize inductive intelligent behaviors with the sequential self-organization of simpler structural components ("Behavioral artificial intelligence") simulating real and brain function ("Computational intelligence") or are the application of statistical methodologies.

Conventional artificial intelligence involves machine learning methods, which are characterized by rigorous mathematical algorithms and statistical methods of analysis and divided into:

- Experienced or specialized systems (**Expert systems**), which implement programmed logic routines, designed exclusively for a specific task, to draw a conclusion. To this end, large amounts of known information are processed.
- **Case-based reasoning**. The solution to a problem is based on the previous solution of similar problems.
- **Bayesian networks.** They are based on statistical analysis for decision-making.
- **Behavior-based AI.** Method of shredding the logical process and then manually constructing the result.

Computer artificial intelligence is based on learning through repetitive processes (configuration). Learning is based on empirical data and non-symbolic methods. It can be distinguished in:

- **Artificial neural networks**, with very powerful pattern recognition capabilities. They simulate the function of the neurons of living beings.
- **Fuzzy logic systems**. They are decision-making techniques under uncertainty. They are based on the existence of non-strictly segregated situations, the severity of which is taken into account on a case-by-case basis. There are already many applications of these techniques.
- **Evolutionary computation**. Their development arose from the study of living organisms and relate to concepts such as population, mutation and natural selection

(survival of the fittest) to more accurately solve a problem. These methods can be further distinguished into evolutionary algorithms and swarm intelligence, such as algorithms that simulate the behavior of an ant community.

Focusing mainly on machine learning, we have the following analysis. It should be clarified that, in general, the field of machine learning develops three ways of learning, analogous to how man learns: supervised learning, unsupervised learning and supportive learning. In more details:

- **Supervised Learning** is the process where the algorithm constructs a function that represents given inputs (set of training) in known desired outputs, with the ultimate goal of generalizing this function to inputs with unknown output. Used in problems:
    - Classification
    - Prediction
    - Interpretation
- **Unsupervised Learning**, where the algorithm constructs a model for a set of inputs in the form of observations without knowing the desired outputs. Used in problems:
    - Association Analysis
    - Clustering
- **Reinforcement Learning**, where the algorithm learns an action strategy through direct interaction with the environment.
- **Ensemble methods** combine results from multiple learning algorithms or different initial data to obtain better overall performance

Having this basic introduction, the case of using artificial intelligence for the efficient energy management of green ports will be presented below, specifically after an introduction to zero emission port the main port attributes related energy management will be examined and an overview of particular AI techniques will be discussed

2. Green port concept

A “Green port” concept implies environmentally friendly and sustainable operations of the port infrastructure and berths. This framework represents an important trend in port development in recent years. Emissions from ships’ auxiliary engines at a berth to supply power to vessel consumers are estimated to be ten times higher than emissions from port operations. Possibilities for their reduction is also much more significant [1]. One of the most viable options for a substantial decrease of greenhouse gases emissions at ports is the implementation of cold ironing.

Shore-to ship electrification; also known as Cold Ironing, is an old expression from the shipping industry that first came into use when all ships had coal-fired iron-clad engines. The term cold ironing refers to the gradual cooling of the iron engines and eventually their complete cooling. This happens when a ship ties up at the port and there is no need of feeding the fire of the iron engines. Cold ironing, in the meaning of shore-to-ship electrification, has been used by the military at naval bases for many years when ships are docked for long time periods. For example in Russia, it was popular to use the systems at local ports since the early 70s of the 20th century. As the world's vessel fleet is increasing, calls at ports are becoming more regular. Furthermore, hoteling power requirements have increased, and thus the concern of onboard generator emissions during docking periods has become the main air pollution issue. These are:

- Connection to the electrical grid and electrical energy transfer 20-100 kV to a local station when transformed to 6-20 kV.
- The electrical energy of 6-20 kV is delivered from the local station to the port's terminal station.
- There is a frequency conversion from 50 Hz to 60 Hz, depending ship's type.
- Next distributed to all electrical connections of terminals. For safety reasons, it is required special cable handling. This mechanism could be electro-mechanic or electrohydraulic.
- Onboard of the ship-specific adaptation for connection is required.
- Depending on the power of the ship, the voltage is transformed to 400 V. The transformer usually is placed in the engine room.
- The two systems are coordinated to work in parallel. There are practical problems associated with the procedures some of them are:

Frequency: The electricity of a ship can 50 Hz or 60Hz according to the ship type while the frequency of the European Union electrical grid is constant to 50 Hz. Some equipment of many ships which is designed to operate at 60 Hz may be able to operate at 50 Hz as well. This equipment is only limited to lighting and heating and is a small amount of the total power demanded by the ship. Motor-driven equipment like pumps and cranes, will not operate at their design speed and that will lead to damaging effects on the equipment. Consequently, a ship using 60 Hz electricity will require the conversion of the frequency of the European grid from 50 Hz to 60 Hz via a frequency converter. Voltage (M/V onboard): The difference in voltage between shore power and ship's power requires a specific onboard transformer (Fig. 1).

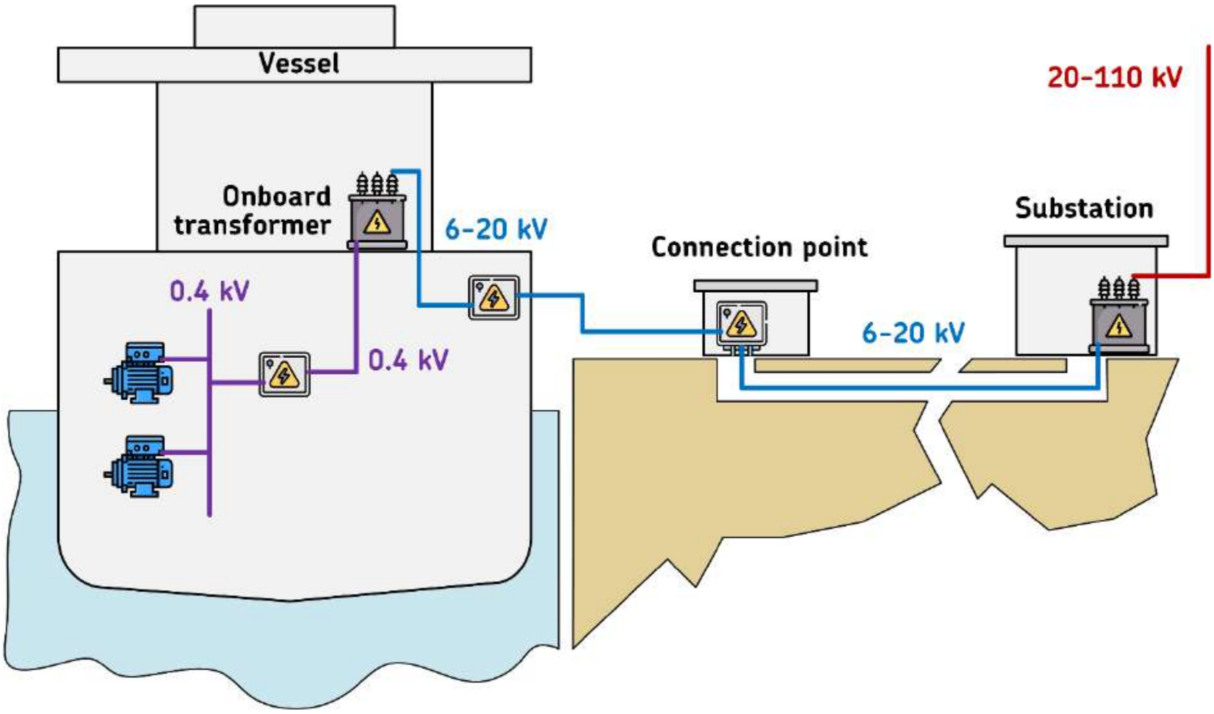

Figure. 1. General arrangement of cold ironing [2][1].

Safety: Cold ironing produces a high risk of injuries due to the requirement of direct handling of very heavy and cumbersome HV cables & connectors. Health is also a disadvantage by requiring handling of heavy loads in awkward positions, cold ironing exposes, in the long term, quayside personnel to back injuries. Non Compliance with National regulation, especially the European Directive 90/269/EEC3 is also an issue.

Several ships' types - berthing procedures: There are a variety of onboard power demands, system voltages, and system frequency vessels when they are at berth.

The vessel types usually are the Container vessels, Ro/Ro-and Vehicle vessels, Oil and product tankers, and finally cruisers. The docking pattern of each kind of ship and the usage of cranes is also a problem. Additionally, table 1 shows a summary of power demand for typical types of ships.

Table 1. Summary of Power Demand [3].

	Average Power Demand	Peak Power Demand	Peak Power Demand for 95 % of the vessels
Container vessels (< 140 m)	170 kW	1 000 kW	800 kW
Container vessels (> 140 m)	1 200 kW	8 000 kW	5 000 kW
Container vessels (total)	800 kW	8 000 kW	4 000 kW
Ro/Ro- and Vehicle vessels	1 500 kW	2 000 kW	1 800 kW
Oil- and Product tankers	1 400 kW	2 700 kW	2 500 kW
Cruise ships (< 200 m)	4 100 kW	7 300 kW	6 700 kW
Cruise ships (> 200 m)	7 500 kW	11 000 kW	9 500 kW
Cruise ships (total)	5 800 kW	11 000 kW	7 300 kW

3. Green port approach

Marine port power supply system normally is a traditional distribution system with well-developed infrastructure and similar to metropolis energy supply system in terms of complexity [4]. Electricity usage in ports is rising significantly for the last decade and will continue to increase due to operational, regulatory and environmental factors. Control and optimization of such systems become more and more complicated. To reach zero-emission aims and meet challenges regarding sustainability and environmental friendliness of the marine ports, new technologies are coming. One of the possible solutions is use of promising type of power system - so called “Smart Grid” concept [1].

The concept of “Smart Grid” [5] defines a self-healing network equipped with dynamic optimization techniques that use real-time measurements to diminish network losses, sustain voltage levels, rise reliability, and improve asset management. The operational data acquired by the smart grid and its subsystems will allow system operators to quickly recognize the best strategy to secure against attacks, vulnerability, and so on, caused by various contingencies. However, the smart grid first hangs on identifying and researching crucial performance measures, designing and testing suitable tools, and developing the proper education curriculum to equip current and future personnel with the knowledge and skills for the deployment of this highly advanced system.

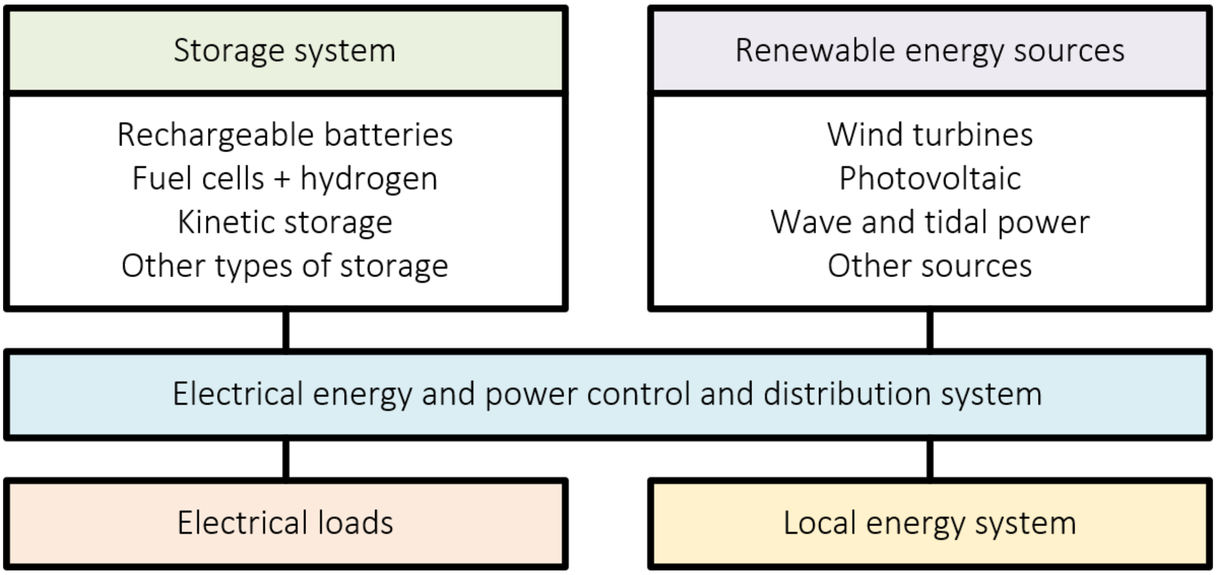

Figure 2 Schematic diagram of marine port power supply system microgrid concept [6], [1].

The control and distribution center is fitted with several renewable energy sources namely offshore wind turbines, PV sources for the park or from the buildings, wave or tidal energy depending on port potential, and geothermal energy according to ports abilities. The center is connected with a permanent electric grid used according to the needs and a digital metering system (in several areas such as docks and port's facilities) to monitor the port's energy demand and so to distribute the required available electrical power. The excessive power produced from renewable sources is transformed to hydrogen or stored in new technologies high-capacity batteries. The hydrogen produced is used for a fleet of electric cars for port's operations. The intention is that 100% power for all ports from renewable sources, and thus the power availability and the weather conditions should be carefully examined. In this case, an optimization algorithm will be very helpful to optimize the size of the power storage devices and the renewable sources. Furthermore, a power management algorithm can provide optimization of the power balance between renewable sources, storage devices, and the electrical grid. It can also perform optimum scheduling of the storage devices to increase the lifetime of such devices like batteries, decreasing maintenance cost and increasing the overall profit in the power market

The main motivations of a zero-energy port system are the following [7]:

- **Pollution reduction**, as required by the new regulations set by IMO and EU [8]. Those new regulations support the replacement of electric energy supply based on fossil fuels by renewable energies. Among them is the cold ironing procedures (i.e., stopping the engines of vessels during berthing) and also minimize the electrification of other auxiliary systems using fossil fuel energy [9]

- **The adaptation of harbors to the technological evolution of vessels and to shore-to-ship requirements**. Replacement of fossil fuels will be a fact for the next years meaning that electrical solutions such as electrical machines and storage systems will be among immediate priorities [10]. Cold ironing systems and the connection with offshore renewable energies will require a specific energy management system Among the potential actors in the future are the electrical vessels that require a specific load and ancillary.
- **The harbor changes required to meet the needs of the forthcoming years**: increasing maritime exchanges and maritime extension of harbor areas, development of electrical transport (vehicles, boats), etc. These loads represent approximately 80% of the annual electrical energy demanded in seaport;
- **The harvesting and use of fatal energy sources that exist in harbor areas**, but are rarely exploited: renewable energy sources such as solar photovoltaic energy or wind energy [11]

4. AI methods for zero emissions port's energy management

In this section, a brief consideration of AI methods potential will be presented based on the state-of-the-art review applied to the smart grid. The main attributes that will be discussed are load forecasting, Power Grid Stability Assessment, Faults Detection, and Smart Grid Security.

Load Forecasting

Renewable energy is dependent on temporal environmental conditions when integrated into a port's electric grid creates uncertainties on scheduling and operations of the electric grid and load forecasting is a key component to keep the system The load forecasting is classified in 3 major categories [12] : (1) short-term LF (STLF), which predicts the load from minutes to hours; (2) mid-term LF (MTLF), which predicts the load from hours to weeks; and (3) long-term LF (LTLF), which predicts the load for years.

- **Short-Term Load Forecasting.** There are many proposals, using the ensemble method, for this particular forecasting, for Short the efficiency and accuracy of STLF can be improved. Many Deep learning-based methods are used to solve similar problems. In recent years, and multilayer deep neural networks (DNNs)DNNs have been used to obtain the potential knowledge for a forecasting model

- **Mid-Term Load Forecasting** is used to coordinate load dispatch, maintenance scheduling, and balance demand and generation There is research on the deployment of a Deep Neural Network model [13] with an optimized training for mid-term forecasting in power systems in power systems and presented the effectiveness of the model. It is also provided a neural network-based model 0 combined with particle swarm optimization (PSO) and showed the feasibility and validity of the model.
- **Long-Term Load Forecasting:** is used to predict the power consumption, system planning, and scheduling of generation units new capacities installations in power systems. Artificial Neural Network is used as the first option and Support Vector Machines and Recursive Neural Networks follows

Power Grid Stability Assessment

The power grid stability assessments are fundamental for ensuring the reliability and security of the power system. Power system stability is the ability to stay at an equilibrium operation state or quickly reach a new equilibrium state of operation after a perturbation. Four different categories belonging to this attribute followed by the suggested AI techniques for their calculation are:

- **Transient Stability Assessment:** Machine learning algorithms using decision trees as a first choice, Support Vector Machines (SVM) and Artificial Neural networks.
- **Frequency Stability Assessment:** Mainly machine learning is used.
- **Small-Signal Stability Assessment:** Convolutional Neural Networks are mainly used for Particle Swarm Optimization (PSO).
- **Voltage Stability Assessment:** Artificial Neural networks, Support Vector Machines and algorithms based on decision trees.

Faults Detection

Mainly it is used for the fault location detection of the system (composed for the main grid and renewable energy sources distributed among several geographic locations) after extracting features by using measurements and compared them with SVR and ANN models.

Smart Grid Security

With the integration of advanced computing and communication technologies, the smart grid integrates distributed and green energy with the power grid by adding a cyber layer to the power grid and providing two-way energy flow and data communication. However, this has exposed the smart grid to numerous security issues due to the complexity of smart grid systems and the inherent weakness of communication technology. The most probable outcomes of smart grid cyberattacks are operational failures, synchronization loss, power supply interruption, synchronization loss, power supply interruption, high financial damages, social welfare damages, data theft, cascading failures, and complete blackouts.

5. Conclusions and future research

Ocean-going marine vessels represent one of the largest, most difficult to regulate, source of air pollution in the world and are also an essential component of the international trade and goods movement process. These marine vessels are similar to floating power plants in terms of electric power, and it has been indicated that the marine vessels are growing in length and they will therefore require greater electric power need. In this paper, it has been shown that shore-side power supply is a really interesting subject matter and that today's marine vessel emission regulation needs to be stricter. Most of the ports worldwide are investigating the possibilities to use shore-side power supply. The new concept of the smart grid using renewable sources requires appropriate energy management which could be facilitated nowadays from Artificial Intelligence Techniques. In the paper, a brief and initial overview of potential methods from AI is presented to facilitate the energy management of the so-called zero-emission port. Among those methods there are some very promising methods suitably fitted for the port's smart grid consisted of several geographically distributed renewable energies. Particle Swarm Optimization looks superior among others and its exploitation for zero emission's port will be among our future research

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