Arab Academy
for Science Technology & Maritime Transport

The International Maritime Transport and Logistics Conference
"Marlog 10"

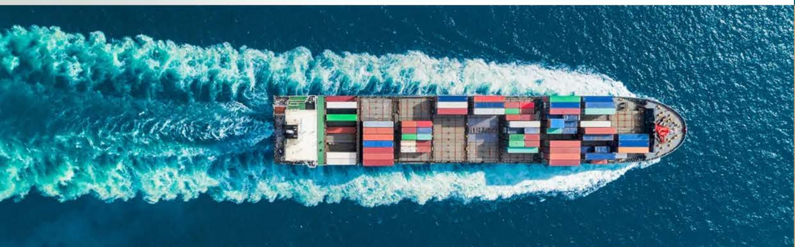
Digitalization
in Ports & Maritime Industry

Conference Proceedings

Editor-in-Chief
Prof. Akram Soliman Elselmy
Head, Conference Organizing Committee

10
2021
Marlog

مركز الأكاديمية للنشر
ACADEMY Publishing Center



13 - 15 June, 2021
Hilton Green Plaza Hotel

Arab Academy for Science, Technology and Maritime Transport

The International Maritime Transport and Logistics Conference

Digitalization in Ports & Maritime Industry

MARLOG 10

13 – 15 June 2021

Conference Proceedings

Editor-in-Chief

Prof. Akram Soliman Elselmy
Head, Conference Organizing Committee
Professor of Port Planning and Coastal Engineering
Arab Academy for Science, Technology, and Maritime Transport

ISBN: 987-977-85808-3-9
E-ISSN: 2682-3764

Digitalization in Ports & Maritime Industry

Table of Contents

Marlog 10 Conference Research Papers

Introduction:

Over the past two decades, digital transformation has become an essential tool in the business sector which foretells a significant leap in the patterns of business, industries and supply chains as well as a potential change in the world trade map.
Considering that about 90% of the world trade volume is currently transported across seas and oceans, it is essential that ports, logistics and maritime transport industry be ready to meet and cope with the challenges expected from such digital transformation to keep its share of the world trade. In addition, digitalization of the maritime industry provides new opportunities to enhance the efficiency, productivity, and sustainability of logistics.

The concept of smart ports, aims to adopt digital technologies to enable better planning and management of activities and resources in ports and share real-time information concerning the supply chain. Digital technologies like big data, Internet of things, and block chain have recently been entered and used in supply chain management.

Digital technologies enable companies and authorities to create opportunities for transparency, efficiency and collaboration which hold great potential for all the parties involved in this industry.

The current and previous events and crises that the world is going through, such as Covid-19 epidemic, proved the need to maximize the benefits of digital transformation in the maritime transport and logistics industry as an optimum solution to reduce the consequences of such crises.

Objectives:

The conference aims to discuss the horizons of digitalization in ports, logistics and maritime industry through the following topics:

- Digital Transformation in Ports: Challenges & Opportunities.
- Smart Logistics and Supply Chain Management.
- Innovative Artificial Intelligence & Robotics Technologies for Port Operation.
- Digital Ecosystems for Smart Ports.
- Cyber-security Risk Management and Assessment.
- The Role of Digitalization of Ports in Reducing COVID-19 Consequences.
- Modern Trends for Enhancing Human Resources Capabilities in Maritime Industry within Digital Transformation.

Themes

Theme 1: Digital Transformation in Port Services Administration & Marketing

- Shipping digitalization management (concepts, strategies & business models).
- Motives for digital transformation in the container shipping sector.
- Digital tools to increase efficiency in operations, safety and reliability.
- Digitalization of maritime freight market.
- The role of data analytic in the integration of governance systems in ports.

Theme 2: Digitalization of Supply Chain: Implications for Future

- Digital smart logistics: Concepts and strategic perspective.
- The role of digitalization of supply chain on blockchain integration.
- Digital supply chain towards smart management and operation.
- Preliminary considerations for 4IR-driven supply chains.
- Industry 4.0 and supply chain sustainability.

Theme 3: The Role of Digital Transformation of Ports to Reduce COVID-19 Consequences

- COVID-19 to accelerate digitalization of the maritime industry.
- The role of digitalization of ports to drive post-COVID-19 recovery.
- Analysis of COVID-19 impact on shipping based on Big Data.
- Innovative smart solutions for ports in the era of COVID-19.

Theme 4: Artificial Intelligence and Robotics: Ports and Logistics

- Modern Artificial Intelligence Applications in intermodal transportation.
- Business intelligence competencies for port community systems.
- Smart port-city: A catalyst for the global world economy development.
- Autonomous shipping and inland navigation.
- Machine learning innovations in container terminals.
- Innovative robotics technologies for port operation.

Theme 5: Cyber-security Risk Management in Maritime and Logistics Industry

- Cyber risk challenges in the maritime transport systems.
- Cyber-security assessments for critical port infrastructure.
- IOT solutions for risk assessment in ports.
- Cloud computing security issues and solutions in maritime and logistics industry.

Theme 6: Smart Ports Entrepreneurial Ecosystem Development

- Encouraging kick off port city ecosystems innovations.
- Smart Reliable and energy-saving solutions in ports.
- Digital business for maritime and logistics ecosystems.
- Smart Ecosystem - Success story (best practice).

Theme7: Reinforcing Capacity Building for Supporting Digitalization in Ports and Maritime Industry

- Digital transformation of human resource management in maritime and logistics sector.
- Raising cyber-security awareness in port and logistics community.
- Future Professions in the era of digitization of maritime industry.
- Promote peer-to-peer learning and knowledge sharing in the workplace.

Organizing Committee:

Prof. Ismail Abdel Ghafar Ismail Farag	Conference Chairman,
Prof. Akram Soliman Elselmy	Head of Organizing Committee
Dr. Mohey Eldeen Elsayeh	Dean, College of Maritime Transport & Technology, AASTMT.
Prof. Alaa Mahmoud Morsy	Vice Dean, Port Training Institute, AASTMT.
Dr. Sara Elzarka	Dean, International Transport & Logistics institute, AASTMT
Dr. Khaled Elsakty	Dean, College of International Transport & Logistics, AASTMT, Cairo.
Dr. Sara Elgazzar	Dean, College of International Transport & Logistics, AASTMT Alexandria.
Dr. Mohamed Mahmoud Ali	President Assistant for Technology Development, AASTMT.
Dr. Ahmed Othman	Dean, Consultations and Research Center, AASTMT.
Dr. Sandra Hadad	Vice Dean for Postgraduate Studies and Scientific Research, College of International Transport & Logistics, ASSTMT.
Capt. Mahmoud El-Bawab	Vice Dean, Maritime Postgraduate Studies Institute, AASTMT.

Technical Committee:

Head of Technical Committee: **Prof. Yousry El Gamal**	Professor of Computer Eng. College of Engineering, AASTMT. Former Minister of Education, Former Head, board of Trustee, Egypt-Japan University, Egypt.
Prof. Martin Renilson	President, Royal Institution of Naval Architects, Australian Division, Australia.
Prof. Bojan Rosi	Dean, Faculty of Logistics, University of Maribor, Slovenia
Prof. Roberto Revetria	Professor of Mechanical Engineering, University of Genoa, Italy.
Prof. Changqian Guan,	Head, Department of Marine Transportation, U.S. Merchant Marine Academy, USA.
Prof. Sam Yahalom	Professor, Department of International Trade and Transport, State University of New York Maritime College, USA.
Prof. Son "Shan" Nguyen	Department of Maritime and Logistics Management Australian Maritime College, National Centre for Ports and Shipping, University of Tasmania, Australia.

Prof. Salman Nazir	Training and Assessment Research Group (TARG), Department of Maritime Operations, Faculty of Technology, Natural Sciences and Maritime Sciences, University of South-eastern Norway, Norway.
Prof. Aristotelis Naniopoulos	Division of Transportation, Infrastructure and Regional Planning Engineering, Faculty of Engineering, Aristotle University of Thessaloniki, Greece.
Prof. Ahmed Amin	Professor, Civil Engineering Department, Suez Canal University.
Prof. Yasser Elsonbaty	Dean, College of Computing and Information Technology, AASTMT.
Prof. Islam El-Nakib	Dean, College of International Transport & Logistics, AASTMT, El Alamein.
Dr. Gehan Saleh	Egyptian Prime Minster Advisory for Economic Affairs.
Prof. Alaa A. Abdel Bary	Vice President for Graduate Studies & Scientific Research, AASTMT.
Dr. Gamal Ghalwash	Vice President for Training and Community Service, AASTMT.
Dr. Mohammed Daoud	Vice President for Maritime Affairs, AASTMT.
Dr. Elsenousy Balbaa	Vice President for African & Asian Affairs, AASTMT.
Dr. Hyundeok Kim	Dean, College of Future Convergence, Sunchon National University, South Korea.
Dr. Babak Banijamali	Vice-Chairman of Maritime Navigation Commission (MarCom) World Association for Waterborne Transport Infrastructure, PIANC
Dr. Nikitas Nikitakos,	Visiting Professor, Netherlands Maritime University College, Malaysia. Professor of Shipping Informatics and New Technologies, Department of Shipping Trade and Transport, University of the Aegean, Greece
Dr. Gianfranco Fancello	Professor at the Department of Civil and Environmental Engineering and Architecture, Transportation sector, University of Cagliari. General Manager, Centre of Excellence for Transport of the Sardinia region, Italy.
Dr. Patrizia Serra	Associate Professor, Department of Civil and Environmental Engineering and Architecture - Transportation sector, University of Cagliari, Italy
Eng. Francesc Carbonell	Head of Sector, Transport and Urban Development, Union for the Mediterranean.
Mrs. Ana Rumbeu Daviu	Training Director, Valencia Port Foundation, Port Authority of Valencia, Spain.

The International Maritime Transport & Logistics Conference

MARLOG 10

Digitalization in Ports & Maritime Industry

Program

13 – 15 June 2021

The International Maritime Transport & Logistics Conference

MARLOG 10

Digitalization in Ports & Maritime Industry

1St Day

Sunday, 13th June 2021

*All timings mentioned in the agenda are in GMT+2 – Cairo time

Opening Session

09:00 Opening Address

- **Prof. Akram Soliman Elselmy**
  Head of the Conference Organizing Committee
- **Prof. Ismail Abdel Ghafar Ismail Farag**
  Conference Chairman
- **Dr. Dina Al-Dhaher**
  Head of Transport & Tourism, The League of Arab States
- **H. E. Admiral Osama Rabie**
  Chairman and Managing Director, Suez Canal Authority
- **Major-General Mohamed Taher Elsherief**

  Alexandria Governor
- **H.E. Lieutenant General Kamel Al-Wazir**
  Minister of Transport

09:45	➢ Recognition of Instrumental Figures
10:00	➢ Signing a memorandum of understanding between Arab Academy for Science, Technology and Maritime Transport and the Tug Training & consultancy B.V
10:30	➢ Opening of the International Maritime Exhibition
11:00	➢ Tea Break

Session 1

"Digital Transformation in Port Services"

Session Chair

Prof. Yousry El Gamal

Chairman of IT Committee, National Council of Education, Culture, and Science

(UNESCO, ISESCO, ALECSO)

Former Minister of Education, Former Chairman, Board of Trustee,

Egypt-Japan University of Science and Technology, Egypt

12:00 Digitalization of Ports: The Role of Infrastructure

Mr. Francisco Esteban Lefler

President, World Association For Waterborne Transport Infrastructure (PIANC), Brussels, Belgium

12:20 Mediterranean Ports at the Heart of Digital Transformation

Dr. Philippe Guillaumet

Secretary General of the Medports Association, France

12:40 A Systematic Literature of the Maritime Transport Industry 4.00 Applications

Dr. Khaled El Sakty and Miss. Mona Awad

Dean, College of International Transport and Logistics, Cairo, AASTMT, Egypt.

13:00 Linking Digitalization to Sustainable Development: the Case of the Port of Gothenburg

Dr. Anastasia Christodoulou, Dr. Dimitrios Dalaklis, Dr. Aykut Ölcer and Dr. Fabio Ballini

Research Associate, World Maritime University in Malmö, Sweden

13:20 **Session Discussion**

13:30 **Break**

Session 2

"Digitalization of Supply Chain: Implications for Future"

Session Chair

Prof. Roberto Reviteria

Professor of Mechanical and Industrial Engineering, University of Genoa, Italy

Session Co-Chair

Prof. Dr. Ayman Adel Abdel Hamid

Dean, College of Computing and Information Technology
Arab Academy for Science, Technology & Maritime Transport

13:40 Integrated Route. One Destination
Rear Admiral Mohamed M. AbdelAziz
Advisor - Port Affairs, General Authority of the Suez Canal Economic Zone (SCZone), Egypt

14:00 Smart Port of the Future – Digital Transformation of the Port Community
Mr. Nico Suys
Head, Business Development for Port of Antwerp International for the Region North Africa, Antwerp, Belgium.

14:20 Digitalization: The Future of Maritime
Dr. Mohamed Mahmoud
President Assistant for Technology Development,
Arab Academy for Science, Technology and Maritime Transport, Egypt

14:40 New Maritime Scenarios in the Mediterranean through the Use of Geo-maps
Mr. Alessandro Panaro
Head of Maritime Department
Italian Research Center for Economic Studies (SRM), Italy

15:00 The Concept, Statue Quo and Prospects of Shipping Digital Transformation
Dr. Xu Kai
Chief Information Officer, PhD, Senior Engineer, Master's Supervisor,
Shanghai International Shipping Institute (SISI), China.

15:20 **Session Discussion**
15:30 **Lunch**

The International Maritime Transport & Logistics Conference

MARLOG 10

Digitalization in Ports & Maritime Industry

2nd Day

Monday, 14th June 2021

Session 3

"Artificial Intelligence and Blockchain Technology

Applications in Ports"

Session Chair

Mr Nico Suys

Head, Business Development for Port of Antwerp International
for the Region North Africa, Antwerp, Belgium

09:00 Artificial Intelligence for Supporting Maritime Terminal Management, Safety and Security

Prof. Roberto Revetria

Head, Student Orientation Committee, University of Genoa, Italy

09:20 Digital Twins and their Applications in Ports

Eng. Marco Politi

Vice President of Sales, DBA GROUP, Italy

09:40 Block Chain Technology Application at Container Transportation Industry

Miss. Afra Guo

Deputy General Manager of the Business Process and System at COSCOSHIPPING lines, China

10:00 Blockchain Adoption from the Shipping Industry

Dr. George Vaggelas, Dr. George Kapnissis, Dr. Apostolis Panos, Dr. Helen Leligou and Dr. Maria Doumi

Partner at "Ports and Shipping Advisory"
Associate Professor, Department of Shipping, Trade & Transport, University of the Aegean, Greece

10:20 **Session Discussion**

10:40 **Break**

Session 4

"Smart Ports Entrepreneurial Ecosystem Development"

Session Chair

Dr. Babak Banijamali
Vice-Chairman of Maritime Navigation Commission (MarCom)
World Association for Waterborne Transport Infrastructure, PIANC

Session Co-Chair

Dr. Mohammed Dawood

Vice President for Maritime Affairs

Arab Academy for Science, Technology & Maritime Transport

11:00 Digitalization Tools towards a Zero Net Emissions Port: Green C Ports and Valenciaport
Mr. Raul Cascajo Jimenez
Head, Environmental Policies, Port Authority of Valencia, Spain.

11:20 Towards Smarter, Cleaner and more Energy Efficient Ports through Digitalization and Automation
Eng. Francesc Carbonell.
Head Of Sector, Transport And Urban Development, Union For The Mediterranean, Spain

11:40 A Proposed Framework for a Port-area Vessel Speed Reduction System (VSR)
Capt. Mohamed Rowihil
Head of Maritime Cooperation Unit, Agreements & International Cooperation Center
Arab Academy for Science, Technology and Maritime Transport, Egypt

12:00 SCZone Digitalization Strategy
Eng. Mohamed Khamis
IT General Manager, Northern Sector, Suez Canal Economic Zone (SCZone), Egypt

12:20 **Session Discussion**
12:30 **Tea Break**

Session 5

"The Role of Digital Transformation in Container Terminal Development"

Session Chair

Dr. Mohammadreza Allahyar

Co-chair of Cooperation commission of PIANC/Member of Board and Deputy of Engineering and Port Development Infrastructures

Ports and Maritime Organization of Iran

Session Co-Chair

Dr. Aly Aly Fahmy

Dean of the Artificial Intelligence College

Arab Academy for Science and Technology and Maritime Transport

13:00 The Development of Smart Ports in China
Dr. Luo Bencheng
Senior Researcher and Chief Engineer,
Logistics Research Center of China Waterborne Transport Research Institute, China

13:20 The impact of Applying Smart Ports Requirements on the Competitiveness of Aden Container Terminal
Capt. Mohamed Elhussiny, Mr. Mohamed Amzarba and Dr. Ahmed Ismail
Lecturer, Nautical Basic Studies Department, College of Maritime Transport & Technology,
Arab Academy for Science, Technology & Maritime Transport, Egypt

13:40 A Simulation Model for Analyzing and Optimizing Container-Terminal Operations
Dr. Mohamed Faragalla
Computer Operator, Port Said Container & Cargo Handling Co. (PSCCHC), Port Said, Egypt

14:00 Container Market Concentration in the Era of Digitalization: Evidence from North African Sea Ports
Dr. Ahmed Ismail, Capt. Abdulla Wanis and Dr. Arbia Hlali
PhD Candidate, Arab Academy for Science, Technology & Maritime Transport, Libya

14:20 **Session Discussion**
14:30 **Lunch**

The International Maritime Transport & Logistics Conference

MARLOG 10

Digitalization in Ports & Maritime Industry

3rd

Day

Tuesday, 15 June 2021

Session 6

"Cyber-security Risk Management in Maritime and Logistics Industry"

Session Chair

Prof. Alsnosy Balbaa

Vice President of AASTMT for African & Asian Affairs

Professor of Environmental Issues Management in Seaports

09:00 Securely Enabling Maritime Digital Transformation
Mr. Patrick Grillo
Senior Director, Solutions Marketing, Fortinet, USA

09:20 Role of Digitalization and Internet of Things (IoT) in Fostering Ports Security
Dr. Mohamed Abdelfattah and Capt. Ahmed Ibrahim
Head of Quality Assurance Unit, Regional Maritime Security Institute (RMSI),
Arab Academy for Science, Technology and Maritime Transport (AASTMT)

09:40 Port Innovation against Cyber Threats
Mr. Rafael Company
Director of Safety and Security, Valencia Port Foundation, Valencia, Spain

10:00 Innovative Navigation Role of ECDIS in Decision Support System
Capt. Ahmed Khalil Barghash, Dr. Saleh Mesbah and Dr. Nafea Shaban
Senior Marine lecturer, Integrated Simulator Complex,
Arab Academy for Science, Technology and Maritime Transport, Alexandria, Egypt

10:20 **Session Discussion**

10:30 **Break**

Session 7

"Reinforcing Capacity Building for Supporting Digitalization in Ports and Maritime Industry"

Session Chair

Capt. Anwar Buftain

Team Leader, Fleet Personnel, Kuwait Oil Tanker Company, Kuwait

Session Co-Chair

Dr. Gamal Ghalwash

Vice President for Training and Community Service
Arab Academy for Science, Technology & Maritime Transport

10:50 Smart Port Research and Personnel Training Platform Construction
Dr. Qingcheng Zeng
Professor in school of Maritime Economics and Management,
Dalian Maritime University, China

11:10 Digitalization & Implementation in Maritime Training
Capt. Tim Lodder
Entrepreneur in Modern Learning Solutions, Founder & CEO Blue Orange Wave, Netherlands

11:30 The Readiness of the Maritime Education for the Autonomous Shipping Operations
Dr. Karim Aboul-Dahab
Senior Specialist, Maritime Telecom Services,
National Telecom Regulatory Authority (NTRA)

11:50 **Session Discussion**
12:00 **Tea Break**

Session 8

"Digital Tools to Increase Efficiency in Ships' and Ports' Operations"

Session Chair

Prof. Ahmed Amin

Professor, Civil Engineering Department, Suez Canal University

12:20 Digital Method for Refloating a Ship Stranding During Transit Suez Canal Using Its Own Means

Eng. Abd Elfattah Swidan, **Eng. Mohamed Walid Refae, and Prof. Mohamed Kotb**
Salvage Engineer, Egyptian Navy, Alexandria, Egypt.

12:40 Emerging Technologies in East Port-Said Megaproject

Capt. Mamdouh Awad
Marine Lecturer in the Sea Training Institute (STI),
Arab Academy for Science, Technology and Maritime Transport, Egypt

13:00 The Performance Evaluation of Smart Communication System for Ports across Different Seasons

Dr. Mahmoud Beshr, Dr. Moustafa H. Aly, and Dr. Ivan Andonovic
Head of Centralized Administration of Secured Certificates and Documents
Assistant Professor and Senior Consultant,
Arab Academy for Science and Technology and Maritime Transport

13:20 **Session Discussion**

13:30 **Break**

Closing Session

<u>Chairman</u>

Prof. Ismail Abdel Ghafar Ismail Farag

Conference Chairman

14:00 **Keynote Speech:**

Prof. Ismail Abdel Ghafar Ismail Farag

14:15 **Proposed Recommendations**

14:30 **Recognition of Speakers, Keynote Speakers and Sessions' Chairmen**

15:00 **Lunch**

MARLOG
10
Conference
Research Papers

A Systematic Literature of the Maritime Transport Industry 4.00 Applications

MONA AWAD & KHALED EL SAKTY
Maritime Research and Consultation Centre, AASTMT, Alexandria, Egypt, mawad@mrcc.aast.edu
Arab Academy for Science and Technology and Maritime Transport, Cairo, Egypt, khaled.sakty@aast.edu

ABSTRACT

Industry 4.0 implications in maritime transport and its related logistics activities become an indispensable factor for enhancing the competitiveness, facilitating communication, information sharing, and better coordination and collaboration between global supply chain partners. In addition, the implications aim at enhancing the productivity, safety, and environmental issues along with the shipping industry. In the context of maritime transport, the literature has provided an insight into the application of industry 4.0 techniques to the maritime transport activities in various disciplines base such as operation area, safety and security, environment issues and information exchange. These researches have used a variety of methodologies such as case studies, simulation, survey study, economic modelling, mathematical modelling, and content analysis. Thus, this paper aims to provide a general review of a systematic literature on the industry 4.0 techniques in the maritime transport sector. The literature is categorized into to various methodological issues such as research methodology, research base disciplines, and data analysis techniques that provide meaningful implications on methodological evolution in maritime transport research. It is concluded that the most industry 4.00 applications take place in the maritime transport operations, while simulation, big data, drones, and the artificial intelligence are the most applied tools in the maritime industry. Also, it is founded that there is a slow-move to apply the new technologies in some related maritime activities.

Keywords: Big data, industry 4.00, logistics activities, maritime transport, systematic literature

1 INTRODUCTION

Maritime transport plays a significant role in moving goods worldwide. This is due to its main characteristics in terms of cheaper cost than other modes of transportation, attaining economies of scale, and carrying out massive volumes. As a result, many research papers have given attention to this area using different methodologies with several theoretical and practical implications. Some papers focused on improving the overall performance of the maritime transport industry, while others focused on developing different areas such as efficiency, safety, environment, security, the flow of information, productivity, and handling rates.

Increasing the competition between companies to serve global customers required developing integrated systems, analytical applications, and fast communication and information technologies.

This provided companies with real-time transmission of information, visualization, and supply chain digitization. In the maritime context, many technologies and systems have been developed such as 5G technologies.

The main purpose of this paper is to provide a review of those industry 4.00 applications in the maritime transport industry using a systematic literature review strategy. It aims to provide an insight to what extent the implementation of the industry 4.00 applications takes place in maritime transport, what are the various methodologies applied, and what are the data analysis techniques implement industry 4.00 applications.

The rest of the paper is organized as follows. In the following section, the paper reviews the related literature concerning Industry 4.00 implications in ports, shipping, and logistic activities. In section three, the research questions are addressed and the research methodology has explained. The analysis and findings are discussed in section four. In section five, the conclusion, practical implication, and future research take place.

2 THE ADOPTION OF INDUSTRY 4.0 IN SEAPORTS AND RELATED LOGISTIC ACTIVITIES

The first two industrial revolutions depended on the body of workers to produce a majority of goods and services, but in the last two ages of revolutions, the production depended on the mind of workers. Knowledge workers are considered the main assets and primary drivers of the industrial age. They provide research, creativity, and leverage to achieve the organization's objectives more efficiently., So, the challenge now is how companies can motivate their knowledge to release their human potential (Xu et al., 2018) Based on the excessive use of human knowledge, X. et al. (2018) described Industry 4.0 as a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres. While Schwab (2016) described it by the case of using mobile internet over a wide range, using smaller, cheaper, and more powerful sensors embedded in infrastructures, and by artificial intelligence and machine learning.

Industry 1.0, 2.0, and 3.0 implications are of the most important to maritime transport and all related logistics activities. And their importance is for improving cargo flows, information flows, shipping navigation, and monitoring the vessels and vehicles operated in the terminal.

2.1 Generations of industry 4.00 application in maritime transport:

Heilig et al. (2017) differentiates between three main generations of the digital transformation in maritime transport, which are called paperless procedures, automated procedures, and smart procedures. Thus, the focus of these generations is mainly derived from the important role of digitalization in port operations. Table 1 shows the main characteristics of each generation as follow:

TABLE 1: Generations of Digital Transformation in Maritime Transport

generations	**1st generation** " paperless procedures"	**2nd generation** "automated procedures"	**3rd generation** "smart procedures"
timeline	**1960- 1989**	**1990- 2009**	**2010-2015**
Events	The world had witnessed the born of Containerization which required efficient information flows to cope with the new role of ports as integrated transportation systems and logistics hubs, the containerization requires huge investments into infrastructure, superstructure, and equipment	• In the mid-1990s, the Shipping lines formed the first global strategic alliances. • And also in the mid-1990s, some ports faced a problem related to the continuous growth in container shipping and it seemed to reach the limits and of course, this growth had an impact on the traffic and environment. • In the late 1990s. there was interest in e-commerce systems • In the mid-2000s, Increasing demand for single-window systems. • Global economic crisis of 2008-2009 led ports to be more cautious and follow more digital inspections.	• there are new trends in the Information Technology sector in order to enhance improving the gathering, storing, processing, and analysis of various and large data sources. • Attention has increased toward Port-centric decision support in order to identify inefficiencies points and bottlenecks on the overall port level. • Increasing the demand for value-added information services by customers to be kept in touch with related processes. • There is a trend toward exchanging information between different ports for the purpose of establishing successful partnerships.
IT/Is	Electronic Data Interchange (EDI), Port Community System (PCS), UN/EDIFACT standards, Terminal Operating Systems (TOS)	e.g., Laser, vessel traffic services,(VTS), automatic identification systems(AIS), truck appointment system(TAS) , radio-frequency identification(RFID).	e.g., Mobile Technologies, Sensors/Actuators, Cloud Computing, Distributed Computing/Processing, Machine Learning.
Digital applications	• Level 1: Adoption of basic IT superstructure and software applications to support individual activities of terminals. (e.g., booking, invoicing, accounting); •level 2:Developing EDI standards to enhance electronic document exchange with internal and external actors. • Level 3: Using TOS to give an integrated overview on core business processes within terminals and using these data in order to enhance the collaboration with external actors. • Level 4: Integration enables planning, management, and coordination of interdependent activities within the terminal. • Level 5: Paperless interactions between interacting actors in inter-organizational business processes.	• Level 1: Installation of new techniques that depended on sensors and laser techniques, Installation of automatic identification techniques. • Level 2: Integration of automated equipment using certain software with Terminal Operation System (TOS) provide necessary data related to terminal operations and this allows a (semi-) automated control of terminal equipment and vehicles (e.g., ASCs, AGVs). • Level 3: the adoption of these automated processes required restructures for organization policies, activities as well as and efficient information management. • Level 4: the establishing of e-marketplaces in order to support trade and cooperation in the maritime industry • Level 5: Global alliances between shipping lines and seaports required an agreement between services and IT/IS. • level 6: port-centric coordination of truck drayage operations using TAS to mitigate traffic and environmental problems.	• Level 1: Installation of sensors to manage and control the terminals' infrastructure, equipment, and cargo during transit (e.g., smart containers). • Level 2: enhancing the accessibility of information by integrating different devices, with wireless network access, and information services such as self-service registration services, electronic traffic panels. •Level 3: Integration of port-based, actor-based, and external IT systems in scalable cloud environments to allow a constant flow of relevant information, Cloud computing allows the port to scale up or down IT infrastructure to better adapt to the dynamic requirements of the port community

Source: Heilig, et al., 2017.

2.2 The application of Industry 4.00 in different maritime transport aspects.

`The industry 4.00 implications are developed by combining enhanced digital and physical connectivity in order to make better use of available resources, and supporting the integration process between carriers, seaports, and intermodal transport with the globalized shipper supply chains. In addition, they aim to support the integration between different traffic control centers (road, sea, railway) into a main port traffic center that allows ongoing interaction with actors being actively involved in the port's supply chain. , Also, those techniques provide responsiveness to changeable circumstances as well as considering economic and ecologic impacts of the actions by using various integrated sources of information used to support (near) real-time decision making (Heilig et al., 2017).
In return, the maritime industry will benefit from this adoption by providing a chance for better utilization for available equipment and space, create new business opportunities, make the supply chains more agile, and facilitate real-time information flows, but on the other side, the adoption of these digitalization programs require a lot of investments, new learning, and it may cause risks and potential costs to maritime actors (UNCTAD, 2019). Figure (1) displays the main aspects of maritime activities.

- *Industry 4.00 application in the maritime transport sector and its related logistic services:* ***in Operations Area***

Industry 4.00 has changed the handling process in seaports and terminals. For example on the gate side of the port, sensors have installed to read the license plates of the trucks (LPR cameras), Optical Character Recognition systems (OCR) that identify the loaded containers, card readers for the drivers, pressure plates on the ground to count their trucks (Tam et al.,2018), and all of these techniques are built based on IoT., These systems can notify the lorry drivers with the entrance times to the terminal, at the same time, AI gives the terminals a dynamic forecast of the workload they will face according to the surrounding conditions; such as road and access route saturation, real ship arrival time, and degree of terminal saturation, etc. Artificial intelligence (AI) can provide terminal planners with an indicative best solution for the best stowage and yard plans depend on the past experiences included in the big data and blockchain. , This may enable terminal operators to undertake quick control over container traffic in the container terminal yard. Artificial intelligence (AI) will provide terminal planners with an indicative best solution for the best stowage and yard plans depend on the past experiences included in the big data and blockchain, and this may enable terminal operators to undertake quick control over container traffic in the container terminal yard (Ono et al., 2021, Snijders et al, 2012). All of this information is transformed to partner on supply chains such as general port authority, container terminal operator and marine service providers customs clearance, quarantine inspection, and other commodity importation and delivery related procedures, shipping lines and this information are transmitted using data processing systems for implementing these procedures.

- *Industry 4.00 application in the maritime transport sector and its related logistic services:* ***in environment issues***

Nanotechnology has risen as a recent interdisciplinary branch of science and technology. According to Oxford Dictionary, Nanotechnology refers to "*the branch of*

technology that deals with dimensions of less than 100 nanometres, especially the manipulation of individual atoms and molecules".
Nanotechnology is also able to change the shipping industry in many ways especially shipping security, safer transportation, and environmental aspect as well as improving energy supply. (Sea news, 2019).

When the ship sails in the open ocean, it faces many environmental problems such as the accumulation of harmful organisms (such as algae) that cling to the ship and this of course increases the weight of ships and makes their tow more difficult. In addition, the nanomaterial incorporated in the non-stick coating has a great role in preserving marine life because the previously used coating agent had toxic properties that harm the lives of many marine organisms.

- *Industry 4.00 application in the maritime transport sector and its related logistic services:* ***safety and security purpose***

Data safety and information security are becoming a more important trend in the current digital time. Cybersecurity has a great role in improving the safety of all maritime transport partners and protecting different IT systems from unauthorized access, manipulation and disruption.
The maritime transport sector faces a different type of cyber risk which includes incorrect data transfer from the shipping line to the vessel and vice versa, as well as the risk created on board, where the crew doesn't know how to deal with every operational equipment installed onboard especially in case of disruption., and also the losses that created in case the ship systems are attacked by hackers.

On automated ships, the sailing system relies entirely on satellite-based communications to receive necessary software updates on their long voyages.
Automated ships are vulnerable to a wide range of viruses in different parts such as the ship's ultrasonic anemometer, a highly accurate wind measurer, and its wireless repeater. In this case, the malware finds its way to hack the other systems especially if the network failed to get access permissions and security instructions. (Tam et al., 2018)

Therefore, the usage of cybersecurity in maritime transport sectors enhances many functions such as monitoring engine operation, service and management of spare parts, loading, handling, crane, pump control and laying planning, and vessel performance monitoring.

- *Industry 4.00 application in the maritime transport sector and its related logistic services:* ***information exchange purpose***

The digitization process is working to improve the information exchange between the logistics actors where the shipping activities are no longer restricted to a specific time or location but need additional coordination through the exchange of temporary information in the supply chain using new technology applications.
Hence, Cloud Computing (CC) is used in logistic centers to enable customers to access the online platform from various devices and get their services in real-time (Bruque et al. 2019). Likewise, logistic services providers aim to use Cloud Computing and different online platforms in order to monitor cargo flow, cargo transportation, customs clearance, organize warehousing, cargo distribution, and finally manage any added value activity.

Moreover, the use of IoT and Location Detection technologies (LD) in warehouses enables monitoring the handling process and the geographic position of individuals, vehicles, and cargo through simple applications installed on any electronic devices such as smartphones and laptop computers. The usage of these tools inside logistics centers enables LPSs to take timely action in case of accidents or bottlenecks, helps reduce the time required to find the cargo inside the warehouse, and provides valuable insights when making strategic decisions (Douma et al., 2010) (Haddud,2017) (Parola,2020).

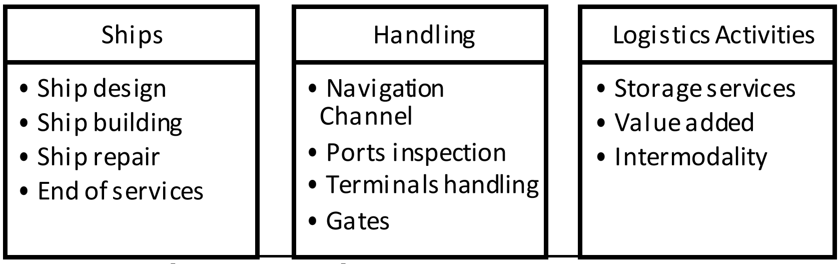


Figure 1: Industry 4.00 Applications in Maritime Transport Sector
Source: developed by the authors

3 METHODOLOGY

This paper aims to provide an insight into the applications of industry 4.0 techniques to maritime transport activities and their related logistic services according to a systematic literature review protocol.
Henriette et al. (2015), Kitchenham et al. (2009), Mahraz et al. (2019) have defined systematic literature review as a well-structured approach to select, analyze and evaluate papers in order to identify the gaps in a certain discipline.
The research strategy is based on six steps as shown in the following figure:

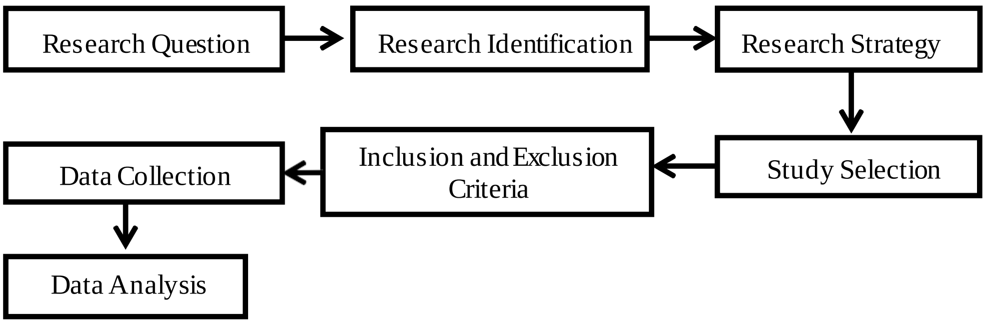


Figure 2: Systematic Literature Review Protocol
Source: developed by the authors

3.1 Research Questions:

This paper has addressed the following question and sub questions:
• What are the disciplines provided by research papers on applications of industry 4.00 in the maritime transport industry and related logistics activities?

o What are the research methodologies that implement industry 4.00 applications in the maritime transport sector?

- What are the data analysis techniques implement industry 4.00 applications in the maritime transport sector and related logistics activities?
- What is the limitation of applying industry 4.00 in the maritime transport sector and related logistics activities?

3.2 Research Identification:

This phase of the systematic protocol aims to examine and assess research on digital transformation in the maritime sector including shipping, ports, and logistics industries based on the research questions mentioned above (step one).

3.3 Research Strategy:

The search strategy starts with determining the journals with high impact factor in the maritime transport sector (Appendix 1) depending on the main digital libraries such as Taylor and Francis, springer link, El Savier, and science direct, and then deriving major terms related to industry 4.00 application types as mentioned in table 2.
The search of articles was performed without any time restrictions on publications and this search was performed using Egyptian Knowledge Database "EKB". This bibliographic database holds more than 3000 "open access" journals, and more than 300,000 book series.

Table 2: Industry 4.00 Applications

1	Internet of things IoT	21	Business Analytics,
2	Artificial intelligent	22	Green Information Technology
3	Nanotechnology	23	Automated Guide Vehicle
4	Digital supply chain	24	Building Information Modelling
5	Blockchain	25	CPS Cyber-physical systems
6	Cloud computing	26	Fibber Bragg Grating.
7	Deductive manufacturing	27	Integrated Supply Chain Management.
8	5G	28	Low Power Wide Area Networking.
9	Cybersecurity	29	Machine to Machine.
10	Smart Assets Management	30	Radio Frequency Identification.
11	Energy Solutions	31	Remotely Piloted Aircraft Systems.
12	Drones, robotics, and automation	32	Real-Time Locating System.
13	Augmented Reality	33	Ship Information Management Systems
14	Virtual Reality	34	Wireless Sensor Networks.
15	Machine Learning	35	Location Detection technologies (LDs),
16	Horizontal and Vertical System Integration (HVSI)	36	Mobile devices (MDs),
17	3DP & AM	37	Multilevel Customer Interaction (MCI),
18	Simulation and Modelling	38	Customer Profiling (CP)
19	Additive Manufacturing (AM)	39	Smart Sensors (SSs).
20	Big Data (BD)	40	Green logistics

Source: developed by the authors

3.4 Study selection

This step helps define selection criteria for target papers and articles. Hence, this paper follows the listed selection criteria in order to achieve the objectives of the stud. These criteria are as follows:

- The papers should be related to the application of industry 4.00 in the maritime sector.
- The papers preferred to be written in the English language.
- The articles should be published in a scientifically indexed journal.

3.5 Inclusion and Exclusion Criteria

With the study selection criteria defined, it is time to set the boundaries of the study by defining the concept of inclusion and exclusion. Non-peer-reviewed articles, white paper, technical report, abstract, short paper, and Books are excluded.

3.6 Data collection

The initial list of considered publications from the different digital libraries is around 1,564 articles starting from 2014 until 2018. The reviewer did the results based on the main topic and summary in order to review based on inclusion and exclusion criteria.

The final list of considered publications included 202 articles. Both authors carried out the selected study process independently. Each reviewer performed the screening of the results based on title and abstract for each publication that was considered according to the inclusion and exclusion criteria. Then, a comparison of screening results is realized, in case of difference, verification is jointly made to reach a consensus. At the end of this process, 153 articles were excluded and 49 articles were kept for the quality assessment step.

3.7 Data Analysis

In the end, some results came out of the extracted data. The data synthesis includes a descriptive analysis to provide a background about the included articles and an analysis of their findings in order to underline the future directions of research. In this step, we applied descriptive analysis in order to give brief information about the included articles, and determine the future directions of the research.

- Search Synthesis and Classification Matrix:

The matrix provides a quantitative visualization of the data extracted from the most recent published research on industry 4.00 applications in maritime transport. The classification chart was generated using a literature survey synthesis.

Since the focus of the literature on operations management and processes in ports and terminals, Table 2 shows different aspects of the maritime transport sector as a whole. The horizontal axis is grouped into 3 categories: Industry 4.00 Applications, Data Analysis, and maritime transport aspects. The vertical axis lists the main research methodologies used by different types of researches. The matrix is scalable in terms of adding new attributes such as another technology type.

The attributes in the Industry 4.00 applications include limited applications of industry 4.00 (14 application) which was discussed in recent researches. The attributes in data analysis include: regression, descriptive stat, a bibliometric analysis, or the article didn't use any statistical tool especially in the case of simulation.

The attributes in research methodologies include simulation & modeling, case study, conceptual framework, content analysis, Economic modeling, mathematical model, and survey. The research has 2 attributes; for topic and validation approach. All the attributes of the classification matrix can have either, Yes (Y) or No (N). The use of exclusive values, such as Yes or No is explicit in showing what was or was not covered in the literature. The analysis of the selected studies is shared below.

Table 2: Research Classification Matrix

Research methodologies	Industry 4.00 Applications							Data Analysis	Maritime transport aspects
	Artificial intelligent	Automated-guided vehicles	Drones, robotics, and automation	Big Data	Blockchain	Cyber-physical systems	Digital supply chain		
Simulation & modeling	No	Y	No	No	No	No	No	-	port operation
	No	No	No	No	No	Y	No	-	port operation
	No	No	No	Y	No	No	No	-	port safety
	No	No	No	No	No	Y	No	-	port safety
	y	No	No	No	No	No	No	correlation coefficient analysis	sailing
Conceptual framework	No	No	No	No	y	No	No	descriptive stat	information exchange / ship operation
	No	No	No	No	No	No	y	descriptive stat	logistic centers operation
Content analysis	No	No	No	y	No	No	No	descriptive stat	sailing
	y	No	No	y	No	No	No	bibliometric analysis	information exchange / ship operation
	No	No	No	y	No	No	No	a bibliometric analysis	information exchange / port operation
	y	No	No	No	No	No	No	-	information exchange / ship operation
	No	No	No	y	No	No	No	-	information exchange / ship operation
	No	No	No	No	No	No	y	a bibliometric analysis	ship/port operation
	No	No	Y	No	No	No	No	-	ship operation
Economic modeling	No	No	Y	No	No	No	No	-	sailing
Mathematical model	y	No	No	No	No	No	No	-	information exchange / ship operation
	No	No	Y	No	No	No	No	-	ship / operation
	No	No	No	Y	No	No	No	regression	information exchange / port operation
	No	No	No	Y	No	No	No	-	logistic centers operation
	y	No	No	No	No	No	No	-	logistic centers information exchange
Survey	No	No	y	No	No	No	No	descriptive stat	sailing

Source: developed by the authors

Cont. Table 2: Research Classification Matrix

Research methodologies	Industry 4.00 Applications							Data Analysis	Maritime transport aspects
	Energy Solutions	Green logistics	Internet of things	Remotely Piloted Aircraft Systems	RFID	Ship Information Management Systems	Simulation and Modelling		
Simulation & modeling	No	No	No	No	No	No	y	-	logistic/ information exchange
	No	No	y	No	No	No	No	-	Sailing
	No	No	No	No	No	No	y	-	ship operation
	No	No	No	No	No	No	y	-	Sailing
	No	No	No	No	No	No	y	regression	ship/ information exchange
	No	No	y	No	No	No	No	-	port safety
	No	No	No	No	y	No	No	-	logistic center operation
	No	No	No	No	No	No	y		port operation
	No	No	No	No	No	No	y	-	ship/environment
	No	No	No	No	No	No	y	-	ship operation
	No	No	No	No	No	No	y	-	shipbuilding
	No	No	No	No	No	No	y	-	the sale of vessels
	No	No	No	No	No	No	y	-	port/information exchange
Case study	No	y	No	No	No	No	No	-	port environment
	y	No	No	No	No	No	No	-	port environment
	No	No	No	No	No	No	y	-	Sailing
	No	No	y	No	No	No	No	-	ship/information exchange
	y	No	No	No	No	No	No	descriptive stat	shipbuilding/ environment
Conceptual framework	No	No	No	No	No	y	No	descriptive stat	ship environment
Content analysis	No	No	No	No	No	No	y	descriptive stat	port operation
	No	No	Y	No	No	No	No	a bibliometric analysis	logistic centers information exchange
Economic modeling	Y	No	No	No	No	No	No	-	ship/environment
Mathematical model	y	No	No	No	No	No	No	-	ship/environment
Survey	No	No	No	Y	No	No	No	-	logistic centers operation

The analysis has shown that most of the studies are using AI in a ship and logistic services for the exchange of information purpose, these studies used mathematical modeling, content analysis, and simulation and also used different statistical tools for data analysis.

Big Data was used in different maritime aspects for port and ship operation, information exchange, and safety purposes. These studies have conducted a content analysis as well as mathematical modeling to apply a research objective.

Also, the automated-guided vehicles were rarely used and that to simulate the port operation. As well as the digital supply chain, blockchain, green logistics, Remotely Piloted Aircraft Systems, RFID, and Ship Information Management Systems are introduced rarely in the literature. Most of Energy Solutions researches were conducted on port/shipbuilding for environmental purpose. These studies have developed case studies, economic modeling, and mathematical modeling as a research methodology to answer the research questions. Drones, robotics, and automation were described for ship operation and sailing.

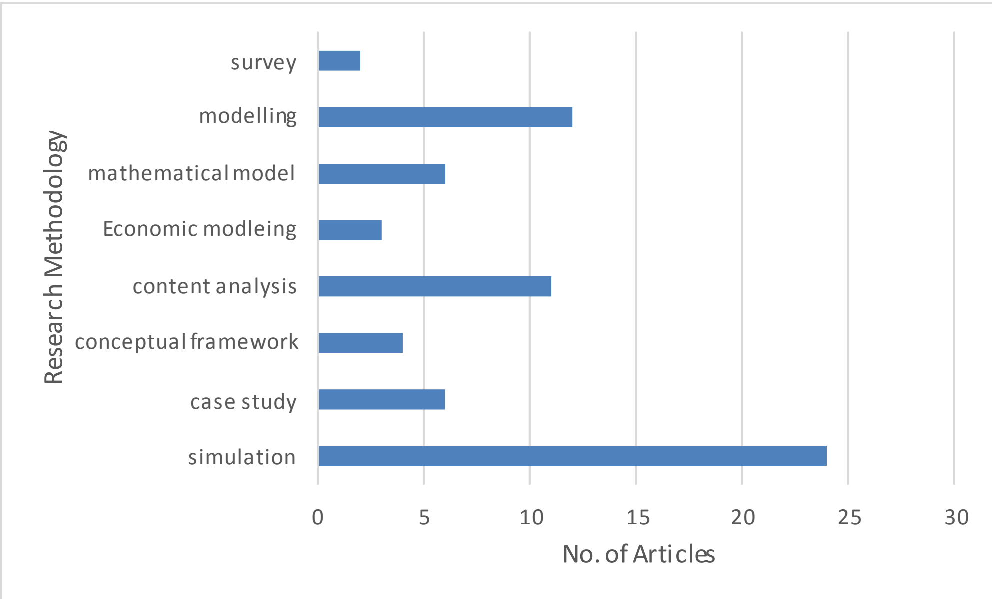


Figure 3: The Most Applied Research Methodologies in a Maritime Transport
Source: developed by the authors

Simulation and modeling are the main research methodology used in literature as shown in Figure 3, where 53% of articles in maritime transport employing this type of methodology. It is followed by 16% of articles that used content analysis as a research methodology, 9% for mathematical modeling, and 9% using the case study.

The literature survey has introduced and examined the application of 40 new techniques of industry 4.00 in different fields, but unfortunately, about 14 types of applications were introduced in the maritime researches as indicated in Figure 4

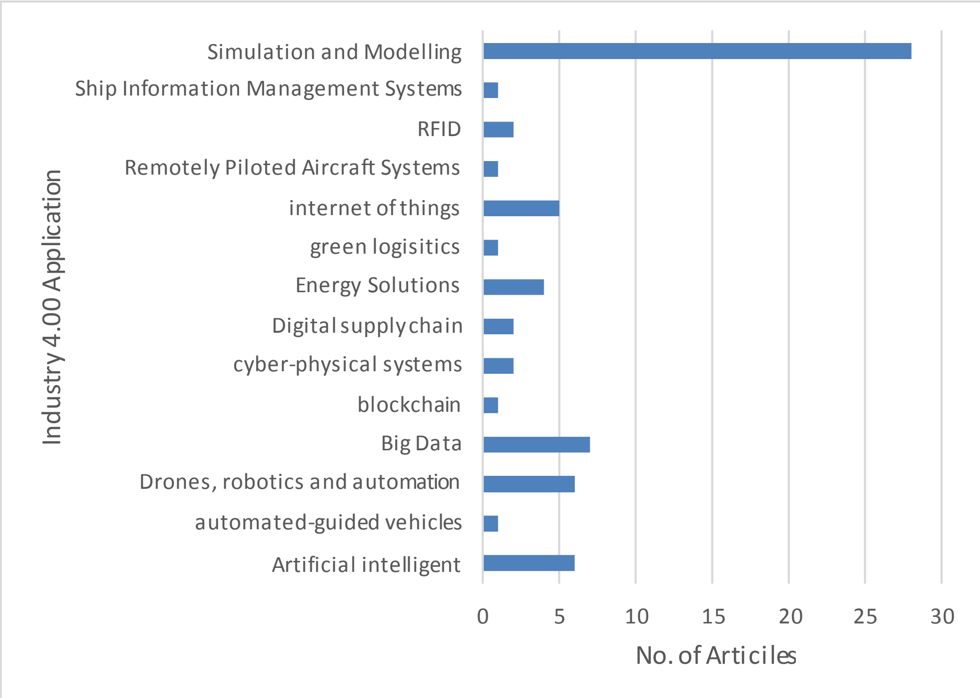


Figure 4: Industry 4.00 Applications in a Maritime Transport
Source: developed by the authors

Simulations and modeling are two of the most discussed applications in previous studies, and because they were used before the industry's 4.00 revolution. And then followed by big data, the Internet of things, artificial intelligent techniques, where 27% of revised articles used them in developing the maritime aspects.

Despite the great effort of an international organization such as IMO to protect the environment and enhance maritime transport to be environmentally friendly, the energy solution and green logistics techniques are of less used application in a revised journal.

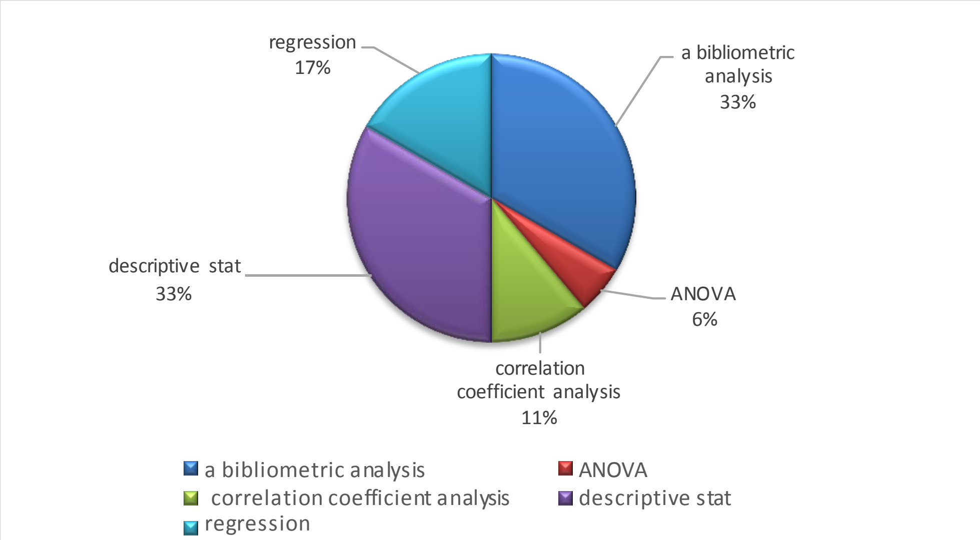


Figure 5: Data Analysis in a Maritime Transport
Source: developed by the authors

As displayed in Figure 5 The results of the data analysis used in the articles showed that about 75% of revised articles did not use any statistical tool, and the remaining 25% of articles used different statistical methods were, 33% of them used descriptive statistics techniques and bibliometric analysis, it is followed by 17% of revised articles relied on the regression.

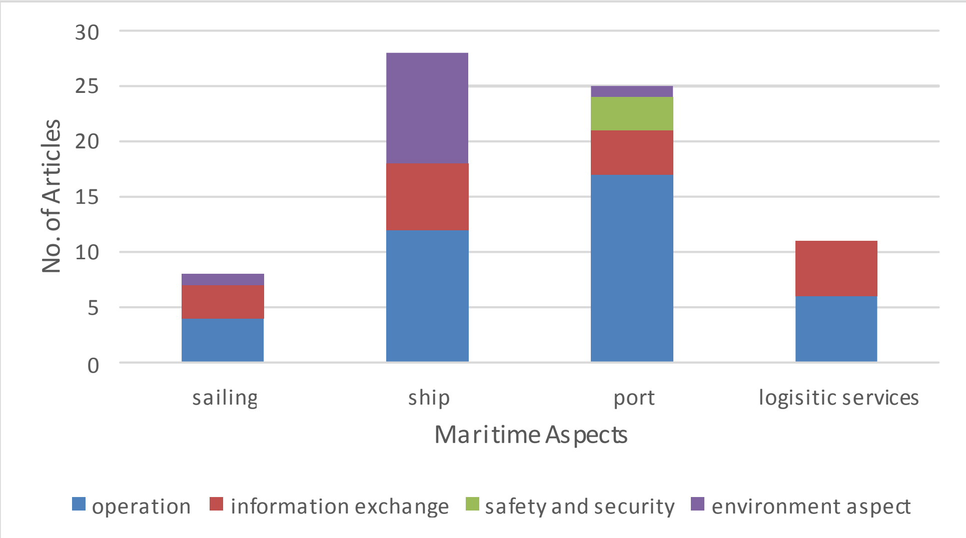


Figure 6: Applied Researches in Maritime Aspects
Source: developed by the authors

Figure 6 indicates the number of articles that applied industry 4 applications in each maritime aspect: sailing, ship industry, ports, logistics services. Since the focus of literature was on the shipping industry, 43% of revised articles discussed the ships industry especially the operation issues. The port and terminal handling process was the second focus of the literature, in which 68% of articles have introduced the port operation aspects. The logistics services and sailing were of the last interest of researchers in applying industry4.00 applications in these 2 fields.

CONCLUSION

The results of this research show that there are still a limited number of papers that discuss the implementation of industry 4 applications in maritime transport-related activities and functions. The analysis is enabled us to shed light on the actual number of applications developed by limited papers in the maritime sector. Despite the fact that Industry 4.00 includes 40 types of applications and techniques, most of the marine literature only discusses 14 types, where 42% of them are related to simulation and modeling applications. There are still limitations of this research that have related to the methodology and data analysis tools to conduct an appropriately well-designed study leading to valid and reliable results.

Most studies used "digitalization", or "digital transformation" phenomena to describe the application of new techniques in the maritime transport sector. But it did not provide the in-depth study to develop different disciplines of ports, ships, and logistical centers using industry 4.00 techniques. This research provides valuable insights for the gap in research methodology and data analysis techniques that need to be developed as well as encourage new academic investigations and findings.

RECOMMENDATION

It is recommended to investigate the applications of industry 4.00 tools (approximately 40 tools) in related maritime- industries such as ship building, ship scrapping, ship registration, and intermodality.
Also, it is recommended to study in the economic, environmental, and social impacts of 4th industry in the maritime transport activities, especially the negative impact of applications in addition to the positive effects. The future studies should increase the research in the application of industry 4.00 in safety and security, environment issues.

REFERENCES

Bruque, C., S., Moyano Fuentes, J., Marin, M., & Manuel, J. (2015). Cloud computing, Web 2.0, and operational performance: the mediating role of supply chain integration. *International Journal of Logistics Management.*

Douma, A., & de Langen, P. (2010). Challenges for Using ICT to Improve Coordination in Hinterland Chains: An Overview. Challenges for Using ICT to Improve Coordination in Hinterland Chains, 1000-1019.

Haddud, A., DeSouza, A., Khare, A., & Lee, H. (2017). Examining potential benefits and challenges associated with the Internet of Things integration in supply chains. *Journal of Manufacturing Technology Management*.20-42.

Heilig, L., Schwarze, S., & Voß, S. (2017). An analysis of digital transformation in the history and future of modern ports.

Henriette, E., Feki, M., & Boughzala, I. (2015). The shape of digital transformation: a systematic literature review. *MCIS 2015 proceedings*, 10, 431-443.

Kitchenham, B., Brereton, O. P., Budgen, D., Turner, M., Bailey, J., & Linkman, S. (2009). Systematic literature reviews in software engineering–a systematic literature review. *Information and software technology*, 51(1), 7-15.

Mahraz, I., Benabbou, L., & Berrado, A. (2019). A Systematic literature review of Digital Transformation. *In Proceedings of the International Conference on Industrial Engineering and Operations Management*, Pilsen, Czech Republic. 23-26.

Ono, K., Masayuki, T. & Yasuhiro, A., (2021). AI Port Initiatives - Possible Modernization of Port Operation and Management Through Cutting Edge ICTS, *34th PIANC World Congress.*

Parola, F., Satta, G., Buratti, N., & Vitellaro, F. (2020). Digital technologies and business opportunities for logistics centres in maritime supply chains. *Maritime Policy & Management*, 1-17.

Schwab, K. (2016). The Fourth Industrial Revolution: World Economic Forum. Zulfu Dicleli: The Optimist Publications. pp, 15.

Sea news. (2019). Five amazing ways nanotechnology is changing the shipping industry.

Xu, M., David, J. M., & Kim, S. H. (2018). The fourth industrial revolution: Opportunities and challenges. *International journal of financial research*, 9(2), 90-95.

Snijders, C., Matzat, U., & Reips, U. D. (2012). "Big Data": big gaps of knowledge in the field of internet science. *International journal of internet science*, 7(1), 1-5.

Tam, K., & Jones, K. D. (2018). Maritime cybersecurity policy: the scope and impact of evolving technology on international shipping. *Journal of Cyber Policy*, 3(2), 147-164.

UNCTAD.(2019). Digitalization in Maritime Transport: Ensuring Opportunities for Development.

APPENDIX A: List of Revised Journals: High impact factor in maritime transport

No.	Journal
1	Maritime Policy & Management
2	Maritime Economics & Logistics
3	Transportation Research Part A: Policy and Practice
4	International Journal of Logistics Research and Applications
5	International Journal of Shipping and Transport Logistics
6	Transportation Research Part C: Emerging Technologies
7	Transport Reviews
8	Transportation
9	Transportation Research Part E: Logistics and transportation review
10	International Journal of Logistics: Research and Applications

Linking Digitalization to Sustainable Development: the Case of the Port of Gothenburg

Anastasia Christodoulou
World Maritime University, Sweden, ac@wmu.se
Dimitrios Dalaklis
World Maritime University, Sweden
Aykut Ölcer
World Maritime University, Sweden
Fabio Ballini
World Maritime University, Sweden

ABSTRACT:

Digitalization has become a main priority of ports globally, with the use of automation and exploitation of advanced technology applications -such as Artificial Intelligence (AI) and Big Data Analytics- evolving as important parameters that can substantially improve and promote efficient port operations. This paper discusses the link between digitalization and sustainable development of ports. From the review of relevant 'smart ports' around the globe, it becomes obvious that the majority of these ports have also been proactive at the adoption and implementation of sustainability initiatives. The paper analyses the case of the Port of Gothenburg – the largest Scandinavian port – that has been a pioneer in sustainable development and is about to launch a digital platform during the second half of 2021 that will link digitally and help to improve the coordination of operations for all relevant stakeholders – shipping companies, freight forwarders, rail operators – at the port area.

Keywords: digital technologies, automation, ports, supply chain, sustainability, SDGs, shipping, Port of Gothenburg

INTRODUCTION:

The role of ports in global trade is paramount; these vital transportation links are handling around 80% of goods transferred all over the world, trying to cope with rising demands on operational efficiency and productivity and, at the same time, effectively contribute into sustainable development and especially to the goals of the United Nations 2030 Agenda for Sustainable Development (Alamoush et al., 2021). The challenge of conciliating these increasing demands is expected to rise in the years to come given the predicted growth of container handling globally and the diversified nature of global trade with larger vessels and quicker transfer of goods along the supply chain. A possible solution to these challenges can be provided by the expansion of digitalization in ports and the integration of innovative (digital) technologies, such as Internet of Things (IoT), big data, Artificial Intelligence (AI) and blockchain, into port operations and processes to enhance economic and operational efficiency along with environmental sustainability in the port areas. Given the increased digitalization of supply chains globally, ports need to preserve their role as „nodes‟ within these chains by being transformed into „digital nodes‟ (Dalaklis et al., 2020).

Although the port and shipping industry is often regarded as conservative and "resistant to change", many proactive and forward-looking ports around the world are already using these innovative technologies with clear economic, operational and environmental benefits and as a result they are often characterised as „smart ports‟. Following the example of other industrial sectors, the digitalization of port processes could lead to increased efficiency and productivity and a better management of resources, as it will enable the cooperation of all relevant stakeholders – shipping companies, freight forwarders, rail operators – at the port area (Acciaro et al., 2020). According to Yang et al. (2018), the „cornerstone‟ of digitalization is the IoT as it enables the gathering of information from all industrial assets and, in this sense, smart ports are based on IoT, as this technology offers the basis for bringing together all port stakeholders and operations that is a prerequisite for harmonised and optimised port activities.

This article aims to provide an overview of the innovative technologies adopted by smart ports around the world and highlight their link to sustainable development via employing an exploratory review of various sources. It is quite obvious that the vast majority of smart ports have also been proactive at the adoption of sustainability initiatives. However, the implications of smart technologies on the sustainable development of the ports has not been adequately addressed by the existing literature and it is exactly this gap that this study aims to fulfil. The conceptual framework of this study is built on the design features of smart ports identified by the existing literature; furthermore, it is based on the analysis of the case of the Port of Gothenburg that is currently expanding its digital transformation by launching a (digital) platform that will enable the effective and seamless sharing of data among all relevant stakeholders in the port.

This article is structured as follows. After this introductory Section, Section 2 describes the notion of smart ports and the implications from the integration of smart technologies at ports and the whole supply chain. The link between digitalization and sustainability is discussed in Section 3, while Section 4 provides an overview of smart port solutions implemented around the globe. The case of the Port of Gothenburg is analyzed in Section 5, by focusing on the applications and technologies implemented at the container terminal and the Energy port. Finally, conclusions drawn on the relevant results are presented in Section 6.

SMART PORTS:

Although there is no single definition of smart ports, there are certain features and common characteristics that these ports share. As referred above, smart ports make use of innovative digital technologies including IoT, AI, big data and blockchain to improve their performance and competitiveness with data analytics also supporting decision-making processes. In smart ports, real-time information is shared among all port stakeholders, therefore enabling effective communication and collaboration among all involved parties and ensuring a seamless port operation with benefits going beyond the port limits, to the whole supply chain. The sharing and data analysis of this real-time information at ports is enabled through several innovating technologies, including (but not limited to):

1. *Big Data*: With access to large datasets and predictive analysis, the shipping industry will be able to improve its logistics performance by properly tracking cargo and preventing delays and enhance the operational efficiency of the industry.

2. *AI*: AI applications within the shipping industry can be used for example to strengthen/optimise routes for the conduct of navigation and even determine the best course at the best speed.

3. *IoT*: The IoT framework will enable the shipping industry to reduce operating costs, as well as enable real-time tracking and monitoring of cargo operations, among others. loT connectivity in ports will also provide data insights that will allow them to take valuable data-driven decisions.

4. *Blockchain Technology*: The shipping industry could benefit from the blockchain technology through faster and more efficient services and improved data visibility, as the paper trail of millions of containers around the world could be managed and tracked more effectively, with various associated benefits ranging from cost reductions to customer satisfaction.

5. *5G*: The efficient connection of all stakeholders involved in the supply chain would be enabled from data being transferred with an increased speed and in real-time conditions.

Various ports around the world have already implemented or are considering to implement smart innovative technologies to maintain a competitive advantage, enhance their productivity and competitiveness and answer their customers" needs. Different ports are in different phases of digital transformation with most of them focusing on the real-time information sharing and connectivity of port stakeholders (Jovic et al., 2019). Examples of smart port initiatives can be found in different parts of the world - from Europe to Asia, Australia and North America (Yang et al., 2018) with European ports leading the way to digitalization. This can be explained by their location in relation to the port-cities, as many of them are inner-city ports that suffer from congestion and also by the highly competitive environment into which they operate and their need to offer a differentiated service to attract new customers and maintain the ones they already have.

The following Table includes some of the smart technologies implemented by ports in Europe and globally identified via the relevant exploratory review.

Table 1. Smart technologies implemented by ports around the world

Port Authorities	Smart Technologies
Port of Hamburg (Germany)	- Sensors, cameras and „smart lights" on roads that help monitor and direct traffic, optimise traffic and reduce emissions - 5G networks that enable virtual reality for vital infrastructure monitoring
Port of Rotterdam (Netherlands)	- IoT based-sensors are used to generate a „digital twin" and enable augmented intelligence through a simulation of the port"s physical features with multiple variables changed and tested quickly and effectively) - a digital platform that enables the reduction of vessels" waiting times by up to 20% with autonomous, unmanned gantry cranes handling cargos efficiently and quickly as soon as they reach the port
Port of Antwerp (Belgium)	- blockchain technology that enables a secure transfer of rights to be exchanged between often competing parties
Port of Los Angeles (USA)	- Port Optimizer, an information portal designed to digitise maritime shipping data for cargo owners and supply chain stakeholders through secure, channelled access
Port of Seville (Spain)	- a „FIWARE Platform" that deploys IoT services for container tracking and also management of railway traffic
Port of Valencia (Spain)	- a smart IoT network of cranes, straddle carriers, trucks, and forklifts that gather data on location, status of operations and energy consumption
Port of Livorno (Italy)	- 5G networks and IoT solutions are optimising logistic loading/unloading operations, at the same time, minimising idle times for ships and the transit time of goods
Port of Qingdao (China)	- 5G connection supports control data for a programmable logic controller (PLC). These operations require millisecond-level latency control signals, as well as stable, remote and real-time control requirements which only key 5G technologies can deliver

Source: Authors' elaboration based on the findings of the exploratory review

Apart from the smart innovative technologies adopted by individual ports, an international partnership – ChainPORT - has also been established, initiated by the ports of Hamburg and Los Angeles and joined by the ports of Antwerp, Barcelona, Busan, Felixstowe, Indonesia, Montreal, Panama, Rotterdam, Shanghai, Shenzhen and Singapore. The main aim of this partnership is sharing of knowledge and cooperation for the optimal application and investment on smart technologies at ports.

Despite these ongoing digital solutions implemented from smart ports, there is currently no single definition of smart ports. Molavi et al. (2020) proposed and developed a quantitative tool, the Smart Port Index (SPI) for defining and assessing the performance of smart ports. The SPI is based on a number of

Key Performance Indicators (KPIs) that encompass four distinct processes of a smart port: operations, environment, energy, and safety and security and enables port authorities to assess their current operations for continuous improvement. According to the findings of Molavi et al. (2020), the ports of Hamburg, Singapore, Los Angeles, Vancouver, Rotterdam are among the ports have high SPIs, especially in relation to their Smart Environmental and Energy Sub-Indices. In line with the Paris Climate Agreement that targets to limit the global average temperature increase to well below 2 °C above pre-industrial levels and the Initial Strategy on the reduction of GHG emissions of the International Maritime Organization that aims at least halving emissions from international shipping by 2050, compared to 2008 levels, these ports have been proactive at the development of tools to facilitate the reduction of CO2 and other greenhouse gas emissions from shipping, port and landside operations and have taken initiatives to enable energy transition, improve energy efficiency and stimulate circular economy (UNFCCC, 2015; IMO, 2018). Indicative examples include providing onshore power supply (OPS), incentivizing best-performing vessels, investing in infrastructure to supply low carbon fuels and port call optimization as well as improving energy efficiency of operations in the port area (Ölcer et al., 2018; Christodoulou, 2019; Christodoulou and Cullinane, 2019). An important characteristic of the sustainability initiatives of these ports is their holistic and comprehensive approach as they are covering the four dimensions of port-related operations: a) vessel operations, b) port operations, c) hinterland operations and d) port-city interference (Alamoush et al., 2021; Christodoulou et al., 2021).

SMART PORTS AND ENVIRONMENTAL SUSTAINABILITY:

In their effort to maintain their competitive advantage and address diverse challenges associated with their operations (such as congestion and delays), negative impact on the environment (air, water and noise pollution, waste disposal), energy consumption, ports around the world are adopting smart technologies that open up new horizons and approaches to port operations planning and management. Apart from the direct benefits towards operational efficiency, regulatory compliance, and customer satisfaction, smart ports establish themselves as important digital nodes in the global supply chain, but also as logistics information exchange hubs serving their regional transport ecosystem. By digitalizing their processes, smart ports establish a platform that enables the sharing of real-time information among all the participants in the cargo, freight, and passenger ecosystems enhancing collaboration, aligning activities and supporting both an environmentally sustainable and value creating transport system. Through the digital transformation of their processes, smart ports also provide sustainable services through improved operations and answer to the UN 2030 Agenda for Sustainable Development, especially SDGs 3 (good health and well-being), 7 (affordable and clean energy), 9 (industry, innovation and infrastructure), 11 (sustainable cities and communities), 13 (climate action) and 14 (life below water).

To begin with, the use of the IoT that enables real-time tracking and monitoring of the cargo in addition to 5G networks that improve stakeholders consistent and uninterrupted connectivity help optimise loading and unloading times in ports minimising at the same time idle times for ships and transit time of goods and leading to fewer emissions. Cutting emissions at the port area brings about substantial health and environmental benefits. More specifically, local air pollutants such as sulphur oxides, nitrogen oxides and particulate matter have severe health impact on populations in close proximity to the ports and also cause eutrophication and acid rain (Corbett and Winebrake, 2007; Winnes et al., 2015; Christodoulou and Cullinane, 2020). Carbon dioxide emissions contribute to global warming and climate change and have a global impact (Styhre et al., 2017). Besides these direct environmental benefits, Just-in-Time Operations at ports with the introduction of smart technologies will also result in the optimal operating speed of vessels arriving at the port as they will only approach the port when the berthing availability is ensured. As vessels currently spend long times waiting at anchorage, this time could potentially be minimized leading to optimal operational speed for vessels and reduced GHG emissions (Poulsen and Sampson, 2019). By using 5G routers and IoT sensor technology for the collection, aggregation, analysis and communication of data, inventory management can be greatly improved allowing ports to accommodate larger vessels and containers through the use of intelligent load automation. Furthermore, with the use of sensors and cameras that automatically collect and share information such as weather, traffic and pollution data, the traffic flow of ships can be determined automatically leading to shorter loading and unloading times and allowing more cargo to be cleared in less time.

Although the development of sustainable smart ports can effectively promote operational and environmental aspects of the supply chain, only few studies have discussed smart ports from a sustainable perspective. Yang et al. (2020) drew on the triple bottom line theory and concluded the most important parameters for the establishment of sustainable smart ports include policy support, integration, knowledge and skills.

The implications from the use of digital technologies at ports go beyond their strict boundaries promoting the sustainable development of the city/region where they are located. An example of these applications is the Pixel Port project; real-time data are gathered through digital technologies that provide valuable information to cities concerning the impact of activities in the surrounding areas. Another practical example is related to the measurement of road traffic generated by the port activity and the related emissions. By enabling the gathering of this type of data, future models can be developed for the planning of vessel movements, the arrival/departure of trucks or even personal mobility around/within cities that lead to sustainable smart port ecosystems. In contrast to port-city interaction in its current form, within a Smart Port Ecosystem the interaction between ports and city is moving to a data-driven interaction that should offer more transparency and thus release the tension between global shipping corporations, local players and society (Lind et al., 2018). In this context, ports will have a higher positive spillover effect, not only at regional/national level, but also on a local level.

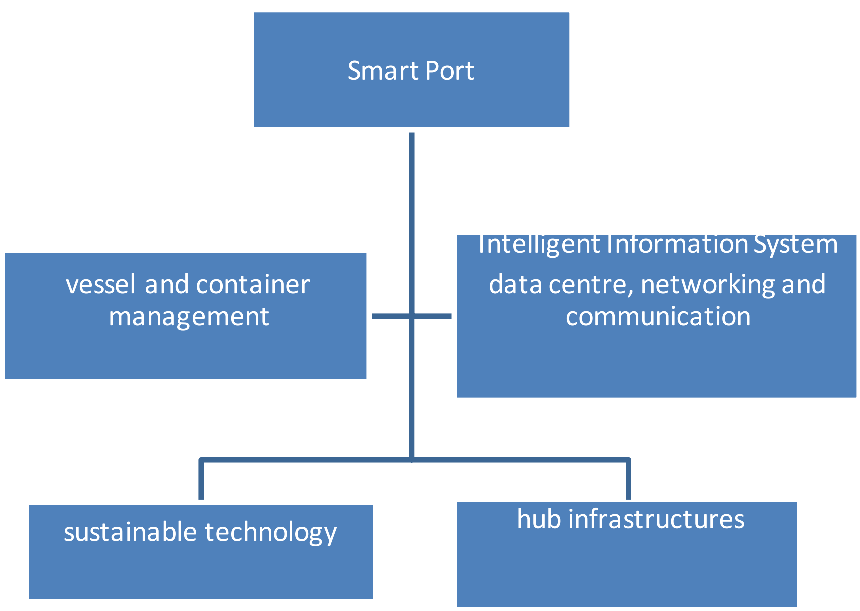
Going far beyond the individual port and port region, port digitalization is anticipated to bring about the creation of „a wider network of hubs that are equally digitized and ambitious" - a Smart Port Network (WPSP, 2020). Within this network, automated ports will connect and exchange real-time data improving in this way the efficiency of their collective operations. The basis of a global logistic chain will be a Port Community System that will add value to all involved stakeholders through lower costs and faster delivery speeds and, at the same time, contribute to sustainable transport logistics due to the simplification of processes as it will require a single submission of data into well-connected transport and logistics chains. This level of port digital transformation, though, seems quite far at the moment and presupposes massive capital investments from both operators and government bodies.

CONCEPTUAL FRAMEWORK:

As suggested by Yau et al. (2020), ports have evolved over time, with the „current (most often termed as fifth)" generation of ports encompassing „customer- and community-centric smart ports" that are distinguished by five main features: (a) smart applications related to vessel and container management; (b) smart technologies, including automation, data centre(s), networking and communication; (c) sustainable technologies related to increased energy efficiency and reduced greenhouse gases emissions; and (d) development of hub infrastructures to foster collaboration among different ports. Bessid et al. (2020) also identified certain design features of smart ports that include an Intelligent Information system that would enable better planning and management within ports and between them as well as smart port logistics and more specifically intelligent traffic flow and smart port infrastructure.

Taking into account both these approaches for the establishment of smart ports, we developed the conceptual framework for the analysis of the case of the Port of Gothenburg.

Figure 1. Conceptual framework



Source: Adapted from Yau et al. (2020) and Bessid et al. (2020)

PORT OF GOTHENBURG:

The Port of Gothenburg is the largest Nordic port, accommodating 30% of Swedish foreign trade and 50% of all container traffic. It is the only Swedish port that can receive the world's largest containerships and serves as a hub for a broad range of shipping routes within and outside Europe. The Port of Gothenburg has container, ro-ro, car, passenger and oil and energy terminals with the main exports comprising steel, vehicles and forest products as well as paper, pulp and timber products. Imports include mainly consumer goods such as clothes, furniture, food and electronics (Gothenburg Port Authority, 2020).

The Port of Gothenburg has an extensive environmental/climate action plan and is certified with the environmental standard ISO 14001 (Gothenburg Port Authority, 2020). The port has proceeded with major investments in alternative energy sources (like the Energy Port"s pipe-heating system, the alternative energy sources for buildings, the consumption of biogas and electricity from the port"s production vessels), provision of onshore connections and charging stations for cars, cycles, lately electric cars to reduce energy consumption and emissions from its operations. The port also rewards vessels with good environmental performance using environmentally differentiated port tariffs, offers onshore power supply (OPS) to visiting vessels and provides LNG charging stations for vessels. It is worthwhile to mention that the Port of Gothenburg was the first port to introduce a high-voltage onshore power supply for cargo vessels in 2000 (World Ports Sustainability Program).

Concerning its involvement in regional and global collaborations targeting global warming and enhancing the contribution of ports to UN SDGs, the Port of Gothenburg is quite active having joined a collaboration with ten other Nordic ports for the exchange of information and cooperation to address environmental and climate challenges. At global level, the Port of Gothenburg is part of the World Ports Climate Action Program (WPCAP) and formed a network with the ports in Amsterdam, Antwerp, Barcelona, Bremen, Busan, Hamburg, Le Havre, Los Angeles, Long Beach, New York/New Jersey, Rotterdam and Vancouver in a number of projects addressing global warming.

PORT OF GOTHENBURG – DIGITALISATION:

It is a self-explanatory fact that the majority of ports around the world have used digital solutions more extensively throughout the COVID 19 pandemic due to the physical interaction restrictions and the need of ports to maintain an efficient workflow. Digitalization is currently one of the top priorities at the Port of Gothenburg as the digital technologies and applications already implemented were proven essential during the pandemic. The port is currently investing in AI and digital connectivity through the development of a digital platform that is anticipated to advance freight flow transparency and lead to increased productivity, reduced lead times and faster delivery capacity throughout the entire transport chain benefiting everyone linked to the port (Port of Gothenburg, 2020). This information portal – called

Port Optimizer – is a cloud-based software solution designed to digitize maritime shipping data for all stakeholders across the port ecosystem through secure, channeled access. By gathering disparate data sources from different stakeholders across the supply chain, the Port Optimizer creates a unique data source for the entire process and helps address key port challenges, including the limited visibility of cargo in transit, disparate and inaccurate data sources and conflicting objectives between different port stakeholders. The Port of Gothenburg will be the first European port using this software solution as a similar platform is already in place at the Port of Los Angeles (USA) having resulted in enhanced productivity from vessels to shore and from the terminals to the customers as well as increased throughput and improved efficiency.

The greatest challenge for the effective implementation of this digital solution is related to bringing together the various actors - shipping companies, terminal operators, rail operators, forwarding companies, freight owners, and inland terminals – that cooperate in the Port of Gothenburg and form a complex freight transport network. The integration of this platform in ports" processes means that all the fragmented information of the separate IT systems of the different port stakeholders will be processed in order to visualize and optimize the numerous processes at the port and enable a new digital services „ecosystem' and requires the adoption of a cohesive approach working with all the parties concerned. This rapid, high-quality information will facilitate flexible planning and collaboration between the different operators at the port with clear benefits for all involved parties. The importance of real-time cargo tracking and information exchange for the development of efficient maritime supply chains was also highlighted in the findings of Christodoulou and Kappelin (2020) with major shippers indicating the need of digital solutions for enhanced port operations. For example, significant environmental gains from just-in-time arrival can come about for the shipping companies, while freight owners, rail operators, and terminal operators will benefit from real-time tracking of their goods. This will enhance the role of the Port of Gothenburg as a freight hub and, even transform it on a „digital" hub of the supply chain.

PORT OF GOTHENBURG ENERGY PORT:

The Energy Port of the Port of Gothenburg is the largest Nordic open access energy port with 24 berths that receive over 2500 calls and handle more than 23 million tonnes of energy products each year (Karras, 2020). In order to answer the need of quicker and more efficient handling of goods in such a high-intensity environment, the Gothenburg Port Authority launched a unique data system in 2019 – called Permesso - designed to coordinate and monitor work at the Port of Gothenburg Energy Port (Port of Gothenburg, 2019). The integration of smart automation and digitized processes has led to quicker and more efficient handling of goods, while maintaining safety as the first priority.

The main novelty of Permesso (that was designed and developed „in-house") is that work permits at the Energy Port can now be issued online and coordinated digitally for planned and ongoing maintenance and development. The system enables a clear overview of all projects in progress in various parts of the

Energy Port on any given day and simplifies the process of issuing permits for all the work of different customers involving a large number of contractors. The permit necessary to carry out the work can now be issued online instead of dealing with the paperwork manually as the port staff can approve a permit or request additional information directly on screen. In this way, the new system saves an incredible amount of time and effort for customers, contractors and port administration.

Besides Permesso, at the beginning of April 2020, the Gothenburg Port Authority also launched a smart digital application designed to make bunkering at the Energy Port easier and quicker. The „Bunkering App‟, which is one of the first in the world to offer this range of functionality, is dedicated to bunkering operators in the Energy Port and eliminates reports that are now submitted via e-mail or telephone. Bunkering notifications are now sent through the application, while it also synchronizes bunkering statistics and makes planning and carrying out loading operations easier for operators. The implementation of the application has led to increased efficiency at the Energy Port and has maximized the use of bunker wharves (Karras, 2020).

PORT OF GOTHENBURG CONTAINER TERMINALS:

APM terminals Gothenburg is Nordic region‟s largest container port handling more than 8,000 containers every week. Despite the fact that the cargo volumes accommodated at the Port of Gothenburg are by far the largest in the Nordic region, it is quite challenging for the port to attract large vessels due to its geographical location being the actual terminal point of the world‟s largest trade corridor: Asia–Europe. Gothenburg‟s location, on the other hand, offers certain advantages due to the close proximity for vessels to reach the dock from open sea and the central location of Gothenburg between Sweden and Norway with 25 daily rail shuttle departures to over 300 destinations in both countries.

APM Terminals have proceeded with large investments that have enabled the reception of the world‟s largest containerships offering, at the same time, world-class logistics services and enhancing the port‟s competitiveness. These investments include, among others: a) diesel-electric straddle carriers, b) Super-Post Panamax cranes for loading and unloading the largest vessels, c) new Reachstackers (large counter-weight trucks for lifting heavy containers) and e) Self-service gate for trucks. These major investments made by APM Terminals Gothenburg have increased capacity and efficiency with handling time at the truck bays reduced by 40% and increased customer satisfaction. An indicative fact is that, in January 2019, 4,350 containers were handled during a single vessel call – a new record for the entire Nordic region - that reaches handling capacity at major European ports. Digital technologies along with skilled employees and good co-operation with customers made this achievement possible (APM Terminals Gothenburg).

APM Terminals use the terminal operating system – called Navis -, employed by the vast majority of container terminals around the world (APM Terminals Gothenburg). The system has improved terminal management efficiency through „the specification of the fastest routes for straddle carriers to take in the terminal and the enhanced interface and digital data exchange with customers, including planning and payment details" (APM Terminals Gothenburg). APM Terminals have also launched the digital Track and Trace initiative that enables customers to save time by check the status of containers at the terminal digitally. The self-service gates at APM Terminals allows truck drivers to manage their business on their own „with equipment automatically scanning and photographing the containers and vehicles to verify that everything is correct increasing the number of service hours per day" (APM Terminals Gothenburg). Longer opening hours through the automatic gates for trucks introduced by APM Terminals enable the port"s customers to use their trucks more efficiently leading at the same time to reduced handling time for trucks. It is worthwhile to mention the average gate handling time at APM Terminals Gothenburg is only 26 minutes, compared to 56 minutes that is the European average.

Table 2. Digital technologies implemented at the Port of Gothenburg

Digital technologies implemented at the Port of Gothenburg	
Intelligent Traffic Flow - vessel and container management	- „Bunkering App" - Navis - Track and Trace initiative - diesel-electric straddle carriers - Super-Post Panamax cranes for loading and unloading the largest vessels - Reachstackers (large counter-weight trucks for lifting heavy containers)
Intelligent Information System - data centre, networking and communication	- Permesso - Port Optimizer - automatic gates for trucks
Smart Port Infrastructure - sustainable technology	- OPS - LNG fuelling points - alternative energy sources for buildings - environmentally differentiated port tariffs - LNG charging stations for vessels
Hub Infrastructures	- Nordic ports network - World Ports Climate Action Program (WPCAP)

Source: Own elaboration based on the findings of the exploratory review

As can be seen in Table 2, there is a variety of digital applications adopted by the Port of Gothenburg to facilitate and enhance vessel and container management ranging from the „Bunkering App" that enables bunkering notifications to be sent digitally to customers to the investment in automated cranes for the quicker and efficient loading and unloading of the largest containerships. The port has also invested in digital technologies that enable data sharing, networking and communication with Port Optimizer being a milestone for the digital transformation of the port processes. Sustainable technology is another area where the port has invested largely with investments targeting reduced energy consumption and addressing the negative environmental impact of port operations. The Port of Gothenburg has also developed hub infrastructures to foster collaboration among different ports being part of regional and global networks that cooperate and interact to tackle climate and environmental challenges related to port operations. Although the port is currently a major transshipment hub in the region and an important information exchange hub, the level of automation and digitalization of the ports in general does not allow the creation of a Smart Port Network with automated ports inter-connected and able to exchange real-time data between them. Such a development presupposes structural organizational advances and massive capital investments from both operators and government bodies.

CONCLUSION:

The issues of connectivity and interconnection are clearly standing out for their influence upon business activities, with terms like "age of boundless connectivity" and "intelligent automation" being often used to describe the future business setting. It is therefore not a coincidence that a report under the title, "Transport 2040: Automation, Technology, Employment - The Future of Work", which was recently launched by the World Maritime University (WMU), put forward the notion that: "*Technological progress and innovation have occurred throughout history and changed its course, […] Currently, we are about to embrace what is now termed the Fourth Industrial Revolution, which is characterized by the introduction of artificial intelligence, robotics, more and more interconnection, among other innovations*" (World Maritime University, 2019).

It is also clear that over the course of time, the role of ports has also changed significantly via their transformation into information exchange hubs gathering data from shipping lines, trucking and off-dock storage providers besides their traditional role as transshipments hubs. The integration of digitalization and automation into ports" processes and operations has already started in a number of major ports around the world going hand by hand with the investments in sustainable technologies and increasing the efficiency of the overall maritime transportation ecosystem. Digital processes and real-time exchange data do not only have a positive impact on ports themselves that strengthen their competitive advantage and keep up with their customers" changing needs, but also creates value for all stakeholders involved in shipping operations through collaboration, aligned activities and decision-making that improves vital processes across their operations. These developments support both an environmentally sustainable and value creating transport system.

Besides the operational and financial benefits for ports, digitalization also strengthens the vital role of ports in contributing to the UN SDGs and aligning their operations with the Paris Agreement and the Initial IMO GHG Strategy for the reduction of GHG emissions from shipping. Different digital solutions help ports around the world address diverse challenges associated with their operations (such as congestion and delays), negative impact on the environment (air, water and noise pollution, waste disposal), energy consumption and open up new horizons and approaches to port operations planning and management.

The implications from the use of digital technologies at ports go beyond their strict boundaries promoting the sustainable development of the city/region where they are located. By gathering real-time data through digital technologies, city can have access to valuable information concerning the impact of port activities in the surrounding areas. Moreover, future models can be developed for the planning of vessel movements, the arrival/departure of trucks or even personal mobility around/within cities that lead to sustainable smart port ecosystems. In this context, ports will have a higher positive spillover effect, not only at regional/national level, but also on a local level.

Going far beyond the individual port and port region, port digitalization is anticipated to bring about the creation of „a wider network of hubs that are equally digitized and ambitious" - a Smart Port Network that will enable automated ports to inert-connect and exchange real-time data improving in this way the efficiency of their collective operations. This level of port digital transformation, though, seems quite far at the moment and presupposes massive capital investments from both operators and government bodies.

The need for massive capital investments from major port operators for the efficient connection of ports with all relevant stakeholders – including shipping companies, shippers, freight forwarders - is also underlined through the case of the Port of Gothenburg. Another barrier to ports" digital transformation comes from the advanced and multiple skills required from port employees and logistics operators to provide advanced planning and services at the port. There is, therefore, a raising need for ports to focus heavily on both training their personnel and on recruitment to promote and stimulate their digital transformation.

FUNDING:

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

REFERENCES:

Acciaro, M., Renken, K., & El Khadiri, N. (2020). Technological change and logistics development in european ports. European Port Cities in Transition, 73-88. https://doi.org/10.1007/978-3-030-36464-9_5

Alamoush, A. S., Ballini, F., & Dalaklis, D. (2021). Port sustainable supply chain management framework: Contributing to the United Nations" sustainable development goals. Maritime Technology and Research, 3(2), 137-161. https://doi.org/10.33175/mtr.2021.247076

APM Terminals Gothenburg. *The Gothenburg Gateway: A shorter distance to world markets benefits all of Sweden.* file:///C:/Users/ac/AppData/Local/Temp/gothenburg-gateway-eng-final.pdf

Bessid S., Zouari A., Frikha A., & Benabdelhafid, A. (2020). *Smart Ports Design Features Analysis: A Systematic Literature Review*. 13ème Conférence Francophone de Modélisation, Optimisation et Simulation - MOSIM"20, 12-14 November, Agadir, Maroc.

Christodoulou, A. (2019). Maritime Environmental Performance Indices: Useful Tools for Evaluating Transport Supplier Environmental Performance?. WIT Transactions on The Built Environment, 187, 187-198. https://doi.org/10.2495/MT190171

Christodoulou, A., & Cullinane, K. (2019). Identifying the main opportunities and challenges from the implementation of a port energy management system: A SWOT/PESTLE analysis. Sustainability, 11(21), 6046. https://doi.org/10.3390/su11216046

Christodoulou, A., & Cullinane, K. (2020). Potential for, and drivers of, private voluntary initiatives for the decarbonisation of short sea shipping: evidence from a Swedish ferry line. Maritime Economics & Logistics, 1-23. https://doi.org/10.1057/s41278-020-00160-9

Christodoulou, A., & Kappelin, H. (2020). Determinant factors for the development of maritime supply chains: The case of the Swedish forest industry. Case Studies on Transport Policy, 8(3), 711-720. https://doi.org/10.1016/j.cstp.2020.07.008

Christodoulou, A., Pastra, A., Doelle, M., & Johansson, T. (2021). Four Spheres of Influence: The Critical Role of Ports in Global Decarbonization Effort. In *Ocean Yearbook 35*, edited by Chircop, A., Coffen-Smout, S. and McConnell. M. Brill Academic Publishers. ISBN: 978-90-04-45021-9

Corbett, J.J., Winebrake, J.J., Green, E.H., Kasibhatla, P., Eyring, V., & Lauer, A. (2007). Mortality from ship emissions: a global assessment. *Environmental science & technology*, 41(24), 8512-8518. https://doi.org/10.1021/es071686z

Dalaklis, D., Katsoulis, G., Kitada, M., Schröder-Hinrichs J.-U., & Ölcer, A.I. (2020). A "Net-Centric" Conduct of Navigation and Ship Management, *Maritime Technology and Research*, 2(2), 90-107. https://doi.org/10.33175/mtr.2020.227028

Gothenburg Port Authority. (2020). *Sustainability Report 2019*. https://www.portofgothenburg.com/gothenburg-port-authority/sustainable-port-authority/

Jović, M., Kavran, N., Aksentijević, S., & Tijan, E. (2019). The Transition of Croatian Seaports into Smart Ports. 42nd International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO), Opatija, Croatia pp. 1386-1390. doi: 10.23919/MIPRO.2019.8757111.

International Maritime Organisation. (2018). *Initial IMO Strategy on Reduction of GHG Emissions from Ships*. Resolution MEPC.304(72). Adopted on 13 April 2018. London, UK.

Karas, A. (2020. Smart Port as a Key to the Future Development of Modern Ports. *TransNav, the International Journal on Marine Navigation and Safety of Sea Transportation*, 14(1), 27-31. doi:10.12716/1001.14.01.01

Lind, M., Watson, R.T., Ward, R., Bergmann, M., Bjørn-Andersen, N., Rosemann, M., Haraldson, S., & Andersen, T. (2018). *Digital Data Sharing: The Ignored Opportunity for Making Global Maritime Transport Chains More Efficient*. https://unctad.org/news/digital-data-sharing-ignored-opportunity-making-global-maritime-transport-chains-more

Molavi, A., Lim, G.L., & Race, B. (2020). A framework for building a smart port and smart port index. *International Journal of Sustainable Transportation*, 14:9, 686-700. DOI: 10.1080/15568318.2019.1610919

Port of Gothenburg. (2019). *Unique digital solution makes the Port of Gothenburg smarter*. https://www.mynewsdesk.com/goteborgs_hamn/pressreleases/unique-digital-solution-makes-the-port-of-gothenburg-smarter-2943889

Port of Gothenburg. (2020). *Digital transformation set to produce Port of Gothenburg 2.0*. https://www.portofgothenburg.com/news-room/press-releases/digital-transformation-set-to-produce-port-of-gothenburg-2.0/

Poulsen, R.Y., & Sampson, H. „Swinging on the anchor": The difficulties in achieving greenhouse gas abatement in shipping via virtual arrival. *Transportation Research Part D: Transport and Environment*, 73, 230-244. https://doi.org/10.1016/j.trd.2019.07.007

Styhre, L., Winnes, H., Black, J., Lee, J., & Le-Griffin, H. (2017). Greenhouse gas emissions from ships in ports–Case studies in four continents. *Transportation Research Part D: Transport and Environment* 54, 212-224. https://doi.org/10.1016/j.trd.2017.04.033

UNFCCC. (2015). Paris Agreement, 21st Conference of Parties (COP21). Paris, France.

H. Winnes, L. Styhre, & E. Fridell. (2015). Reducing GHG emissions from ships in port areas. *Research in Transportation Business & Management* 17, 73–82. https://doi.org/10.1016/j.rtbm.2015.10.008

World Maritime University. (2019). *Transport 2040: Automation, technology, employment - The future of work*. Retrieved from https://commons.wmu.se/lib_reports/58

World Ports Sustainability Program. (2020). *World Ports Sustainability Report*. https://sustainableworldports.org/wp-content/uploads/WORLD-PORTS-SUSTAINABILITY-REPORT-2020-FIN.pdf

Yang, Y., Zhong, M., Yao, H., Yu, F., Fu, X., & Postolache, O. (2018). Internet of things for smart ports: Technologies and challenges. *IEEE Instrumentation & Measurement Magazine*, 21(1), pp. 34-43. doi: 10.1109/MIM.2018.8278808

Yang, Y., Xue, X., Gao, Y., Zhang, H., & Du, X. (2020). Constructing sustainable coastal ecological environment: A hierarchical structure for sustainable smart ports. In: Zheng, C.W., Wang, Q., Zhan, C., & Yang, S.B. (eds.). Air-Sea Interaction and Coastal Environments of the Maritime and Polar Silk Roads. *Journal of Coastal Research*, Special Issue 99, pp. 358–363. Coconut Creek (Florida). ISSN 0749-0208

Yau, K.A., Peng, S., Qadir, J., Low, Y., & Ling, M.H. (2020). Towards Smart Port Infrastructures: Enhancing Port Activities Using Information and Communications Technology. *IEEE Instrumentation & Measurement Magazine*. doi: 1109/ACCESS.2020.2990961

Ölçer A. I., Kitada M., Dalaklis D., & Ballini F. (2018). *Trends and Challenges in Maritime Energy Management*. WMU Studies in Maritime Affairs, 6. Springer, Cham. ISBN 978-3-319-74575-6

Artificial Intelligence for supporting Maritime Terminal Management, Safety and Security

Gabriele Galli, Marco Mosca, Roberto Revetria, and Roberto Mosca

***Abstract*—Port management is known to be an extremely complex task since it needs to coordinate several systems and even the smallest mistake or inaccuracy can have a high impact not only economically but also in terms of safety and security of people and goods. The following document proves how Industry 4.0 technologies can turn out extremely useful to boost port management and increase revenue along with safety and security. In particular, this paper introduces a cyber-physical system of a real port terminal (Terminal San Giorgio, Genoa) based on a modular architecture composed by three main components: i) tracking system of the entities present in the port, ii) the Digital Twin of the port operations and, iii) the platform for Artificial Intelligence services.**

***Index Terms*—Artificial Intelligence, Digital Twin, Industry 4.0, Port, Simulation.**

I. Introduction

IN recent years, international scientific literature highlighted the importance that cyber-physical systems are increasingly obtaining within all production systems and business processes.

Gamer et al. provided an interesting taxonomy in which both the historical role of industrial automation systems and their evolution in autonomous systems that are able to independently learn to make better and better decisions about the processes they manage [1].

The enabling technologies of this process are constituted precisely by sensors that must be increasingly connected and able to supply their own power also through energy harvesting techniques [2], availability of fast connectivity offered by 4G and 5G networks, integration with operational databases such as ERP systems [3], creation of Digital Twins of real systems with a high degree of fidelity [4], and certain cognitive ability to be able to perceive, understand, and finally solve complex problems of choosing alternatives by making excellent decisions or, if not possible, at least with a minimal error [5].

Manuscript received June 01, 2021; revised July XX, 20XX.

Gabriele Galli is a Ph.D. student at Industrial and Manufacturing System Engineering Department (I.M.S.E), University of Michigan-Dearborn, Dearborn MI 48128 USA (e-mail: ggalli@umich.edu).

Marco Mosca is a Adjunct Professor at Mechanical, Industrial and Transport Engineer Department (D.I.M.E.), University of Genoa, Genoa, Ge 16126 Italy (e-mail: marco.tullio.mosca@unige.it)

Roberto Revetria is a Professor at Mechanical, Industrial and Transport Engineer Department (D.I.M.E.), University of Genoa, Genoa, Ge 16126 Italy (corresponding author to provide phone: +39 320 7982 156; fax: +39 010 317750; e-mail: roberto.revetria@unige.it).

Roberto Mosca is a Professor at Mechanical, Industrial and Transport Engineer Department (D.I.M.E.), University of Genoa, Genoa, Ge 16126 Italy (e-mail: mosca@diptem.unige.it)

In this view, Damiani et al. introduce different applications of Industry 4.0 trends such as Augmented Reality, Wearable Devices, Sensors, Thermography tools, QR codes, Finite Element Analysis Simulation, and Digital Twins. Moreover, two applications based on the cooperation of some of these tools are provided. The first one is based on the estimation of the mechanical risk of a breakdown in metallic shelves. On the other hand, the second one aims to detect the overheating risk for electrical equipment [6]. Reference [7] introduces a short but effective review of SDKs and Wearable Devices for augmented reality applications in the industrial working environment [5].

These choices will be increasingly made on the basis of Artificial Intelligence tools (e.g., convolutional/recurrent deep learning networks, expert systems, etc.) whose importance and practical applicability are now constantly growing alongside machine-based optimization systems and reinforcement learning. The integration of these technologies must be carried out through an appropriate orchestration of systems and processes involved. These must be capable of evolving the technology used from a simple automation tool to an autonomous system capable of learning new knowledge and making the appropriate decisions.

Galli et al. introduce an innovative block that allows to deal with parallel processes in DT and to easily switch from a Business Process Modeling Notation to a simulation environment. Applications of this block can be found both in port and in healthcare environments [8-9]. Morra et al. introduce a DT based on System Dynamics simulation to perform predictive analysis on a short period based on energy consumption management. This model helps to choose the best period for buying electricity. The study has been implemented in the container terminal of an Italian port [10]. Another study still based on the same port has been carried out by Briano et al. and it shows a Decision Support System in which a System Dynamics simulation models the port activities. The system is integrated with an ERP system in order to receive Real-Time data, allowing also a what-if analysis to support the decision-making process [4]. Another interesting work based on simulation in a port environment is presented by Bruzzone et al. This work aims to introduce an 'a priori' risk analysis supported by the simulation to evaluate the environmental impact [11].

II. System Structure

The TEBETS technological demonstrator was built using a modular architecture that included three main components (Systems): i) the tracking system of the entities present in TSG, ii) the DT of Port Operations and iii) the Platform for AI services. The architecture of the demonstrator is shown in figure 1.

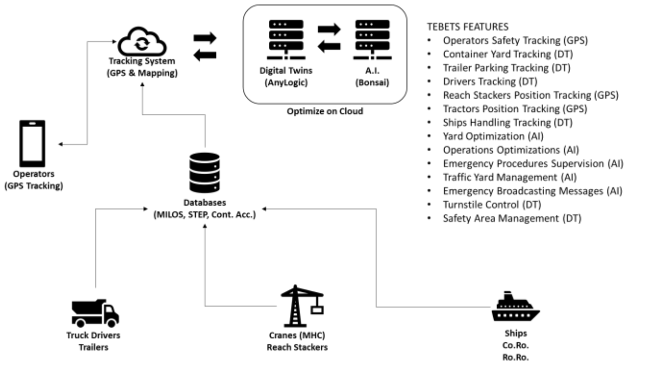


Fig. 1 Architecture of the Demonstrator

In turn, each main system is divided into sub-systems capable of providing the specific services in order to create an autonomous system following the project plan. In particular, the GIS system incorporates the functions of data concentrator, tracking and management of georeferenced events, the situational reporting system and alerting systems to mobile devices using both mail and SMS channels. The DT system integrates the simulated event calculation subsystem and the three-dimensional visualization platform of the operating scenario while the AI system provides the decision-making subsystems and the training subsystem of the algorithms themselves.
Within the Technological Demonstrator some data sources have been identified which can be summarized in the following:

Access control: the subsystem allows to have the access data (check-in and check-out) of all the drivers who enter and leave the TSG through one of the gates, in this way the people who are inside the TSG area are traced. This information is uploaded once every five minutes to the Tracking system (GIS) and can be viewed at any time through a special web interface (figure 2).

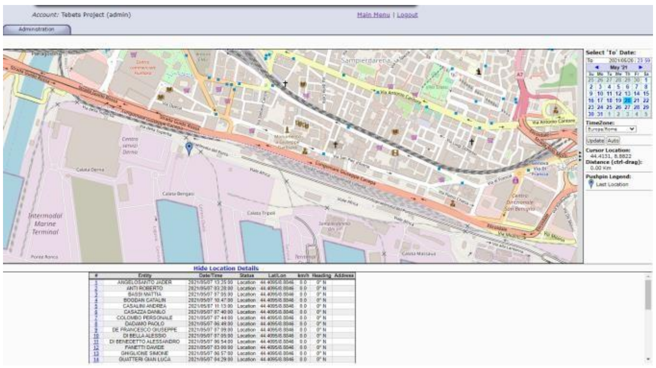


Fig. 2 - Drivers View (Check-In Event)

These data are made available directly to the DT system through a REST API interface in JSON format through an application developed on Apache Tomcat using JSP and Servlet technology to ensure maximum usability of the information.

MILOS and STEP systems: these systems provide all the information relating to the movement of goods and to the movement of containers and trailers both in import and export. The information regarding the goods currently present in the TSG is available (they are on the yard for containers and in the parking areas for trailers) as well as the trip details of the origin and destination ship, the possible dangerousness of the goods and the position current viewable on the map as shown in figure 3. The location data is available in both table and cartographic format. Also, in this case, the data are made available directly to the DT system through an API REST interface in JSON format through the same application developed on Apache Tomcat previously described. Obviously, it is possible to view both goods and other resources at the same time on a specific map. Goods are also classified according to their status, for example:

- available at the terminal (in Yard or Parking)
- embarked (with indication of the corresponding ship voyage)
- awaiting disembarkation (with indication of the startdate of the planned operations)
- expectations from road origin (with latest update available)
- expectations from sea (with last update of the expected arrival date)

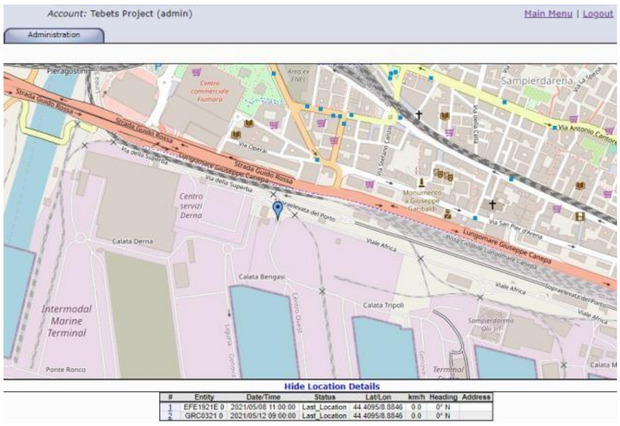


Fig. 3 - Display of Goods (Trailers waiting by road for boarding on ship)

Vehicle tracking systems: this system plans to monitor the position of some vehicles (Reach Stacker and Tractors) every five minutes. This information is acquired by the tracking system and made available directly to the DT system through a REST API interface in JSON format through the same application developed on Apache Tomcat previously described.

Operator Tracking System: this system includes a smartphone app (iPhone and Android) that communicates with a tracking system Servlet and monitors the position (with an update frequency every ten seconds) of each operator equipped with this device. For the purposes of protecting the privacy of the worker, it is not possible to trace the identity of the worker being monitored as each worker enters an anonymized code. The tracking system allows to know, for each device, the entry events in one of the attention areas that have been defined at the analysis level.

The zones have been defined for the following types of operational areas:

- Container Yard: 8 areas in total
- Trailer Parking: 17 areas in total
- Streets: 10 overall areas
- Vehicle storage areas: 4 overall areas
- Operational areas: 3 overall areas

Data acquisition system from devices: the system also allows to acquire specific data from distributed sensors via

WiFi / GPRS / LTE data connection. In general, the following data can be managed for each device:

- AtmosphereFieldInfo
  This is data on the weather conditions of pressure and temperature (e.g., barometer, ambientTemp, cabinTemp).

- ThermoFieldInfo
  Temperatures on the contents of containers / trailers if available.

- AnalogFieldInfo
  These are generic measurements (e.g., wind speed, radiation level, pollutant concentration, smoke, etc.) collected by a network of sensors.

Alerting system: this system allows you to communicate with operators through certain channels such as emails and SMS messages. This possibility is provided to be able to contact operators and provide them with information relating to relevant procedures and events within the terminal. The system has a rules engine with which it is possible to activate a series of messages according to the status of the areas. In particular, different usage scenarios are possible both with reference to safety or operational events. This way, it is also possible to manage the communication process between the platform and the connected entities based on the value detected by the sensors or on the results of a simulation carried out starting from the parameters measured in the field.

Temperature measurement device: In order to face and prevent COVID-19, every person is subject to temperature measurement before accessing the port. This has been done using touchless thermoscanner 4.0 that are able to identify also if the subject wear gloves and mask properly.

III. The TSG Digital Twin in the Tech Demonstrator

The DT was developed starting from MESA Optimize platform, implementing a TSG model with AnyLogic. The model realizes the implementation of the main operations on the handling of trailers and containers based on the data provided by the tracking platform. In particular, the data on the status of the relevant "Entities", namely drivers, operators, tractors, reach stackers, travel Ship, container, and trailers are acquired from this system.
The data relating to the entities of goods in transit have been organized into fifteen flows based on the following logical scheme in order to manage the related processes:

1. Pending ships known to have an ETA (estimated arrival date)
2. Ships currently in mooring whose p-time is known (start date of landing / boarding operations)
3. Ships in course of disembarkation / embarkation operations of which the ETD is known (estimated departure date)
4. Expected containers of which the ship voyage on which they will have to embark is known
5. Expected trailer of which is known the ship journey on which they will have to embark
6. Containers on the yard of which the vessel journey on which they will have to embark is known
7. Parking trailer of which the ship journey on which they will have to embark is known
8. Containers already unloaded awaiting collection
9. Trailer already landed awaiting collection
10. Containers in parking (they will not embark due to logistical problems)
11. Container in transshipment (Ship to ship travel)
12. Containers in shifting (they will be unloaded and re-embarked on the same ship journey for handling needs)
13. Trailers in parking (they will not board due to logistical problems)
14. Trailers in transshipment (From ship-to-ship trip)
15. Trailers in shifting (they will be disembarked and re-embarked on the same ship trip for handling needs)

The safety characteristics of the goods are also known through the presence of a specific flag according to the IMO regulation (IMDGC).
The data is made available for integration into the DT through a REST API in JSON format through the same application developed on Apache Tomcat previously described. The DT is made available in the Cloud environment with two different types of interfaces:

- a 2D / 3D visual interface that allows you to monitor processes
- a REST API interface with JavaScript client and a Java REST API for integration with other services.

The system is therefore extremely modular and supports expansion to other services with direct exposure of the same.

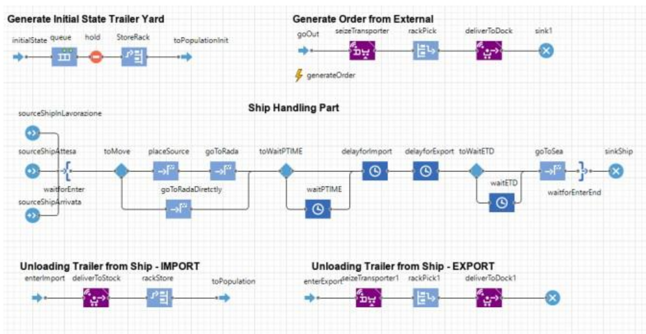


Fig. 4 - Main Agent of the Digital Twin TSG

In order to validate this project, the focus was made to the logic of the Trailers (Figure 4). In this view, the operating logic of the DT of TSG has been divided into five main branches:

- A first branch, called "Ship Handling Part", responsible for the operation of the ship arrival and processing logic
- A second branch, called "Unloading Trailer from Ship - IMPORT" responsible for the process of unloading the Trailer from the ship and positioning it on the Yard of the port
- A third branch, called "Unloading Trailer from Ship - EXPORT" responsible for the loading process of the ship's Trailer starting from the Trailers present on the yard

- A fourth branch, called "Generate Order from External" responsible for managing orders from outside
- A fifth branch, called "Generate Initial State Trailer Yard" responsible for positioning the Trailer in the Yard with reading from the database connected to the DT

Analyzing in detail the management branch of the arrival and processing of the ship, it presents three different points of connection with the data database: the three Source points present at the beginning. They are related to the three possible states that the ship can have: arrived, being processed, and waiting. The logical difference of the following states is:

- *Arrived ship:* it is a ship already positioned in the Terminal at one of the three mooring docks, waiting for the P-Time to be able to start loading / unloading operations
- *Ship In Process:* it is a ship already positioned in the terminal at one of the three mooring docks, which however begins loading / unloading operations as soon as the simulation begins. However, its departure is conditioned by the achievement of the Estimated Time for Departure (ETD)
- *Awaiting Ship:* it is a ship that is generated according to the reading of the Database values (Figure 5). When it is generated, the arrival in one of the terminal bays is simulated and the loading / unloading operations are started as soon as the trucks are available

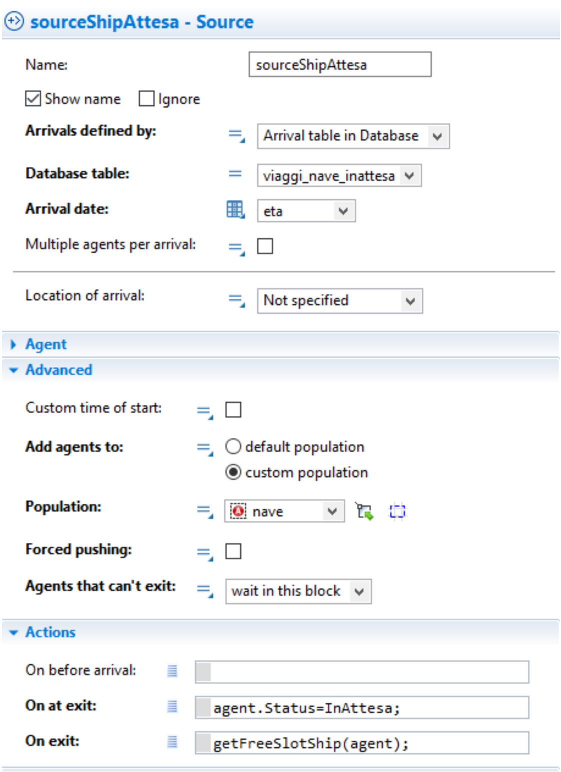


Fig. 5 - Source that generates the incoming ships, according to the reading from the Database

Regarding loading/unloading operations, the logic envisages a first checking whether it is necessary to carry out import operations, intended as a trailer to be unloaded from the ship and placed on the yard. This part is carried out by means of an auxiliary function which interfaces with the supplied database. It is compared if there are entities to be imported in the "Trailer" table with the ID of the ship being processed. After checking the import operations, the "export" operations are verified, that are based on the loading of trailers inside the ship. In this case, the auxiliary function checks if there are any trailers on the yard that need to be loaded on the ship (Figure 7).

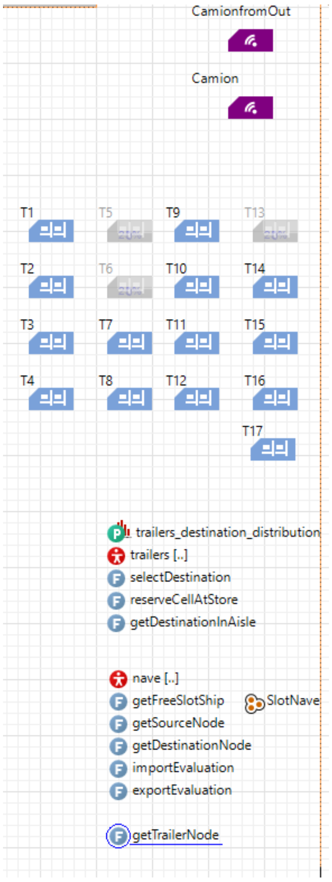


Fig. 6 - Auxiliary functions of the Digital Twin

IV. Process Involving Operators

Terminal San Giorgio (TSG) is located in the old port of Genoa, between Ponte Somalia and Ponte Libia; it covers a total area of 206,000m². Today TSG moves over 100000 containers a year together with other various goods, with a trend of constant growth.

A fully loaded working day is taken into consideration, assuming a number of port operators equal to those detected by the tracking system inside the terminal (drivers and port operators). In the occurrence of a risk situation in one of the areas of the terminal, workers are forced to identify the employee with training in the fire prevention course to evacuate the port area in the fastest and safest way by following the best escape route. From the area where the event arises, three different areas are identified which determine the severity of the damage reported by the operators based on how close they are to the area: who will be closest (critical area) reports serious injuries,

For the workers to walk inside the Terminal, it is necessary to create an area (Polygonal Node) that delimits the space in which you want them to be and the areas in which they appear when starting the simulation. In the case in question, two areas of this type have been created called AreaW1 (Red) and AreaW2 (Green).

Fig. 7 - Areas Mapped in the Digital Twin (polygonal)

V. Fire Incident Scenario

For test purposes, the outbreak of a fire inside the terminal in any area has been replicated. different areas susceptible to fire are created and only one of these is considered for the purposes of the event itself.

Two Polygonal Nodes have been designed: a smaller area (areaInFire1) and a larger one (areaInFire2), in order to identify a highly dangerous area (Red) and a lower dangerous area (Yellow) as shown in figure 8.

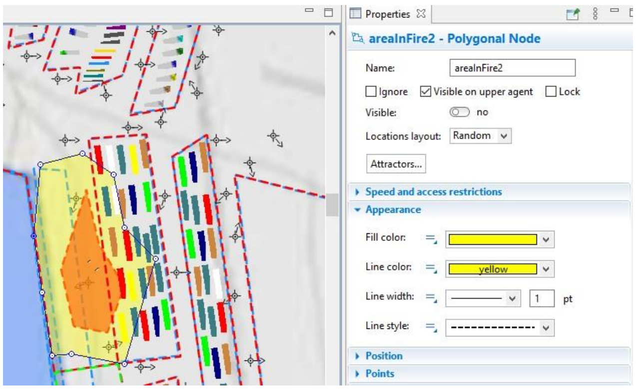


Fig. 8 - Fire Scenario Areas

In our case, the Agents are the port operators who are located inside the terminal. Agents have been created with their image for simulation in 2D and 3D, so that they can be easily identified within the simulation.

To recreate any moment of the working day in the most likely way possible, the simulation is constructed in such a way as to randomly place the staff within the map, simulating the movements due to the work activity within it. The "pedSource" (figure 8) block is used to generate the agents on the terminal layout. The number of people actually present in the terminal have been set inside the block by obtaining their number and position from the tracking system. However, at present the tracking position is known only for port operators while the drivers are located only at the time of entry into the terminal (gate) and removed at the time of their exit: to make the scenario more realistic, more areas are included to reproduce the real density of personnel contained in certain places.

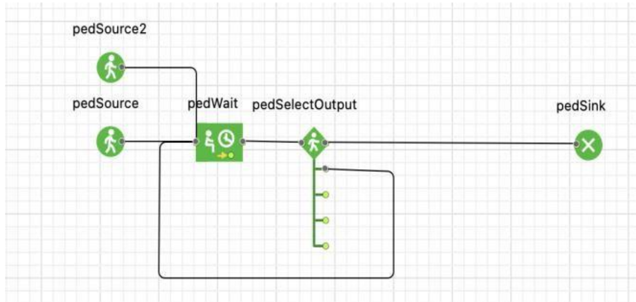


Fig. 8 - Operators and drivers management process

Once the operators and drivers were generated according to the available data, we used the "pedWait" block to simulate the work activities. On our map there are various points called "attractors". Each agent will randomly reach one of these "attractors" stopping for a variable time determined by a function with a minimum value and a maximum value representative of a work activity; at the end of the work interval, the person will go to another "attractor". It is also possible to simulate the turnover of personnel using the "pedSelectOutput" function, through which it is possible to align the personnel who finish their shift and leave with respect to those who go to another "attractor".

In the simulation of the fire scenario, all the flows of operators and drivers heading towards the safe areas are identified through paths that can intersect the dangerous areas: in this way "minimum risk" paths are identified that can be communicated directly to the operators and to drivers through the tracking platform and its integrated messaging system (SMS, What's-up, e-mail). The least risk paths are identified by artificial intelligence algorithms using Microsoft Bonsai.

References

[1] T. Gamer, B. Kloepper, and M. Hoernicke, "The way toward autonomy in industry - taxonomy, process framework, enablers, and implications," IECON Proceedings (Industrial Electronics Conference), pp. 565-570, 2019.

[2] S. Sudevalayam, and P. Kulkarni, "Energy harvesting sensor nodes: Survey and implications," IEEE Communications Surveys and Tutorials, vol. 13, pp. 443-461, 2011.

[3] E. Tantik, and R. Anderl, "Integrated data model and structure for the asset administration shell in industrie 4.0," Procedia CIRP, vol. pp. 60 86-91, 2011.

[4] E. Briano, C. Caballini, M. Mosca, and R. Revetria, "A system dynamics decision cockpit for a container terminal: The case of Voltri terminal Europe," International Journal of Mathematics and Computers in Simulation, vol. 3, pp. 55-64, 2009.

[5] N. Brown, and T. Sandholm, "Superhuman AI for heads-up no-limit poker: Libratus beats top professionals," Science, vol. 359, pp. 418-424, 2018.
[6] L. Damiani, R. Revetria, and E. Morra, "Safety in Industry 4.0: The Multi-Purpose Applications of Augmented Reality in Digital Factories, Advances in Science, Technology and Engineering Systems", Vol. 5, pp. 248-253, 2020.
[7] B. Mladenov, L. Damiani L., P. Giribone, and R. Revetria, "A Short Review of the SDKs and Wearable Devices to be Used for AR Application for Industrial Working Environment", Proceedings of the World Congress of Engineering and Computer Science, vol. 1, 2018.
[8] G. Galli, C. Patrone, A.C. Bellam, N.R. Annapareddy, and R. Revetria, "Improving process using digital twin: A methodology for the automatic creation of models," Lecture Notes in Engineering and Computer Science, pp. 2019.
[9] G. Galli, C. Patrone, C. Battilani, and R. Revetria, "Simulation and Business Process Management notation in Support of Business Process Re-engineering," Transaction on Engineering Technologies, pp. 47-58, 2021.
[10] E. Morra, L. Damiani, R. Revetria, and A. Rozhok, "A case study of a digital twin for designing intermodal railways operations for a maritime terminal," 17th International Industrial Simulation Conference, pp. 98-10, 2019.
[11] A.G. Bruzzone, R. Mosca, R. Revetria, and S. Rapallo, "Risk analysis in harbor environments using simulation," Safety Science, 2000.
[12] [Bruzzone, A. G., Mosca, R., Revetria, R., & Rapallo, S. (2000). Risk analysis in harbor environments using simulation. Safety Science

Blockchain adoption from the Shipping industry: An empirical study

Dr. George Vaggelas, Dr. George Kapnissis, Dr. Apostolis Panos, Dr. Helen Leligou and Dr. Maria Doumi

Abstract

Despite its globalized nature, the shipping industry and bulk shipping are characterizing by the low adaptation of new technologies in their operation and process management. Blockchain technology has numerous applications as it provides transparency, security, and cost reduction in financial transactions. This technology has also been applied in the shipping industry, although at its early steps. The majority of the related literature deals with the applicability of blockchain technology in a shipping company's various processes and the related supply chains, thus focusing on how to apply this technology. The paper, instead, is focusing on the willingness of shipping companies to adopt blockchain technology through an exploratory survey. The paper develops a framework based on a slightly altered version of the classic unified theory of acceptance using technology (UTAUT) and linear regression analysis. The outcome is a set of linear equations of behavioral intention and expectation of the Greek shipping industry to adopt blockchain technology, thus shedding light on the most influential factors. The paper contributes to the related discussion by unveiling shipping companies' intention to adopt blockchain technology daily.

Keywords: Blockchain, Shipping, Greece, adoption, new technologies, UTAUT

1. Introduction

The continuous development of information and communication technologies, their exploitation, and adaptation from various business sectors is becoming increasingly important for their operational and managerial performance and thus for their competitiveness. Human resources play a vital role in the digital transformation since the inability and/or reluctance of a company's personnel to understand the benefits of using innovative solutions may jeopardize technology penetration, bringing significant and multi-layered advantages. How employees and the industry adapts lies in dynamic capabilities, which Teece (1997) first mentioned and applied by Eisenhardt (2000) on technological changes. The concept of the "absorbing" capacity is essential for the complete adaptation of industry to new technologies.

With shipping being the most crucial transport industry as it facilitates more than 90% of world trade (International Chamber of Shipping, 2020), new technologies play a pivotal role in sea transport efficiency. Blockchain, Big Data, and Artificial intelligence have applications in the Maritime Industry, especially in the Greek shipping companies, following more traditional forms of organization and management (see Theotokas 2018) governed by rules of trust procedures, and communication. In the maritime shipping industry, inter-enterprise information sharing systems are outdated, and manual processes are still in place in many cases. This results in a lack of coordination among industry actors pose security risks, low speed of transactions, high cost, and increased workload for authorities, reduce trust between parties doing business in the industry, and ultimately reduces the overall efficiency of the business processes as reported by Jensen et al. (2019).

The advent of blockchain in 2008 and the understanding of the characteristics of this new technology has motivated Information Technology (I.T.) enterprises to create Blockchain-based applications that promise to address these issues in various ways. The existing literature on the blockchain has reported multiple benefits of this technology that can directly impact the way the shipping industry operates. By enabling real-time updates and faster processing of documents in a secure and low-cost way, they allow tasks automation currently performed manually. Consequently, they improve documents' accuracy/credibility, reduce mistakes and ultimately improve the overall business process efficiency (0). The information stored on a blockchain-based application would be visible to all interested and authorized parties, ensuring transparency and trust.

Furthermore, its inherent immutability and use of powerful encryption technology offer high security from fraudulent activities, such as document manipulations. Finally, it reduces intermediaries' presence, allowing market actors to develop direct communication channels, lowering costs and barriers to global trade (Opensea, 2017). Corporate giants such as IBM and MAERSK already apply Blockchain Technology to introduce TRADELENS **Error! Reference source not found.**which corresponds to a broader supply chain process and not purely shipping activity (e.g., Charter parties, Bill of lading).

While it is anticipated that most maritime industry actors will agree on the benefits mentioned above provided by future blockchain applications, not many can envision a “blockchain future” for the industry and provide an assessment of how likely its adoption may be. A literature review on the evaluation of the intention and ultimately the adoption and the use of blockchain technology within several industries (supply chain, accounting, healthcare, and finance) shows that there is an optimistic perspective regarding the intention to use blockchain technology due to the foreseen improvement of the existing procedures. However, a limited attempt has been witnessed in the shipping sector (Papathanasiou, A. et al. 2020).

This article tries to fill this gap by examining the shipping industry's perception towards adopting blockchain technology, gaining an in-depth understanding of the adoption behavior of blockchain technology at a shipping company level. It aims at answering the question, “How likely is it for the blockchain technology to be adopted by the shipping industry actors, and what are the main drivers of adoption?”. To answer this question, we applied a two-step approach, including a) applying the Unified Theory of Acceptance and Use of Technology (UTAUT) theoretical model, b) the development of an appropriate research framework for field research with the use of a questionnaire addressed to Greek shipping companies. The field research outcomes allowed the evaluation of the developed framework apart from understanding just the adoption likelihood. The rationale of focusing on the Greek shipping industry is that the Greek-owned merchant fleet carries almost 20% of the worldwide transported cargo. In comparison, it owns 8,7% of the world fleet (in vessel number) and 17,8% of total capacity (in Dead-weight tons), being a lead country in the global shipping industry. Also, the evaluation of shipping companies willingness to adopt blockchain technology is important not only for the shipping and I.T. industry but also for other sectors. The rest of this article is organized as follows: the research design is described in section 2, the methodological framework followed is presented in section 3, and the field research outcomes are discussed in section 4. Finally, section 5 concludes, highlighting the significant results, discussing potential shipping industry implications, and further research proposals.

2. The research design

The field research focuses on the Greek maritime industry and, more specifically, Greek ocean-going shipping companies. The rationale behind this target group's selection is that shipping companies are among the world trade's main facilitators. Greek shipping companies are the industry leaders (in terms of capacity) and the leading influencer when innovations are introduced in the shipping field. On the other hand, most blockchain and Distributed Ledger Technology (DLT) applications and solutions are currently being designed and developed for shipping companies.

The field research is based on a questionnaire that has been developed upon a set of hypotheses. The questionnaire is aiming at collecting data to test the validity of this model.

2.1 The research hypothesis model

The research base model was chosen among several theoretical technology acceptance models. The Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al. 2003) was identified as the most suitable because it synthesizes eight acceptance models. These include the Technology Acceptance Model (TAM), Theory of Reasoned Action (TRA), Motivational Model (MM), Theory of Planned Behavior (TPB), combined TAM and TPB (C-TAM-TPB) 0, Model of Personal Computer Utilization (MPCU), Innovation Diffusion Theory (IDT) 0and Social Cognitive Theory (SCT) 0.

The proposed framework is based on a slightly altered version of a previously developed framework by 0, which has been applied in India and the USA and measured the blockchain adoption expectation in the supply chain field. Both frameworks are based on the classic unified theory of acceptance and use of technology (UTAUT) 0which examines the determinants affecting the likelihood of technology adoption models 0. The UTAUT model is widely recognized as an established tool for determining the acceptance and the use of innovative technologies combined with blockchain technology, the shipping industry, and interfirm relations. The model of Figure 1 is used for capturing the willingness of blockchain adoption in the shipping industry field.

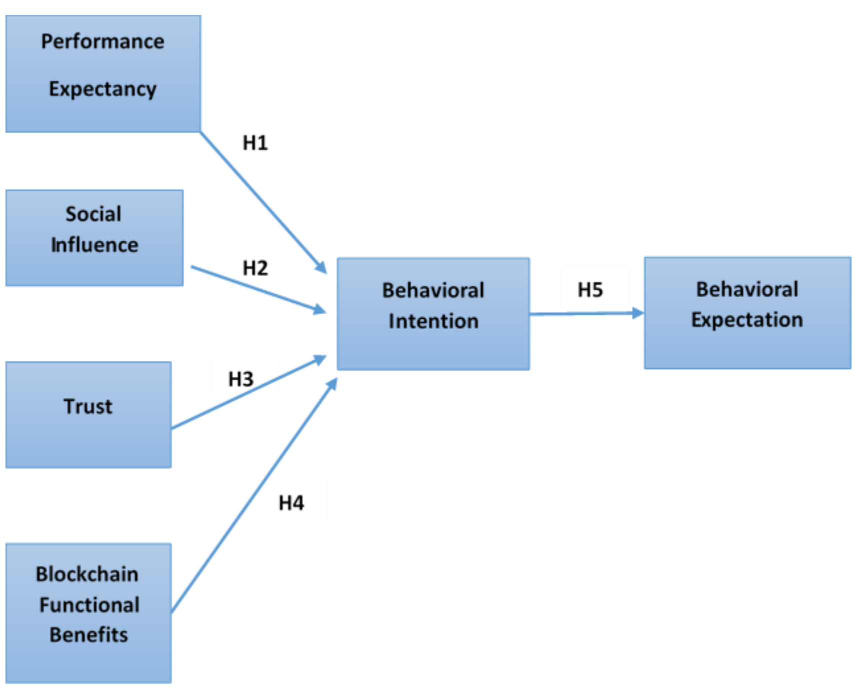


Figure 1 The differentiated research model based on 0

The following constructs were identified as predictors of behavioral intention and behavioral expectation: Performance expectancy, Social influence, Trust, and Blockchain Functional Benefits. We have decided to exclude the Facilitating Conditions and Effort Expectancy constructs included in the UTAUT model and the 0 model. These constructs are defined as "the degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system" and "the degree of ease associated with the use of the system" respectively 0. The rationale of this exclusion is that the technology is still new, has not yet been used by the Greek shipping industry, and the received answers would be unreliable. Also, the Blockchains' "Functional Benefits" and "Trust" among the shipping industry stakeholders (adopted from 0 model) were chosen as additional constructs based on modifications of the UTAUT model, and they are described and analyzed in detail in the next chapter. Thus, considering the Greek shipping industry's peculiarities and the Greek-owned ocean-going shipping companies, the paper developed a differentiated version model, aiming at unveiling the intention and expectation of the Greek shipping industry to adopt the blockchain technology.

2.2 Development of Hypotheses

In this subsection, the selected constructs are analyzed, and the proposed hypotheses are presented.

Performance Expectancy (P.E.), according to 0, is the degree of an individual's expectations on increasing job performance through the use of a system. In the field research of the Greek shipping companies, this parameter is related to the degree of a shipping company employee's expectations regarding an increase in his/her productivity through the use of blockchain technology. Blockchain applications can upgrade the efficiency and the quality of the provided services, and they have raised expectations by improving the traditional established processes of the shipping industry. Alalwan et al. 0have reported that employees' intention to use and adopt a technology depends significantly on performance expectancy. Therefore, the following hypothesis is proposed:

H1. *The expectancy of increasing performance is positively affecting the intention of* *blockchain adoption.*

Social influence (S.I.) is the degree of an individual's perception regarding the use of the new system by other important stakeholders too (see 0. Based on the S.I. definition, the paper considers S.I. as the extent to which the employees are willing to adopt new technologies because other companies and organizations are already using them. In the shipping industry, the interoperability of the I.T. systems, combined with the existing inter-firm relationships, has an important influence on whether to adopt the blockchain across the network. Hence, the following hypothesis is proposed:

***H2.** Social influence is positively affecting the behavioral intention to adopt blockchain.*

Trust of shipping industry stakeholders (Blockchain-oriented TRust), according to 0is the willingness of a party to be vulnerable to the actions of another party because the first party expects that the other party will proceed to a particular activity which is essential to the trustor. Trust is a parameter affecting technology acceptance models' development 00; 0; Liébana-Cabanillas and Lara-Rubio 2017).

On the other hand, the shipping industry is characterized by multiple and complex relationships, and as a result, cooperation needs trust to work effectively and smoothly. The shipping industry is built on trust, and it's the base for building long-lasting business relations between shipping companies and charterers. Blockchain technologies can increase trust and transparency in the shipping industry. They can minimize human intervention in the various processes taking place between the different shipping industry actors (shipping companies, charterers, cargo owners, port authorities, etc.). Blockchain is a shared distributed ledger used in a network or ecosystem to record and verify transactions by a mechanism (consensus) that creates trust in the network. Therefore, the following hypothesis is proposed:

***H3.** The behavioral intention towards adopting blockchain technology can be positively affected by the trust between shipping industry stakeholders.*

Blockchain Functional Benefits (BFB) or Net Benefits are defined (0, as "the effect that an information system (I.S.) has on an individual which is often measured in terms of organizational performance, perceived usefulness, and effect on work practices," or "the extent to which I.S. contributes to the success of individuals. For example, improved decision−making, improved productivity, increased sales, market efficiency, customer welfare, creations of jobs, and economic development," as 0 stated. These two empirical studies, combined with the updated model presented in 0define a relationship between net benefits and Intention to Use or Behavioural Intention. On the other hand, an Information System based on Blockchain technology has some benefits to add to the maritime industry's existing procedures. Therefore, the following hypothesis is proposed:

***H4.** Blockchain Functional benefits positively affect behavioral intention for blockchain adoption.*

Behavioral Intention and Expectation (B.I. & B.E.): Behavioral intention (B.I.) is the degree of conscious plans of an individual towards a specific future behavior 0. On the other hand, behavioral expectation (B.E.) evaluates the probability that an employee will adopt a particular behavior linked with technology in the future (Queiroz and Wamba, 2019). The B.E. is the strong reflection of a behavioral intention over other B.E.'s (Venkatesh et al. 2008)

Based on the above, the following hypothesis is proposed:

***H5.** Behavioral intention for blockchain adoption is positively affecting the behavioral expectation for blockchain adoption.*

3. Methodology

3.1 Questionnaire development

Aiming to unveil the Greek shipping industry's willingness to adopt blockchain technology, a questionnaire has been developed (included in APPENDIX A). The questionnaire went online for uniformity in the data collection and made it more user-friendly to the field research participants.

The questionnaire was first pilot-tested by a group of five (5) scholars and professionals involved in the shipping industry and I.T. without being included in the final research sample. Following the revision process, the questionnaire and a cover letter explaining the survey's overall objectives were sent to the field research target group. Appendix A shows the constructs and their definitions. The questionnaire consists of thirty (30) questions (seven dealing with the respondent's demographic profile and twenty-three for measuring the selected constructs). The field research was conducted from March to May 2020. All constructs were measured by a 7-point Likert scale (strongly disagree – strongly agree) 0.

3.2 Sampling Design and Data Collection

The study's target sample was constituted by management representatives of shipping companies in Greece. Under www.greekshipping.gr, which is an unrivaled maritime database with detailed information and search capabilities, in March 2020, 772 shipping companies were registered in Greece. From these companies, we excluded the small companies (with three or less than three vessels) and the shipping companies operating in the Greek ferry market, and the companies operating auxiliary vessels (i.e., tugs). This exclusion was decided because small shipping companies focus on how to survive in a highly competitive market and less on adopting new technologies in their operation. Also, the passenger and tug boat enterprises are not predicted to use blockchain in their operations, and if they do so, they will use it when it becomes the only way to transact with their customers. On this basis, the number of Greek shipping companies has been narrowed down to 348. At the end of the survey, 56 completed questionnaires were collected, but only 50 were appropriately filled out and suitable for analysis. In other words, we had a response rate of **14.36 %,** which is deemed more than adequate to extract valuable insights.

3.3 Data analysis methods

First, descriptive statistics were used to identify the respondent's profile and the Greek shipping industry's willingness to adopt blockchain in their business processes. Cronbach alpha coefficient was calculated to examine the construct's reliability, and a Spearman correlation analysis was conducted to test the hypotheses. Lastly, a linear regression analysis was conducted to assess whether BFB, BTR, PE, and S.I. predicted the respondents' intention, and a second one to evaluate whether B.I. indicated the expectation (B.E.) to adopt and use the blockchain technology soon, in contrast with 0, whose model was estimated using the Partial least squares structural equation modeling (PLS-SEM).

4. Analysis and results

4.1. Respondents profile

The respondents' demographic profile is presented in Table 1. The demographic data analysis shows the expertise of the respondents; thus, the value of the collected results are:

- 44% of the respondents belong to C-Level, or they are Directors/Managers/Supervisors. They belong to the decision-making group, and they have a more substantial influence in the strategic decision process relating to blockchain technology adoption.
- 28% of the respondents belong to shipping companies operating 21-50 ships, and 20% are operating more than 50 ships. This means that the data collected comes from medium-sized and large shipping companies increasing the field research credibility.
- 54% of the respondents have a working experience of at least six years, followed by those (34%) with 2–5 years' experience, indicating that they are well aware of the processes, ethics, and relationships observed in the sector.

- Considering the education level, 60% of the respondents hold a postgraduate degree, whereas 26% hold a bachelor’s degree.
- In terms of age, most respondents were between 42 and 49 years old (36%).
- The percentage of males and females respondents was 88% and 12%, respectively. This was predictable as the shipping industry in Greece is a traditionally male-dominated sector.

Table 1 Demographic profile (n=50)

	Frequency	%
Gender		
Male	44	88
Female	6	12
Age		
18-25	3	6
26-33	13	26
34-41	9	18
42-49	18	36
50+	7	14
Highest educational level		
No formal education	0	0
Primary	0	0
Secondary	1	2
Diploma/polytechnic	6	12
Bachelor’s degree	13	26
Postgraduate degree (Master/Ph.D.)	30	60
Number of years working in the organization		
Less than one year	6	12
2-5 years	17	34
6-10 years	10	20
11-15 years	5	10
16-20 years	7	14
Over 20 years	5	10
Seniority		
C-Level	5	10
Manager/Supervisor/Director	17	34
Operator	28	56
No of ships (for the S.C.)		

3-5 ships	7	14
6-20 ships	19	38
21-50 ships	14	28
More than 50 ships	10	20

The respondents' above characteristics indicate that the participants are adequate for the research, and the collected responses are of high quality.

4.2 Willingness of the Greek shipping industry to adopt Blockchain

To assess the Greek shipping industry's willingness to adopt blockchain, we first investigate the results gathered concerning the Behavioral Expectation. By analyzing the Mean, Median, and Skewness of B.E., we answer the question, "**How likely is it for the blockchain technology to be adopted by the Greek shipping industry actors**." The evaluation range is from 1 to 7, meaning that evaluations over 3.5 show a positive intention to adopt blockchain. Also, a negative value of Skewness shows that more answers are distributed in the range of "Somewhat agree" to "Strongly agree." Table 2 shows the values of Mean, Median, and Skewness of B.E.

Table 2: B.E. Mean, Median, and Skewness

			Statistic	Std. Error
BEHAVIORAL EXPECTATION	Mean		4.95333	0.01584
	95% Confidence Interval for Mean	Lower Bound	4.4250	
		Upper Bound	5.0599	
	Median		5.0000	
	Variance		0.957	
	Std. Deviation		0.9782	
	Minimum		1.00	
	Maximum		7.00	
	Range		6.00	
	Skewness		-0.548	0.337

The B.E. has a Mean=4.95333 which is significantly greater than 3.5, Median=5.0000, and negative Skewness (namely -0.548). ***These values are verifying that the Greek shipping industry has the intention to adopt blockchain technology.***

Question BI4 ("I am willing to use a demo blockchain application to learn the benefits of this new technology") provided some crucial evidence of the Greek shipping companies' willingness to get to know in practice the benefits of blockchain technology by using a demo application. By analyzing the Mean (5.68), Median (6), and Skewness (-1.023) that appear in Table 3, we can verify that **the Greek shipping companies are willing to discover what are the capabilities of blockchain and how can it add value to current processes in the shipping industry**.

Table 3: BI4 Mean, Median, and Skewness

		Statistic	Std. Error
BI4	Mean	5.68	0.168
	Median	5.83	
	Variance	1.406	
	Std. Deviation	1.186	
	Minimum	1.00	
	Maximum	7.00	
	Range	6.00	
	Skewness	-1.023	0.337

4.3 Model reliability

To assess the model's reliability, which consists of the construct presented in section 2, we examine the Cronbach alpha coefficient. This was calculated for: a) The BFB scale, consisting of BFB1, BFB2, BFB3, BFB4, and BFB5, b) The TRSI scale, consisting of SI1, SI2, SI3, and SI4, c) The BTR scale, consisting of BTR1, BTR2, and BTR3, d) The PE scale, consisting of PE1, PE2, PE3, and PE4, e) the B.I. scale, consisting of BI1, BI2, BI3, and BI4, and f)The B.E. scale, consisting of BE1, BE3, and BE2. The Cronbach's alpha coefficient was evaluated using the guidelines suggested by

0 where >0 .9 excellent, > 0.8 good, > 0.7 acceptable, > 0.6 questionable, > 0.5 poor, and ≤ 0.5 unacceptable.

The results for the reliability analysis are shown in **Error! Reference source not found.**4. The BFB, SI, BTR, PE, B.I., and B.E. constructs had a Cronbach's alpha coefficient of 0.87, 0.91, 0.83, 0.87, 0.88, and 0.88, respectively, and indicating ***excellent and near to excellent reliability***. Consequently, ***the utilization of all the proposed constructs in the proposed research model is well justified.*** It is worth noticing that the lower and upper bounds of Cronbach's α were calculated using a 95.00% confidence interval.

Table 4: Reliability Table

Scale	No. of Items	Cronbach's Alpha Value	Lower Bound	Upper Bound
BFB	5	0.87	0.82	0.93
SI	4	0.91	0.88	0.95
BTR	3	0.83	0.74	0.92
PE	4	0.87	0.81	0.93
BI	4	0.88	0.83	0.94
BE	3	0.88	0.82	0.94

4.4 Hypotheses Testing

A Spearman correlation analysis was conducted between P.E., BTRU, SI, BFB, and B.I. and between B.I. and B.E. to validate the proposed model. Cohen's standard was used to evaluate the strength of the relationship, where coefficients between 0.10 and 0.29 represent a small effect size, coefficients between 0.30 and 0.49 represent a moderate effect size, and coefficients above 0.50 indicate a large effect size 0. The correlations were examined based on an alpha value of 0.05. The results are shown in table 5, and they show that all our hypotheses have from moderate to large effect size.

Table 5: Spearman Correlation Results[1]

	Combination	r_s	Lower	Upper	p
H1:	**PE-BI**	0.42	0.13	0.63	0.002
H2:	**SI-BI**	0.45	0.19	0.64	< .001
H3:	**BTR-BI**	0.45	0.20	0.65	< .001
H4:	**BFB-BI**	0.48	0.24	0.67	< .001
H5:	**BI-BE**	0.39	0.13	0.61	0.005

A significant positive correlation was observed between PE and BI (H1) ($r_s = 0.42$, $p = .002$). The correlation coefficient between P.E. and B.I. was 0.42, indicating a moderate effect size. This means that performance expectancy positively affects the behavioral intention to adopt blockchain.

Another positive correlation was observed between BI and BE (H5) (rs = 0.39, p = .005). The correlation coefficient between B.I. and B.E. was 0.39, indicating a moderate effect size. This correlation indicates that as Behavioral Intention affects Behavioral Expectation, thus Hypothesis 5 is supported.

A positive correlation was observed between SI and BI (H2) (($r_s = 0.45$, $p = .001$)). The correlation coefficient between S.I. and B.I. was 0.45, indicating a moderate effect size. This correlation indicates that as S.I. increases, B.I. tends to increase.

A significant positive correlation was observed between BFB and BI (H4) ($r_s = 0.48$, $p < .001$). The correlation coefficient between BFB and B.I. was 0.48, indicating a moderate effect size. This correlation indicates that as BFB increases, B.I. tends to increase.

A significant positive correlation was observed between BTR and BI (H3) (rs = 0.45, p < .001). The correlation coefficient between BTR and B.I. was 0.45, indicating a

[1] The confidence intervals were computed using $\alpha = 0.05$; n = 50

moderate effect size. This correlation indicates that as BTR increases, B.I. tends to increase.

We also conducted a multiple linear regression analysis to assess whether BFB, BTR, PE, and S.I. predicted B.I. and simple linear regression analysis to model the relationship between B.I. and B.E.

As a predictive analysis, linear regression is used to explain the relationship between one continuous dependent variable from one or more independent variables. It does this by creating a linear combination of all the independent variables to predict the dependent variable. The independent variables can be continuous or categorical (dummy coded as appropriate). The R^2 statistic is used to assess how well the regression predicted the dependent variable. The unstandardized beta (B) describes the increase or decrease of the independent variable(s) with the dependent variable.

The results of the multiple linear regression model were significant: $F(4,45) = 4.82$, $p = .003$, $R^2 = 0.30$, indicating that approximately 30% of the variance in B.I. is explainable by BFB, BTR, PE, and S.I. The Unstandardized Regression Equation based on these results is:

BI = 1.08 - 0.12*BFB + 0.33*SI + 0.43*BTR + 0.09*PE

BFB did not significantly predict BI, $B = -0.12$, $t(45) = -0.58$, $p = .567$. Based on this sample, a one-unit increase in BFB does not have a significant effect on B.I. SI significantly predicted BI, $B = 0.33$, $t(45) = 2.03$, $p = .048$. This indicates that on average, a one-unit increase of S.I. will increase the value of B.I. by 0.33 units. BTR significantly predicted BI, $B = 0.43$, $t(45) = 2.26$, $p = .029$. This indicates that on average, a one-unit increase of BTR will increase the value of B.I. by 0.43 units. PE did not significantly predict BI, $B = 0.09$, $t(45) = 0.41$, $p = .685$. Based on this sample, a one-unit increase in P.E.

does not have a significant effect on B.I. Table 6 summarizes the results of the regression model.

Table 6: Results for Linear Regression with BFB, BTR, PE, B.I., and S.I. predicting B.E.[2]

Variable	*B*	*SE*	CI	β	*t*	*p*
(Intercept)	1.08	0.97	[-0.87, 3.03]	0.00	1.12	.271
BFB	-0.12	0.21	[-0.55, 0.31]	-0.13	-0.58	.567
SI	0.33	0.16	[0.00, 0.65]	0.39	2.03	.048
BTR	0.43	0.19	[0.05, 0.82]	0.32	2.26	.029
PE	0.09	0.23	[-0.37, 0.56]	0.09	0.41	.685

Surprisingly and in contrast with our proposed hypotheses, the Linear Regression Analysis indicated that BFB has a negative instead of a positive influence on B.I. These non-predicted adverse effects on adoption behavior can be explained by the fact that the responders do not have practical experience with blockchain technology. They cannot estimate the related benefits (characteristics such as real-time updates and faster processing of documents, lower cost of transactions, etc.).

The results of the linear regression model (B.E. as dependent variable explained by B.I. as an independent variable) were significant, $F(1,48) = 18.30$, $p < .001$, $R^2 = 0.28$, indicating that approximately 28% of the variance in B.E. is explainable by B.I. BI significantly predicted BE, $B = 0.46$, $t(48) = 4.28$, $p < .001$. This indicates that, on average, a one-unit increase of B.I. will increase B.E.'s value by 0.46 units. Table 3 summarizes the results of the regression model. The Unstandardized Regression Equation based on these results is:

BE = 2.78 + 0.46*BI

[2] The results included of the above table calculated for Confidence Interval at the 95%.

B.I. significantly predicted B.E., $B = 0.46$, $t(48) = 4.28$, $p < .001$, indicating that, on average, a one-unit increase of B.I. will increase the value of B.E. by 0.46 units. Table 7 summarizes the results of the regression model.

Table 7: Results for Linear Regression with B.I. predicting B.E.[3]

Variable	*B*	*S.E.*	95% CI	β	*t*	*p*
(Intercept)	2.78	0.52	[1.73, 3.83]	0.00	5.31	< .001
BI	0.46	0.11	[0.24, 0.68]	0.53	4.28	< .001

The value of R-Squared [4] accounted in B.E. and B.I. (30% and 28% respectively) it seems to be low. R^2 is typically higher because it is easier to specify complete, well-specified models. But in the social sciences, where it is hard to identify such modes, low R^2 values are often expected. Studies that attempt to predict human behavior generally have R-squared values less than 50% because people are hard to predict 0. Also, the exclusion of two basic constructs of the UTAUT model (Facilitating conditions and Effort expectancy) may cause a lower R2 value at the first multiple linear regression model.

5. Conclusions

With new technologies gaining ground in the shipping industry, blockchain technology is among those that their application is under examination. It can lead to increased performance and effectiveness in some shipping operations, especially those related with documents exchange. Based on this, the paper proposes and validates a model that describes the shipping sector's intention to adopt blockchain technology and evaluates the factors affecting this intention. The proposed framework is based on a

[3] The results included of the above table calculated for Confidence Interval at the 95%.

[4] R-Squared Statistic (R^2): Tells how much variance in the dependent variable is explained by only the predictor variables.

differentiated version of the classic UTAUT theoretical model. Through field research with the use of an online questionnaire, the model has been tested in the Greek shipping industry. The proposed factors and predictors have been validated, with the results bringing valuable contributions both in theory and practice. The proposed model showed several relationships with strong coefficients and thus reveals the factors that shape the intention for the adoption of blockchain technology in a shipping company's processes. This kind of information is of value both to the I.T. and shipping companies (Yi et al. 2006; Wu et al. 2011) for their strategic planning and effective marketing. It is also valuable for several shipping industry stakeholders (port authorities, ship agents, brokers, etc.), including shipping policymakers (IMO, etc.), which play a crucial role in standardization and legislation.

In conclusion, the Greek shipping industry is willing to adopt blockchain technology. Performance Expectancy, Social Influence, Trust, and Blockchain Functional Benefits significantly correlate with the industry’s Behavioral Intention. The measured Behavioral Intention has a significant positive correlation with the industry’s Behavioral Expectation. Moreover, the results shed some light on the factors that significantly affect the behavioral intention and expectation to adopt blockchain technology among Greece's shipping companies, which were not covered in the current literature. The paper unveils that at this early stage of blockchain adultness in the shipping sector, Social Influence and Trust are the two critical tools that will stimulate the behavioral intention in adopting the new technology among the shipping companies. In terms of Social Influence, the shipping employees believed that this technology has to be adopted because other enterprises and organizations have already been using them.

Moreover, the shipping industry is characterized by multiple and complex relationships, and as a result, cooperation needs Trust to work effectively and smoothly. As an influencing factor, trust has a dominant role in affecting the adoption of blockchain technology. In terms of Performance Expectancy, the shipping industry employees believed that this technology helps perform their daily activities. Blockchain applications can upgrade the efficiency and the quality of the provided services. They have raised expectations by improving the shipping industry's traditional established processes by minimizing process complexity and uncertainty.

Conversely, Blockchain Functional Benefits is found to have a negative effect at this stage of researching the intention to adopt blockchain technology. This might be due to the limited knowledge and, in some cases, the inexperience of the Greek shipping companies on blockchain technology. That phenomenon will be changed as blockchain technology is researched for several applications in the shipping industry, expecting to gain ground in the medium term.

It is important to stress out that the shipping industry is ready to pilot blockchain-based solutions according to the survey outcomes. However, the major rationale for this decision, i.e., the new technology's functional benefits, seems to be unimportant for the time being. Although Greek shipping's willingness to adopt blockchain has been proven and the main influence factors have been identified, several limitations have to be addressed for future research. First, it would be interesting to conduct the same survey following an informative event to the Greek shipping companies' decision-makers, presenting and explaining the blockchain benefits. Additionally, the fact that the proposed model was tested only in Greece, despite its importance in the global shipping industry, doesn’t allow for a generalization of the research outcomes. Thus, more case studies on a country level will be required to conclude robust global results regarding the shipping industry's intentions towards blockchain technology.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

References

International Chamber of Shipping, http://www.ics-shipping.org/shipping-facts/shipping-and-world-trade. Accessed 1 Nov. 2020.

Abelson, R. P. 1985. A variance explanation paradox: When a little is a lot. Psychological Bulletin, 97, 129-133.

Alalwan, A. A., Dwivedi, Y. K., & Rana, N. 2017, Factors influencing adoption of mobile banking by Jordanian bank customers: Extending UTAUT2 with trust, June 2017 International Journal of Information Management 37(3):99-110 DOI: 10.1016/j.ijinfomgt.2017.01.002

Cohen, J. 1988. Statistical Power Analysis for the Behavioral Sciences. Routledge. ISBN 978-1-134-74270-7.

Colman, A. M., Claire E. Norris, and Carolyn C. Preston. 1997. "Comparing Rating Scales of Different Lengths: Equivalence of Scores from 5-Point and 7-Point Scales." Psychological Reports, no. 2 (April): 355–62. https://doi.org/10.2466/pr0.1997.80.2.355.

Compeau, D. R., & Higgins, C. A. 1995. Computer self-efficacy: Development of a measure and initial test. MIS Quarterly, 19(2), 189. *https://doi.org/10.2307/249688*.

DeLone, W. H., & McLean, E. R. 2003. The Delone and Mclean model of information systems success: A ten-year update. Journal of Management Information Systems, 19 (4), pp. 9-30.

Eisenhardt, K. M., & Martin, J. A. 2000. Dynamic capabilities: what are they? Strategic management journal, 21(10-11), 1105-1121.

George, D. & Mallery, P. 2016. SPSS for Windows step by step: A simple guide and reference, 11.0 update (14th ed.). Allyn and Bacon.

Jensen, T., Hedman, J., & Henningsson, S. 2019. How TradeLens Delivers Business Value With Blockchain Technology. MIS Quarterly Executive, 18(4).

Liébana-Cabanillas F, Lara-Rubio J. 2017. Predictive and explanatory modeling regarding adoption of mobile payment systems. Technological Forecasting and Social Change, Vol. 120, pp. 32-40.

Lin, H. F. 2011. An empirical investigation of mobile banking adoption: The effect of innovation attributes and knowledge-based trust. International Journal of Information Management, 31(3), 252–260. *https://doi.org/10.1016/j.ijinfomgt.2010.07.006*.

Mayer, R. C., Davis, J. H., & Schoorman, F. D. 1995. An integrative model of organizational trust. The Academy of Management Review, 20(3), 709–734. *https://doi.org/10.5465/AMR.1995.9508080335*.

Moore, G. C., & Benbasat, I. 1991. Development of an instrument to measure the perceptions of adopting an information technology innovation. Information Systems Research, 2(3), 192–222. *https://doi.org/10.1287/isre.2.3.192*.

Opensea, 2017. How can the Shipping Industry take advantage of the Blockchain technology? Available at: https://opensea.pro/blog/blockchain-for-shipping-industry [Accessed 30 April 2020].

Papathanasiou, A. et al. 2020. "The (Non-)Application of Blockchain Technology in the Greek Shipping Industry". European Management Journal, https://doi.org/10.1016/j.emj.2020.04.007

Petter S., McLean E.R., 2009. A meta-analytic assessment of the DeLone and McLean IS success model: An examination of I.S. success at the individual level Information & Management, 46 (3), pp. 159-166

Petter S., William D., McLean E.P. 2008. Measuring information systems success: Models, dimensions, measures, and interrelationships, European Journal of Information Systems, 17 (3), pp. 236-263

Queiroz M. and Wamba, F. S. 2019, Blockchain adoption challenges in supply chain: An empirical investigation of the main drivers in India and the USA, *https://www.sciencedirect.com/science/article/pii/S0268401218309447*

Riffai, M. M. M. A., Grant, K., & Edgar, D. 2012. Big TAM in Oman: Exploring the promise of online banking, its adoption by customers and the challenges of banking in Oman. International Journal of Information Management, 32(3), 239–250. *https://doi.org/10.1016/j.ijinfomgt.2011.11.007*.

Taylor, S., & Todd, P. 1995. Assessing I.T. usage: The role of prior experience. MIS Quarterly, 19(4), 561. *https://doi.org/10.2307/249633*.

Teece, D. J., Pisano, G., & Shuen, A. 1997. Dynamic capabilities and strategic management. Strategic management journal, 18(7), 509-533.

Theotokas, I., 2018. "Management of Shipping Companies". Routledge, London UK.

Venkatesh, Brown, Maruping, and Bala. 2008. Predicting different conceptualizations of system use: The competing roles of behavioral intention, facilitating conditions, and behavioral expectation. MIS Quarterly, 32(3), pp.483-502. https://doi.org/10.2307/25148853.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. 2003. User acceptance of information technology: Toward a unified view. MIS Quarterly, 27(3). https://doi.org/10.2307/30036540.

Warshaw, P. R., & Davis, F. D. 1985. Disentangling Behavioral Intention and Behavioral Expectation, 228, 213–228.

World Bank, 2002. Transport services: Reducing barriers to trade. Global Economic Prospects. Available at: http://documents1.worldbank.org/curated/fr/285571468337817024/310436360_20050012014556/additional/multi0page.pdf [Accessed April 14, 2020].

Wu, K., Zhao, Y., Zhu, Q., Tan, X., and Zheng, H. 2011. A meta-analysis of the impact of trust on technology acceptance model: Investigation of moderating influence of subject and context type. International Journal of Information Management, 31(6), 572–581. https://doi.org/10.1016/j.ijinfomgt.2011.03.004.

Yi, M. Y., Jackson, J. D., Park, J. S., and Probst, J. C. 2006. Understanding information technology acceptance by individual professionals: Toward an integrative view. Information & Management, 43, 350–363. https://doi.org/10.1016/j.im.2005.08.006.

APPENDIX A

Construct	Cod	Indicators
Blockchain Functional Benefits (BFB)	BFB1	I will use blockchain technology because I believe that it ensures the traceability of the information, and avoid false claims.
	BFB2	I will use blockchain technology because I believe that it will speed up customs clearance and management, in general, of maritime transport.
	BFB3	I will use blockchain technology because I believe that it will digitize and reduce paperwork in the shipping industry.
	BFB4	I will use blockchain technology because I believe that it will reduce the running cost of my enterprise.
	BFB5	I will use blockchain technology because I believe that it will eliminate cyber-attacks in essential maritime activities.
Social Influence (S.I.)	SI1	Enterprises that are important to me think that I should use blockchain technologies
	SI2	Enterprises that influence my behavior think that I should use blockchain technologies
	SI3	Other enterprises in the shipping industry use blockchain, so I also intend to use it.
	SI4	Organizations like IMO, P&I Clubs, BIMCO, and the U.N. have supported the use of blockchain technologies, so I also intend to use them.
Blockchain and trust (BTR)	BTR1	I trust that blockchain protects personal information.
	BTR2	Maritime industry stakeholders can be trusted to carry out blockchain transactions faithfully
	BTR3	I think I can trust Maritime industry stakeholders more if they use blockchain applications.
Performance Expectancy (P.E.)	PE1	I would find blockchain technology useful in my job
	PE2	Using blockchain technology will allow me to accomplish tasks more quickly and efficiently.
	PE3	Using blockchain technology increases my productivity.
	PE4	If I use blockchain technologies, I will increase my chances of getting a raise or a promotion.
Behavioral Intention (B.I.)	BI1	I intend to use blockchain technology in the following months (12 to 24)
	BI2	I predict I would use blockchain technology in the following months (12 to 24)
	BI3	I plan to use blockchain technology in the following months (12 to 24)
	BI4	I am willing to use a demo blockchain application to learn the benefits of this new technology.
Behavioral Expectation (B.E.)	BE1	I expect to use blockchain technology in the following months (more than 24)
	BE2	I will use blockchain technology in the following months (more than 24)
	BE3	I am likely to use blockchain technology in the following months(more than 24)

A Proposed Framework for a Port-area Vessel Speed Reduction system (VSR)

Mohamed S. Rowihil
Arab Academy for Science – Technology & Maritime Transport, Egypt, mrowihil@aast.edu

ABSTRACT

Speed reduction is a well-known energy efficiency operational measure that has been used time after time by ocean-going vessels to cut on fuel costs. Moreover, speed reduction has also been presented as an effective means to reduce air pollutants and GHG emissions.

Lately, a number of seaports around the world have implemented a Vessel Speed Reduction system (VSR) to persuade vessels to slow down to a predetermined speed with the aim of reducing harmful air pollutants such as NOx and Particulate matter within the port-city area while also contributing to the reduction of GHG emissions. Research and practice altogether have shown that a 30% reduction in speed would yield a corresponding 24% to 38% reduction in NO_x, PM and GHGs.

With the subpar air quality levels typical of many port-cities worldwide, where frequency of marine traffic is likely to have a negative effect on air quality, a VSR system is a simple cost-effective option to reduce emissions within the port-city area.

This paper proposes a framework for implementing a VSR system within ports pursuing further emissions reductions. The framework serves two distinct purposes; to assess the viability of a VSR system for the intended port, and to provide a set of guidelines for realizing an effective VSR system in the chosen port. The proposed framework takes into consideration a number of factors including; port specific conditions such as location and prevailing winds, potential partners to the program, and possible incentives.

In order to formulate the framework, a set of currently active VSR systems in the United States, Taiwan and South Korea are used as case studies.

KEYWORDS

Energy Efficiency, Emissions Reduction, Framework, Green Port, Port-area Emissions, Vessel Speed Reduction (VSR)

INTRODUCTION

Background

Seaports perform a central role on both the international and domestic scales. They are the pumps at the heart of international trade with more than 80% of worldwide trade by volume, and 70% by value, being carried by sea and processed through seaports (UNCTAD, 2019). Furthermore, seaports are an integral part of the socio-economic composition of any nation; 11 of the largest 15 cities in the world are coastal cities. Moreover, approximately 40% of world population lives within 100 km of the sea (UN, 2017). Seaports not only play an important role economically and socially, but also have a strong health impact within the port-city area.

A number of port activities including loading and unloading of volatile compounds; operation of vehicles, service crafts and heavy equipment; and the production of electric energy needed for lighting and buildings all have been proven to contribute to the increase of emissions whether pollutants or GHGs in the port-city area. Nonetheless, numerous studies quantifying port-area emissions have shown that vessel emissions have actually contributed more to air pollution than in-port activities. In a study of the Port of Kaohsiung, Taiwan, Berechman and Tseng (2012) compare between in-port ship and truck emissions. The study revealed that 92% of in-port emissions for the year 2010 resulted from ships; with tankers, containers and bulk carriers as the main source of emissions. Most dominant were CO_2 emissions; followed by SOx, NOx, PM_{10}, $PM_{2.5}$, HC, CO and VOC. The same study further estimated the environmental and health costs of ship emissions in the port area to be $119.2 million compared to only $4.2 million dollars for truck emissions (Berechman & Tseng, 2012). The International Transport Forum (ITF), in 2014, claimed that emissions from shipping in port accounted for 18 million tonnes of CO_2 emissions, 0.4 million tonnes of NO_x, 0.2 million tonnes of SO_x and 0.3 million tonnes of PM_{10} in 2011 alone; adding that around 85% of these emissions came from container ships and tankers. Such ship emissions have an impact on the quality of air in the port-city area and cause negative health issues including asthma, heart attacks, hospital admissions, and premature mortality (Winnes, Styhre, & Fridell, 2015). The ITF, as mentioned, forecasts an increase in shipping emissions in port of four times by 2050 reaching 70 million tonnes of CO_2 emissions and 1.3 million tonnes of NO_x emissions. It further points out that Asia and Africa are the most prone regions to this increase in emissions due to the growing maritime traffic and limited mitigation measures (Merk, 2014).

Contrary to common belief, ship emissions effecting the port area are not only released while in port, but also while the ship is awaiting berth at anchor, and during the ship's approach to port or while in transit. Villalba & Gemechu (2011) estimating emissions in the Port of Barcelona (2008) using the MEET (**M**ethodologies for **E**stimating air pollution **E**missions from **T**ransport) method conclude that approximately half of total emissions (175,184 tons) are sea-based; i.e. emitted by visiting and transiting vessels. Container ships and ferries were found to be the major sea-based emitters. Yau et al. (2012) estimated that 17% of NO_x, 11% of SO_2 and 16% of PM_{10} emissions in Hong Kong in 2007 originated from transiting vessels. Similarly, Tichavska and Tovar (2015) using a STEAM (Ship Traffic Emissions Assessment Model) evaluation of cruise-ship and ferry exhaust in the port-city of Las Palmas, Spain confirm that vessel traffic and passenger shipping constitute a primary source of air pollution in the city (Tichavska & Tovar, 2015).

Furthermore, Corbett et al. (2007), through modelling ambient PM concentrations from oceangoing ships, estimated global and regional PM-caused mortalities by applying ambient PM increases due to ships to cardiopulmonary and lung cancer concentration-risk functions and population models. The study concluded that shipping-related PM emissions were responsible for approximately 60,000 cardiopulmonary and lung cancer deaths annually, with most deaths occurring near coastlines.

In 2015, the International Maritime Organization (IMO) published it's "Study of Emission Control and Energy Efficiency Measures (ECEEMs) for Ships in the Port Area". The study identifies three main categories of ECEEMs that may be considered to reduce air emissions in the port area; equipment, energy and operational measures. "Equipment" refers to physical alterations in machinery onboard a ship. "Energy" refers to the different types of energy sources that may be used to power the ship or its equipment. And, finally, "operational measures" refer to measures that affect the modes of operation of the ship and/or the port without incurring any change in equipment or energy source.

The three mentioned categories each involve a number of ECEEMs including technologies, alternatives and methods, measures worth consideration. However, not every measure will be suitable for every port. Each port has its own national context that needs to be examined and its very own "operating profile" which must be understood and assessed well before any decision to implement abatement measures may be adopted. Moreover, due to barriers and constraints, and the relatively high initial capital costs associated with the earlier two methods, the third option "operational measures" may present itself as the most economically feasible solution.

Vessel Speed Reduction System (VSR)

Slow steaming is a time-proven "operational measure". In the wake of the 2008 global recession and as freight rates plunged, shipping companies reduced the steaming speed of their vessels to well below the ships' economic speeds as an operational measure to save on fuel costs. There exists a strong correlation between a vessel's fuel consumption and its speed; where fuel consumption per unit time may be described by a third-degree function of speed. In other words, a humble speed reduction by 10% would result in a reduction in fuel consumption by 27% (Winnes et al., 2015). These same figures are similarly confirmed by the Global Maritime Energy Efficiency Partnerships (GLOMEEP) project of the GEF-UNDP-IMO. Furthermore, the same modest reduction in speed (10%) is estimated to reduce vessel emissions by around 10% to 15% depending on ship type and size (Faber, Huigen, & Nelissen, 2017). Accordingly, a 30% reduction in speed would yield a corresponding 24% to 38% reduction in NO_x, PM and GHGs. Nevertheless, when market and economic conditions are favourable (i.e. high demand, higher freight and cheaper fuel prices), shipping companies tend to favour higher transport work over speed reduction.

A Vessel Speed Reduction system (VSR) is an "operational measure" derived from the concept of slow steaming. The objective of a VSR is mainly to reduce emissions in the port area by reducing vessel engine load to a certain level. This is achieved by encouraging vessels on their outer approach to port to reduce sailing speed, usually below economic speed levels. Being an operational measure, a VSR system requires no additional equipment for the ship or the port. It does not involve the use of costly alternative fuels or energy sources. Additionally, the system does not involve many services and stakeholders and, therefore, does not entail much coordination. A VSR is a simple cost-effective ECEEM that may be employed by a port to reduce ship induced emissions within its port-area. A VSR system may also be employed in port areas for a number of other reasons including; to reduce risk of collision in congested areas, to reduce risk of whale strike and to reduce underwater noise (Leaper, 2019).

VSR systems have been pioneered and used since 2001 in the United States; namely in the ports of Long Beach (POLB), Los Angeles (POLA). The same concept was afterwards adopted by the Port of San Diego (POSD) and the Port Authority of New York and New Jersey (PANYNJ). Additionally, a number of ports in Taiwan and South Korea have recently adopted similar VSR systems.

VSR should not be confused with Virtual Arrival (VA). Also known as *Just-in-Time (*JiT) arrival, VA is the seagoing segment of JiT operations. VA is the concept whereby a vessel is provided with proper information on expected time of arrival to port. The vessel is, then, supposed to optimize its time of departure from the initial port and sailing speed in order to reach the destination port at the expected arrival time. The vessel is expected to steam at a lower speed, saving fuel, and arriving port at the designated time which will normally be when the port/berth is ready to receive the ship. The main advantage of VA is in-voyage fuel savings due to the reduced speed (Just in Time Arrival Guide, 2020). With VA, optimum sailing speed is determined and maintained by the vessel itself with no intervention from the arrival port. The vessel will normally choose to sail at its economic speed as long as she can make it to port in time. Subject to a number of reasons including weather conditions, economic considerations and unforeseen circumstances, the vessel, during any portion of the voyage, may choose to alter speed resulting in varying engine loads and varying levels of emissions. One common example is; the ship's master may choose to increase speed on final approach to port in order to compensate for lost time due to bad weather, resulting in increased emissions within the port area.

VSR, on the other hand, is imposed by the arrival port and usually within a very limited length of the ships voyage; particularly, the outer approaches to the port. The vessel's speed is predetermined by the port usually with regard to vessel type and size in order to reduce emissions in the vicinity of the port.

Figure 1. Relationship between Vessel Speed Reduction and Virtual Arrival

The idea of a VSR is rather simple; make it known to all arriving vessels that they need to slow down to a predetermined speed (according to type and size) within a certain distance from the port. VSR, also, requires less coordination compared to virtual arrival where port operations must be continuously monitored and availability of port facilities such as piers, cranes, pilotage… etc. need to be assessed in order to communicate, usually a few days in advance, an appropriate arrival time to the vessel. Needless to mention, VSR is also much cheaper for both sides (the port and the vessel operator) to implement compared to any technical emissions reduction methods which may require a hefty capital. Additionally, running and administrative costs are also quite low. From a comparative point of view, VSR may be considered one of the simplest methods a port can employ to regulate emissions from incoming vessels.

This paper suggests VSR as a simple cost-effective measure that may be employed to reduce ship emissions in port-areas worldwide, albeit, a number of considerations must be made. Hence, the paper proposes a universal framework for implementing a VSR system within any port-area. The framework serves two distinct purposes; to assess the viability of a VSR system for the intended port, and to provide a set of guidelines for realizing an effective VSR system in the chosen port. The proposed framework takes into consideration a number of factors including; port specific conditions such as geographic location and prevailing winds, potential partners to the program, and possible incentives.

VSR PROGRAMS IN THE USA

The concept of a VSR system, as explained earlier, was first developed in the USA, specifically in the California County area. The Port of Long Beach (POLB), in 2001, became the first port to implement a VSR system, soon to be followed during the same year by the Port of Los Angeles (POLA). In 2009, the Port of San Diego became the third US port to adopt a VSR system followed by the Port Authority of New York and New Jersey (PANYNJ) only one year later.

Geographical Domain

The ports of POLB and POLA are both located in the San Pedro Bay area on the west coast of California, USA. Prevailing winds throughout the year are mostly westerly (for a duration of 9.7 months) blowing in from the ocean with wind speeds varying from 1.5 mph to 15 mph (1.3 - 13 knots). Figure 2 shows the percentage of hours in which the mean wind direction is from each of the four cardinal wind directions, excluding hours in which the mean wind speed is less than 1.0 mph. Approximately 55 nautical miles to the south, the prevailing winds in the Port of San Diego are, for all practical purposes, considered the same. Therefore, for the three ports, for approximately 81 percent of the year ship emissions will be blown over the shore, if without a VSR program.

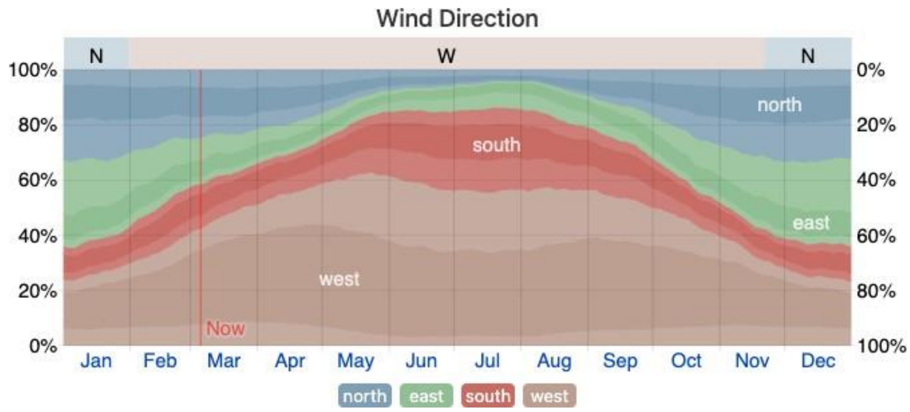


Figure 2: Prevailing wind directions for POLB and POLA. Source: weatherspark.com

As for the Ports of New York and New Jersey, Figure 3 shows that annual wind direction varies a great deal with winds blowing out from the shoreside for the majority of the year; except for approximately four months where it blows in from the sea coming from the south or east. Compared to the ports on the West Coast, the percentage of winds blowing in from sea throughout the year is quite less. It is perhaps for this reason that the Port Authority of New York and New Jersey only set a 20 nautical mile VSR zone.

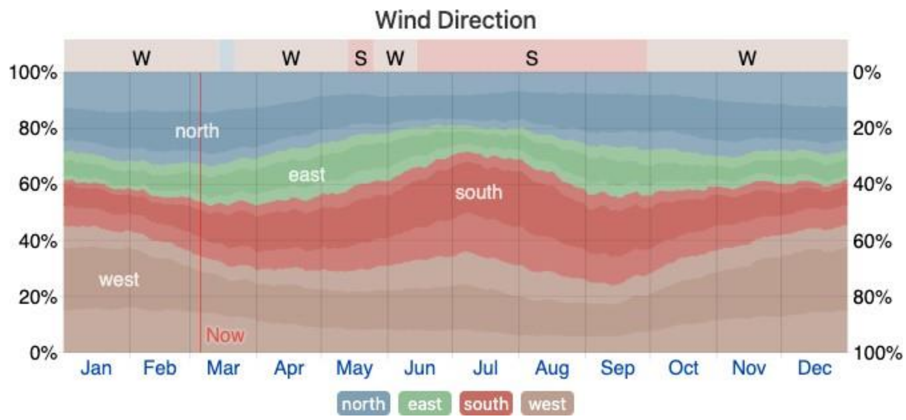


Figure 3: Prevailing wind directions for the Ports of New York and New Jersey. Source: weatherspark.com

VSR themes

The POLB and POLA VSR programs were designed as a *voluntary* program. Initially, vessels were required to reduce speed to no more than 12 knots within a zone extending 20 nautical miles seaward from the port premises. This applied to all vessels irrespective of being inbound or outbound. In 2009, both POLB and POLA further extended their VSR programs to a zone of 40 nautical miles from port (Figure 4). Expected delays in reaching the berth, due to the extended VSR zone, were overcome by moving work assignment from dockside to the VSR zone boundary.

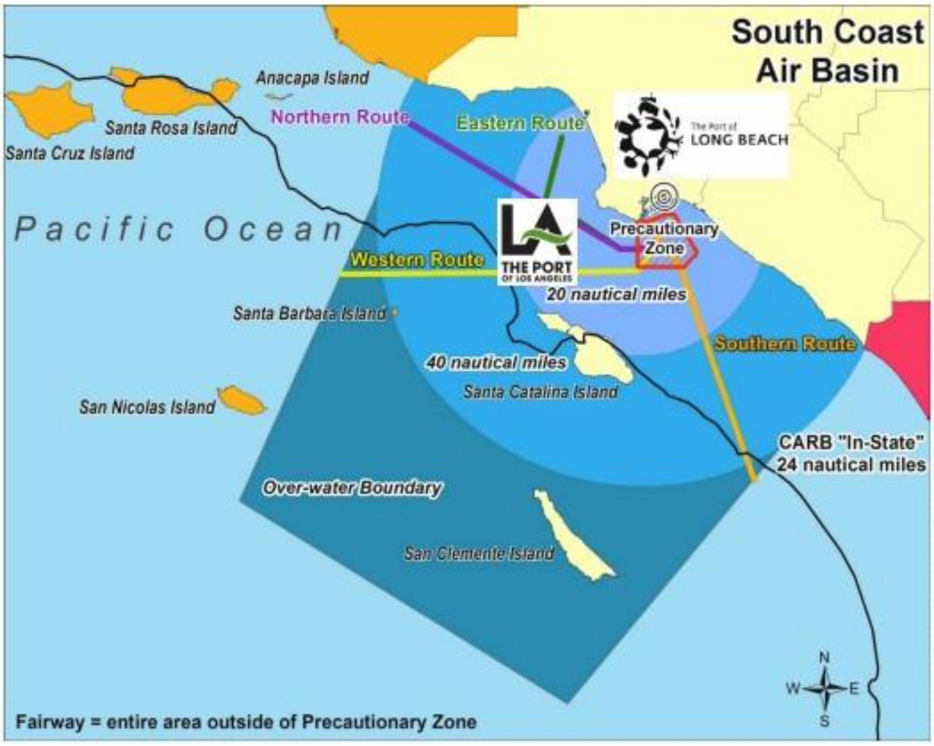


Figure 4: VSR zones for POLB and POLA. Source: www.polb.com

The VSR system for the Ports of New York and New Jersey (PANYNJ) is implemented as part of the Clean Vessel Incentive (CVI) Program where financial incentives are provided to vessel operators who reduce the speeds of their ships to 10 knots or less within 20 nautical miles of the Territorial Sea Line which extends out an approximate 6 nautical miles from the port entrances making the VSR virtually 26 nautical miles (Figure 5).

Figure 5: VSR zone for the Ports of New York and New Jersey. Source: www.panynj.gov

Incentives Scheme

Except for the Port of San Diego, all US ports provide financial incentives ranging from 1.5 to 2.2 million USD per year per port.

As a voluntary VSR program, the incentive offered by the ports of POLB and POLA during the programs' early years was initially in the form of "public recognition". In return for contributing to the port's emissions reduction efforts, the ship would receive a green flag it was entitled to fly. Thus, the program was dubbed the "Green Flag Incentive Program". To further incentivise ship operators to comply, in 2005, a 15 percent discount on dockage fees was introduced. In order to qualify for the discount, an operator's vessels had to comply with the VSR speed limits on 90 percent of their trips for the previous calendar year. Having qualified, the operator's vessels would be rewarded with the mentioned 15 percent discount on dockage fees for the following year. After extending the zone, in 2009, to 40 nautical miles an additional 10 percent discount was offered to complying ships, thus, amounting to a total discount of 25 percent on dockage fees.

The PANYNJ VSR program is one of three incentive schemes under the CVI which is capped at USD 1.6 million. VSR Incentives are payed to eligible shipping companies on a first come first served basis. To become eligible, shipping companies must first enrol their vessels to the CVI program. According to PANYNJ, eleven major shipping companies are enrolled in the program ("Clean Vessel Incentive Program," 2020).

VSR Monitoring

Monitoring of traffic within the VSR limits is conducted via AIS and Radar by the Marine Exchange where speed measurements are recorded at 5 nautical mile increments starting from the outer boundary of the VSR zone. This information is uploaded monthly to the Environmental Database maintained by the respective port authority. Using the uploaded information, average speeds for each ship per transit are calculated and annual VSR compliance data reports are compiled per ship operator. At the end of the fiscal year compliance reports are publicly posted with ship, operator name and compliance percentage for each zone.

As of 2016, the percentage of ships observing the required VSR speeds within the 20 nautical mile zone is, on average, approximately 99 percent in the ports where financial incentives are provided. This percentage drops significantly to 59 percent for the Port of San Diego where no incentives are provided (International Maritime Organization (IMO), 2015).

POLA reported a ship emissions reduction of 90% (1284 tons) for PM, 48% (2,552 tons) for NO_x, 98% (4,723 tons) for SO_x and 33% for CO_2 in 2019 compared to the 2005 baseline (*2019 Air Emissions Inventory Highlights*, 2020). Meanwhile, a 25% increase in cargo throughput was reported for the same period. Similarly, POLB reported a ship emissions reduction of 88%, 58%, 97% and 19% for PM, NO_x, SO_x and CO_2 respectively in 2019 compared to the 2005 baseline. As for PANYNJ, ship emissions reduction of 9.0 tons, 692.2 tons, 42.5 tons and 18,874 tons for PM, NO_x, SO_x and CO_2 respectively in 2019 were reported ("Clean Vessel Incentive Program," 2020).

Partners

Partners of the US VSR programs include; the port authorities, U.S. Environmental Protection agency, California Air Resources Board, South Coast Air Quality Management District, the US Coast Guard, Steamship Association of Southern California, and Pacific Merchants Shipping Association.

Other US Ports evaluated for VSR Implementation

It is noteworthy that the abovementioned US ports were not the only ones to be evaluated for implementation of the VSR program. The ports of Oakland, Seattle, Tacoma and Houston were also evaluated. However, implementation of a VSR program in these four ports was deemed unviable for a number of reasons. For the ports of Oakland, Seattle and Tacoma, it was found that ships already slowed down naturally to compensate for the strong currents prevailing in the sea-area leading to the port; i.e. the port approaches. As for the port of Houston, ships also had to slow down in order to safely navigate the channel leading to the port entrance.

VSR PROGRAM IN TAIWAN

The VSR program in Taiwan started in July 2015 with the Port of Kaohsiung. The program now includes all seven ports under the Taiwan International Ports Corporation (TIPC) (Figure 6). Similar to the VSR program in the US, the TIPC VSR program aims to improve port air quality by encouraging ocean-going vessels to reduce speed in the port area.

VSR theme

The TIPC VSR program is a voluntary program which requires participating ships to maintain an average speed of under 12 knots within a 20 nautical mile radius from each participating port. However, the TIPC program limits eligibility to international cruise and container vessels of 10 thousand gross tons or more ("Vessel Speed Reduction," 2021).

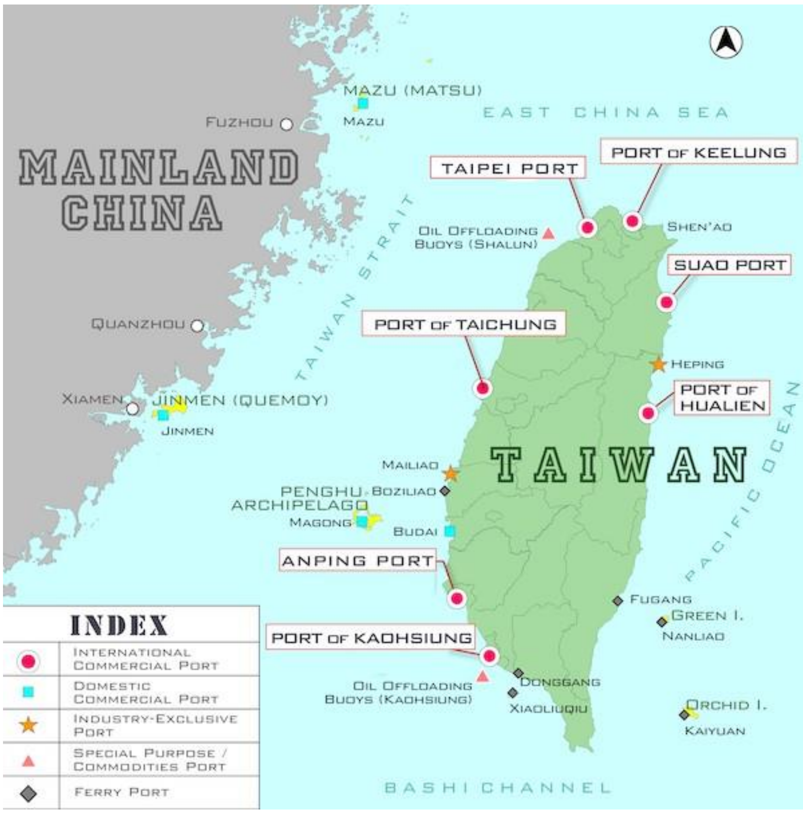


Figure 6: Ports of the Taiwan International Ports Corporation. Source: www.twport.com.tw

Incentives scheme

The TIPC VSR program issues a bonus of NTD 8,000 to a ship every time she meets the VSR criteria both entering and exiting the port, with a total amount of NTD 32 million available each year from January 1st to December 31st. Results are publicly published on the official TIPC website during the months of April, July, November and January of each year for the previous months.

VSR monitoring

The results are based on data provided by the Ministry of Transportation VSR Surveillance System (VSRSS). Eligible ships, therefore, must have their AIS turned on during inbound and outbound transit of the 20 nautical mile zone. Subject to irregular check, validation of the data provided by the VSRSS is conducted by the TIPC port and published on the 10th of each publishing month. A re-evaluation may be conducted upon request of the shipping company. The re-evaluation form, available online, must be submitted within ten days from publishing of the VSR program results.

TIPC reported a speed reduction attainment rate of 40% for 2017 and 60% for 2018 ("Vessel Speed Reduction," 2021).

VESSEL SPEED REDUCTION PROGRAM IN S. KOREA

S. Korea is currently the latest country to adopt a VSR program within its port areas. The program which started in January 2020, incorporates the five largest ports; Busan, Ulsan, Yeosu, Gwangyang and Incheon Port.

VSR theme

The VSR zones for each of the five ports extends 20 nautical miles seaward. Ships eligible for the program differ by each port according to density of visits. However, they have to be among the top 3 fine-dust-emitting ship-types; as for ship size, they have to be ocean-going ships that are no smaller than 3,000 tons. The VSR speed for container ships and car carriers is set at 12knots. Other ship-types including general cargo vessels, crude oil carriers, chemical carriers and LNG carriers are required to observe a speed limit of 10 knots (Ministry of Oceans and Fisheries, 2019).

Incentives scheme

Incentives are issued in the form of a percent refund on docking fees ranging from 15 percent to 30 percent. Ships which normally have a higher steaming speed will enjoy a higher percent refund; e.g. container vessels receive up to 30 percent refund (Ministry of Oceans and Fisheries, 2019).

To be eligible for the refund, ships must show a compliance rate of no less than 60 percent. Percent compliance is planned to increase annually to reach a target of 90 percent.

PROPOSED FRAMEWORK

As a result of studying the afore-mentioned VSR programs, many important features of an effective VSR have been identified. The framework is intended to serve as a systematic guide that may be used by port authorities worldwide to help guide the process including the initial appraisal of the intended program, planning and designing the program specifics, implementing the program, and finally reviewing the program. Figure 7 is a simplified illustration of the six stages of the framework.

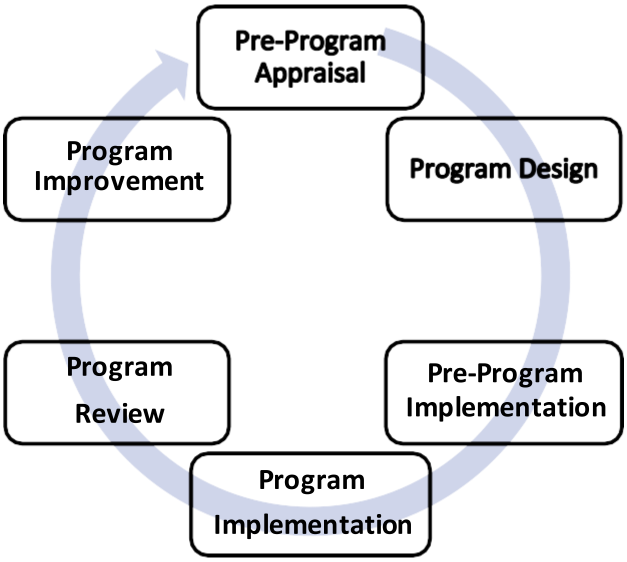


Figure 7. Proposed Framework Cycle

Table 1, in Appendix 1, is a comprehensive illustration of the proposed framework which follows a plan-do-check-act cycle. The 'Plan phase' involves the first two stages; the 'Pre-Program Appraisal' which is intended to assess the viability of the program itself, and the 'Program Design' which lays out the specific details of the program including, but not limited to, the extent of the VSR zone, the details of program monitoring and data collection, the awarding of incentives, etc. the 'Do phase' also involve two stages; the 'Pre-Program Implementation' stage and the actual 'Program Implementation' where all the specifics of the program should be carried out an documented as planned earlier. The 'Check phase' is where the 'Program Review' occurs. At this stage, all features of the program are checked and evaluated leading to the final 'Act phase' where the outcomes of the program review are analysed and action is taken to remedy and perfect the program.

DISCUSSION

As illustrated in the proposed framework (Appendix 1), many details should be carefully planned and attended to for a VSR to be successful. Although not completely necessary, an initial emissions inventory of the port-area may be conducted during the 'Pre-Program' stage. This initial inventory should serve a base-line for comparing future port-area emissions and for assessing possible VSR contribution to emissions reductions. Such base-line comparison should be made available online. Such program transparency is always appreciated by stakeholders and the general public giving the program added value and potency.

Perhaps the most important feature of a VSR is the provision of incentives. Although a VSR may function without awarding of any incentives, best practices have shown that financial incentives make a considerable difference in the effectiveness of the program. The case of the Port of San Diego (POSD) is a good example of this where compliance rate is well below that of other US VSR programs. In this context it is important to note that speed reduction below economic speed will for some vessels come at a cost. This is primarily due to engine design speeds. The California Air Resources Board, in 2009, estimated that the daily increase in operating costs from slowing vessels down by 1 hour ranges from US$250 to $600 (Ahl, Frey, & Steimetz, 2017). It is for this reason that most ports implementing a voluntary VSR system have resorted to the use of financial incentives to motivate ship operators to comply. As an alternative to incentives, the 'polluter pays principle' may be applied, raising the port dues for those ships that have relatively high port emissions. However, competition among neighbouring ports should always be well-thought-out before the 'polluter pays principle' may be considered. Another source of motivation for ship operators may well be the extent of publicity made for the program. As most ship operators seek to create a strong image of social and environmental stewardship and corporate social responsibility (CSR), public and stakeholder opinion may become a strong motivation for operators to exhibit stronger compliance, especially if this compliance will be publicly recognized.

Another feature of possibly no less importance is the proper monitoring of vessel speeds within the designated VSR zones. Failing to collect accurate speed data will lead to, among other things, incorrect judgement of vessel compliance and, therefore, possibly unmerited awarding of incentives or, more importantly, failing to recognize participants worthy of awarding. This, in turn, will lead to a quick drop in compliance rate and eventually failure of the whole program. Consequently, an effective VSR monitoring system needs to be precise, however, without being costly. As mentioned, AIS will normally suffice as the main monitoring tool. It, therefore, must be made very clear that transiting vessels need to have their AIS turned on during the full duration of transit within the VSR zone. Radar may also be used as a complementary means of monitoring vessel speed. An effective monitoring system will include details relating to frequency of monitoring and data collection (e.g. every 5 nm), means of data recording and saving and procedures for analysis and validation of collected data. Automation and digitalization of the system using a simple computer program should increase efficiency of the system, decrease the probability of human error, and minimize the need for additional manpower.

As with any plan-do-check-act cycle, the VSR 'Program Review' stage is extremely important to the effectiveness of the system and success of the program. The frequency of the review depends mostly on the effected incentives scheme. However, a thorough review of all aspects of the system should always be conducted at least once every year. Failure to do so may cause some discrepancies to go unnoticed or to be simply "brushed under the carpet". One method to assure this will not occur is to periodically employ a Strengths, Weaknesses, Opportunities & Threats (SWOT) analysis which preferably should be conducted by an experienced external assessor.

CONCLUSION

Though the concept of slow steaming has been widely used by sea-going vessels to reduce energy consumption, it has lately been used intermittently as means to reduce emissions and GHGs. Vessel Speed Reduction Programs (VSR), since introduced in 2001 by the Port of Long Beach (POLB), have been successfully employed by a number of ports worldwide to realize greater emission reductions and to reduce pollutants within the port-area or city.

Through studying the VSR programs of a number of ports on the United States, Taiwan and South Korea, the paper was able to identify the key concepts, features and different perspectives used in VSR programs. The contribution of this paper lies in assembling these concepts, features and perspectives into one systematic approach for implementing a VSR.

The paper, therefore, proposes a detailed framework that may be used by port authorities to guide the process of implementing a VSR. The framework uses a plan-do-check-act approach and clearly divides the process into six sequential stages; beginning with the initial appraisal of the program for the intended port and leading all the way to the periodic evaluation and improvement of the VSR program.

REFERENCES

2019 Air Emissions Inventory Highlights. (2020). Retrieved from https://www.portoflosangeles.org/environment/air-quality/air-emissions-inventory

Ahl, C., Frey, E., & Steimetz, S. (2017). The effects of financial incentives on vessel speed reduction: Evidence from the Port of Long Beach Green Flag Incentive Program oa. *Maritime Economics and Logistics*, *19*(4), 601–618. https://doi.org/10.1057/mel.2016.12

Berechman, J., & Tseng, P. H. (2012). Estimating the environmental costs of port related emissions: The case of Kaohsiung. *Transportation Research Part D: Transport and Environment*. https://doi.org/10.1016/j.trd.2011.09.009

Clean Vessel Incentive Program. (2020). Retrieved April 1, 2021, from https://www.panynj.gov/port/en/our-port/sustainability1/clean-vessel-incentive-program.html

Corbett, J. J., Winebrake, J. J., Green, E. H., Kasibhatla, P., Eyring, V., & Lauer, A. (2007). Mortality from ship emissions: A global assessment. *Environmental Science and Technology*, *41*(24), 8512–8518. https://doi.org/10.1021/es071686z

Faber, J., Huigen, T., & Nelissen, D. (2017). *Regulating speed: a short-term measure to reduce maritime GHG emissions*. 34. Retrieved from www.cedelft.eu

GEF-UNDP-IMO GloMEEP Project and members of the GIA. (2020). *Just in Time Arrival Guide - Barriers and Potential Solutions*. London, UK: GIA, GEF-UNDP-IMO GloMEEP Project.

International Maritime Organization (IMO). (2015). *Study of Emission Control and Energy Efficiency Measures for Ships in the Port Area*. London, UK.

Leaper, R. (2019). The role of slower vessel speeds in reducing greenhouse gas emissions, underwater noise and collision risk to whales. *Frontiers in Marine Science*, *6*(AUG), 1–8. https://doi.org/10.3389/fmars.2019.00505

Merk, O. (2014). Shipping Emissions in Ports. In *Discussion Paper No. 2014-20*. Retrieved from https://www.itf-oecd.org/sites/default/files/docs/dp201420.pdf

Ministry of Oceans and Fisheries. (2019). VESSEL SPEED REDUCTION(VSR) PROGRAM TO START DECEMBER THIS YEAR. Retrieved April 5, 2021, from https://www.mof.go.kr/en/board.do?menuIdx=1491&bbsIdx=30629

Tichavska, M., & Tovar, B. (2015). Port-city exhaust emission model: An application to cruise and ferry operations in Las Palmas Port. *Transportation Research Part A: Policy and Practice*, *78*, 347–360. https://doi.org/10.1016/j.tra.2015.05.021

UN. (2017). Factsheet: People and Oceans. *The Ocean Conference*, 1–7. Retrieved from https://www.un.org/sustainabledevelopment/wp-conte

UNCTAD. (2019). *Review of maritim transportation*. Retrieved from https://unctad.org/en/Pages/Publications/Review-of-Maritime-Transport-(Series).aspx

Vessel Speed Reduction. (2021). Retrieved March 25, 2021, from https://www.twport.com.tw/en/cp.aspx?n=73EA6EF0477205D4

Villalba, G., & Gemechu, E. D. (2011). Estimating GHG emissions of marine ports-the case of Barcelona. *Energy Policy*, *39*(3), 1363–1368. https://doi.org/10.1016/j.enpol.2010.12.008

Winnes, H., Styhre, L., & Fridell, E. (2015). Reducing GHG emissions from ships in port areas. *Research in Transportation Business and Management*, *17*, 73–82. https://doi.org/10.1016/j.rtbm.2015.10.008

Yau, P. S., Lee, S. C., Corbett, J. J., Wang, C., Cheg, Y., & Ho, K. . (2012). Estimation of exhaust emission from ocean-going vessels in Hong Kong. *Science of The Total Environment*, *431*(1 August), 299–306.

APPENDIX 1

Proposed Framework for Systematic Implementation of a Vessel Speed Reduction (VSR) Program within any port-area

Table 1: Proposed Framework for Systematic Implementation of a Vessel Speed Reduction (VSR) Program within any port-area

Phase	Stage	Considerations/Measures	Remarks/Examples
PLAN	**Stage 1:** Pre-Program Appraisal		
	• Need for Emissions Reduction	Subject to: air quality in port area; port inside ECA or not; contribution of ships to emissions in port area; number of vessels visiting port; type of fuel used by vessels; etc. Establish: an emissions inventory; business-as-usual (BAU) scenario*.	VSR Program may be implemented as a stand-alone ECEEM or as part of an existing program. *To be used as a baseline for future evaluation of the Program.
	• Geographic Location	Asses wind direction and speeds; will ship emissions be blown landward*? Frequency throughout the year; population affected; etc. Does port location already cause ships to slow down to intended VSR speed limit**?	*If "No", no need for VSR. **If "Yes", no need for VSR.
	• Average Ship Speeds	Subject to: types of ships visiting port; frequency of visits; port location; etc. Determined using AIS/VTS data; etc.	If average speeds are less than intended VSR speed limit, no need for VSR.
	• Potential Partners	Port authority; Terminal operators; City municipality; Governmental agencies; Environmental groups (NGOs); Stakeholders; Local community; etc.	The more the Partners, the greater the commitment and the stronger the Program.
	• Potential Participants	Asses willingness of shipping companies to enrol in a VSR program after advising on possible advantages.	Although willingness may seem weak, actual participation usually is stronger.
	• Funding	Assess need of funds for; monitoring equipment*; running costs including provision of incentives**.	*e.g. AIS & Radar (if not already available); **May affect choice of Program incentives.
	Stage 2: Program Design		
	• Zone	Set the VSR zone(s) distance(s); measuring point; sectors; illustrative map; etc.	Typical zones: 20 nm, 40 nm

	• Speed limit	Subject to: types of ships visiting port; approach routes to port;	Typical speeds: 10 kts, 12 kts, 15 kts
	• Duration	Determine program start date; duration; running periods*; etc. Subject to geographical and operational considerations**; etc.	*e.g. all year; portion of year; specific periods; etc. ** e.g. prevailing winds, periods of high throughput; etc.
	• Eligibility Criteria	Subject to: port operational profile; ship emissions profile; typical ship speeds; etc., determine eligible ship types; ship size; excluded ships; enrolment procedures*; etc.	*Are eligible ships automatically enrolled? If not, is enrolment on a ship basis or company basis? And how?
	• Incentives Scheme	Determine types of incentives if any: incentive amounts/percentages; limits and caps; minimum compliance rate; progression of compliance rate; etc.	e.g. acknowledgment; honouring; discounts on port dues; cash refunds; cash rewards; etc. Typical incentives: 15%-30% discount on port dues.
	• Monitoring & Validation	Determine monitoring facilities and methods; requirements from participating vessels*; frequency of data collection; procedures for data validation; methods of publishing results; means of communication to ships/companies; procedures for re-evaluation requests; etc.	Typically, AIS; Radar; VTS stations. *e.g. requirement to have AIS on. Via website; email; written notice; etc.
	• Awarding of Incentives	Shall awards be issued on a ship basis or company basis? Determine procedures for awarding of compliant ships/companies; etc.	Typically awarded on a company basis.
DO	**Stage 3:** Pre-Implementation		
	• Announce Program	Communicate VSR Program details* and requirements to relevant stakeholders**; encourage potential participants to enrol (if required) in Program.	*including all information under 'Step 2'. **Shipping companies; agents; general public; NGO, media; etc.
	• Dispose Information	Make Program objectives, details and forms/documents readily available.	e.g. online via Port website/webpage.
	• Accept Enrolments	Accept enrolment forms/documents from participating vessels; forward to monitoring facilities.	Only required if enrolment is a prerequisite.
	Stage 4: Program Implementation		
	• Launch Program	Commence the Program on the announced start date.	Any modifications to the start date should be promptly announced.

	• Carry out Program	Implement and carry out the program as specified in the design stage.	
CHECK	**Step 5:** Program Review (KPIs)		
	• Ship Compliance	Number of companies/ships which have participated; compliance rate*; possible inclusion of other ship-types; etc.	May be conducted on an annual basis or less subject to awarding intervals. *e.g. on a yearly basis, is compliance rate increasing or decreasing? Why?
	• Program Effectiveness	Measure: possible VSR emissions reductions*; Assess effectiveness of: VSR zone limit, speed limits, duration, incentives, etc. Consider: need for optimizing port operational profile**.	*Compare to BAU baseline. **e.g. relocating vessel work assignments to VSR boundary.
	• Adequacy of Funds	Evaluate: adequacy of funds; possible resources; etc.	Are allocated funds adequate? More funds required? Possible resources?
	• Efficiency of Monitoring System	Evaluate: adequacy of monitoring facilities/capabilities; data collection and analysis; verification of data; outcomes of re-evaluation requests; need for automation/digitalization; etc.	e.g. Does frequency of AIS data need to be increased? Too many re-evaluation requests? Properly addressed?
ACT	**Stage 6:** Program Improvement		
	• Analyse Review Outcomes	Identify discrepancies, deficiencies and points of weakness; determine possible causes.	
	• Amend the Program	Make necessary changes and improvements to the program.	

The impact of applying smart ports requirements on the competitiveness of the Aden container terminal

Author: Capt. Mohamed Elhussiny, Email: housinymohamed766@gmail.com. Lecturer at College of Maritime Transport & Technology. AAST&MT, Alexandria, Egypt.
Co- author: Dr. Mohamed Amzarba, Email: muhammedalawi1977@gmail.com. AAST&MT, Alexandria, Egypt.
Co- author: Dr. Ahmed Ismail, Email: yaseenahmedismail@gmail.com. Deanery of Admission and Registration, AASTMT, Alexandria.

ABSTRACT:
Recently, the application of the smart port concept has become rapidly increasing and it is so important as it contributes to achieving sustainable growth. This research aims to identify the role of applying the concept of smart ports in enhancing the competitiveness of the Aden container terminal. This research will depend on the descriptive and analytical approach as the main method as it is the consistent and appropriate approach to achieve the objectives of the study as a descriptive and analytical study. To achieve the research aim; an electronic questionnaire form was conducted to reach the requirements of applying the modern technology sing SPSS analysis to extract conclusion and recommendation.

Key words: Digitalization, Competitiveness, Smart ports. Container terminals.

INTRODUCTION:
Container terminal ports in any country are the most integral link in the maritime transport process. In addition, it reduces the delay process and provides distinct services which increase the role of ports in distributing and importing & exporting goods. Strengthening the role of ports and increasing their competitiveness has become a necessity to keep pace with the rapid changes in the economic and technological aspects as the ports have focused on improving their business environment, understanding customer requirements, and developing strategic plans that enable them to provide distinct services from other competitors through continuous improvement and the development of modern technological methods to provide Integrated logistical services (Ismail, 2019).

Ports in any country are a basic and supportive pillar of economic development as they play an important role in enhancing trade, regional and international commercial exchange. Therefore, many countries have sought to develop the capabilities of their ports, enhancing their efficiency and improving the quality of services provided by ports to meet the current and future needs of customers. Also, many countries have sought to use information technology and communications to develop and improve the efficiency of their ports which leads to an increase in the total volume of cargo handling, reducing the costs, and reducing the period of stay of the ships at the port which enhances the port's competitive capabilities (Elsayeh, 2015).

Container terminals are the most integral link in the maritime transport process because containers reduce the delay time of the cargo handling process and provide distinct services which lead to maximizing the role of ports in distributing, importing, and exporting the goods. Strengthening the role of ports and increasing their competitiveness has become a necessity to keep pace with the rapid changes in the economic and technological aspects as the ports focused on improving their business environment, understanding customer requirements, and developing strategic plans that enable them to provide distinct services from other competitors through continuous improvement of production requirements, increasing the flexibility in dealing with customers and to develop modern technology to provide integrated logistical services (Elsayeh, 2015).

In recent years, the importance of implementing the concept of smart ports has increased as it contributes to achieving the sustainable growth of the infrastructure of transport, strengthening transport networks, and eliminating any bottlenecks to reach the distant markets as soon as possible.

The most prominent type of the ship's generations are container ships which started in the early sixties and at this time it had the maximum load of the container ship which did not exceed 500 containers. The container ships surpassed the traditional general cargo ships in saving operating expenses because they need relatively less time to complete both the loading and unloading process in the ports and the time of the loading and unloading of the container ships becomes only a few hours. All that depends on investment in modern technology and this type of investment in the maritime industry aims to the existence of environmentally friendly transport systems all over the world and all that can be provided by smart ports.

Recently, the importance of the smart port concept has increased strategically as it is the future trend in the maritime transport industry. The purpose is to strengthen transportation networks around the world, removing technical bottlenecks and barriers, and reach distinct markets in the least minimum time. All of these trends depend on the new technologies which aim to have global environmentally friendly transport systems (UNCTAD, 2019). The research focused on the Aden container terminal by analyzing its technical and service system by conducting an electronic survey.

The importance of the research is summarized in the following points:
1. Presenting a theoretical framework on smart ports, their importance, and the sources of achieving competitiveness in ports, which can be used by researchers and specialists in this field.
2. Highlight the importance of the role of the maritime transport and ports sector in the economic development of any country, and the need to enhance the port's competitiveness.

This research aims to identify the application level of the concept of the smart ports in the Aden container terminal and the extent of the availability of the requirements for the success of the application of the concept of the smart ports and to identify how to achieve competitiveness in Aden container terminal.

LITERATURE REVIEW

Alix (2017) defined the smart port as "more attractive and competitive than traditional ports". In the smart port a lot of effort, boldness, and creativity, and it also requires the presence of artificial intelligence technology, the Internet of things, extreme flow of data, and other technological solutions that make ports smarter in terms of the perfect flow of customer service management, also in the smart port monitoring and exchange data are used to make the best decisions, improve operations, make them more efficient and anticipate the best decisions but, all these transformations have become in their first steps so, the application of digital technology is not one of the most important considerations for the smart port only, but rather an approach relies upon it. The Port Authority also handles technical and technological issues and the challenge is to create environmental systems and societies of importance and smarter practices for the entire system.

The application of the smart port concept needs the following, according to (Aliywah and Abu Al-Azm, 2016).

1. Building a specific concept for a measurable smart port and continuous self-assessment by identifying its components then identifying the real challenges facing the transition towards a smart port. This concept includes a set of elements: environment, communications, technology, ownership, scope, management, human resources, regulations, law, tools, and security.
2. Analysis of the current position of the port's competitiveness capabilities and its growth trends help in determining the port's goal.
3. The competitiveness plan identifying the advantages and disadvantages associated with the concept of the smart port.
4. Developing a strategic plan to shift towards a smart port to exploit opportunities and contribute to the decision-making process.

As for the obstacles facing the future of maritime transport in smart ports, they were discussed by (ADEM, 2015) in two main groups as follows:

A. Lack or shortage of technological solutions
   1. Reducing fossil fuel consumption.
   2. Reducing the impact of ships on the environment.
   3. Solve the safety/security challenges facing ships, crews, passengers, and cargo handling.
   4. Lack of permanent monitoring and adaptive maintenance technology.
   5. Lack of effective production methods to improve competitiveness.

B. Regulating the socio-economic level
   1. Innovations adopted by the crews.
   2. The absence of collateral funds to support the risks that the ship-owner is exposed to.
   3. Lack of research capabilities and tests for maritime transport.
   4. Restrictions related to port infrastructure.
   5. Social acceptance of using of the new types of ships.
   6. Loss of national skills in some key/strategic areas.

As for the study (EL-SAKTY, 2016), it was shown that the concept of the smart ports in the world has become a basic feature for port organizations to serve as smart hubs in the global transport networks, as smart ports are the trend for long-term strategies in the future from now as the study aimed to know The goal of the ports to contribute to sustainable growth by creating the appropriate conditions to adopt the new models for energy sources management, the extent of their dependence on low environmental impact, and how to stimulate innovation in both technologies and processes. Three major issues for smart ports have been studied, which is the smart port logistics main plan. The main purpose of this study is to develop a smart logistical plan for the future. This research also aimed to address the problems in the logistical plan for the future of the smart ports, this requires discussing those criteria that affect the transformation of seaports to be smart in the future in return for addressing the challenges and obstacles facing smart ports and adding Vision 2050 to highlight the required plan for both authorities and stakeholders.

For the study (Alywa and Abu Lazm, 2016) which participated in the International Conference on Maritime Transport and Logistics at the Arab Academy for Science and Technology entitled: "The economic importance of information and communication technology in the smart ports which aimed to analyze the economic importance and the impact of using information and communication technology in improving the performance of ports and the national economy and discussing the experiences of some global smart ports and the uses of information technology of them to extract lessons learned for ports in Egypt and the Arab region. The researcher concluded that the use of smart applications is not sufficient to transform a port into a smart port. But other elements must be available in the port, as well as the information technology needs financial appropriations throughout the port, which needs to study the economic and financial feasibility, and analyze the benefits/cost to ensure the provision of funding sources that can be provided by the private sector. Information technology applications need to develop the human element tools while continuing to qualify it to deal with technology development, and also the information technology has a significant impact on all indicators of the tools which are reflected at the national level.

The researcher recommended the importance of paying attention to the information and the communication technology in the administrative operations and improving the environmental management system to achieve the integrated concept of the smart port, achieving sustainable development, updating information technology with the port, and connect them to an electronic network to ease the procedures.

(Boresh, 2017) explained that there is a great role for the modern technology in improving the port services, from reducing the time of cargo handling and the time of ship operations at port to safe and accurate movement and handling of goods whether, at port or in the hinterland area, and many electronic applications have emerged contributing to its role in developing many services in the port, and in this context, the problem of research came to an answer of the possibility of using modern technology in the port and its effectiveness in improving management.

The research also aimed to highlight the relationship between operations and the use of modern technology in management as, it is observed from the experiences of many ports that the use of electronic applications will contribute to the improving of the port's performance, and exploiting the best resources available in the port. The hypothesis has been formulated that there is a strong relationship between the use of the technology and the increase in the port's performance, and that improving the conditions for exploiting the pillars of electronic management which will lead to the discovery of more skills at the level of seaports, and the use of typical electronic applications which will accelerate the access of ports to the maritime global trade and container transportation.

(Kang and Kim, 2017) concluded that the ports can improve their operational efficiency through various practices including system automation, port area utilization efficiency, improving container routing, and providing facilities for the companies to maximize their performance. In addition, the integrations in information technology or the systems can simplify procedures such as, electronic data exchange (EDI), integration of information and communication technology integration, and joint ventures that can reduce ship delay times, and including benefits related to the operational efficiency of ports, efficient use of resources and energy and also, to save costs by improving operational efficiency.

As for the study (Leonard et al., 2017) it dealt with the importance of digital transformation and the impact on the maritime transport industry where, ports and logistics are part of the supply chain in the maritime transport industry and are greatly affected by these technological changes due to, an increase in logistics services requests such as the increase of costs, efficiency, security and sustainability, and these digital developments are essential to maintain competition in light of the rapid technological changes that help to provide flexible and smooth services in port operations.

According to (Al-Bishi, 2010) The research problem centered around the weakness of the competitiveness of the port of Aden compared to the regional ports. It aimed to study the competitive potentials that the port of Aden possesses and to identify the weaknesses and strengths in the port of Aden. The study also discussed the natural specifications of the port of Aden, and the method of management to be followed in the port, and the efficiency of human resources, and focused on the importance of developing a general plan for the development and modernization of the port of Aden based on the logistical concept of the port's activity.

The study concluded that the port's services are so weak and do not keep pace with developments in the maritime transportation sector and the modern reasons to keep up with the global trade trend, and also to take into consideration the importance of carrying out strategic logistical planning and to identify the priorities of the multiple objectives of the activities of Port of the Aden to advance the port's activity, and also the study recommended the necessity of conducting the studies and the strategic plans to develop the capabilities of the port of the Aden and work to implement them, the need to develop human resources and increasing the investment spending by monitoring financial allocations for the development of Port of the Aden in the state budget.

According to (Saeed, 2012) the study assessed the competitiveness of the Aden Container Terminal by comparing the competitiveness components of the Aden Container Terminal with the competitiveness factors of the container terminals in the competing ports (Jeddah Port, Djibouti Port, Dubai Port, and Port Said Port). The study concluded that the competitiveness of the maritime ports is based on a set of internal and external components and the internal factors are represented by the infrastructure of berths, depths, and stores as well as, the superstructure of the equipment and information systems, and the study also found the Aden container Terminal is less competitiveness comparing to other competing ports (Jeddah, Djibouti, Dubai, and Port Saeed Port) in terms, of the level of potential, performance, and market share. The study recommended the need to develop a comprehensive strategic plan for the Aden Port in general and the container terminal in particular to enhance the competitiveness of the port and to accelerate the development of the Aden container Terminal in line with developments in the shipbuilding industry to attract ships of the new generations and compete to attract transit containers.

In this context, Arasa (2014) aims to highlight the economic and strategic importance of Port of the Aden due to its global position, and to study the state of prosperity and stagnation of the port and compare its stagnation in comparison with regional, and global ports by studying the statistical indicators that reflect the port's performance in terms of ship, and cargo movement the amount of fuel and water provided to ships and use statistical methods to measure port activity and predict the port activates until 2030.

Qardash et al., (2021) aims to study and analyze the causes of the decline in the competitiveness of Aden container terminal and identify the shortcomings and weaknesses during the period from 2015 to 2020, to propose a framework that would contribute to enhancing the competitiveness of Aden container terminal compared to similar container terminals located in the western Arabian Sea region Gulf of Aden and the Red Sea. This research is classified as an analytical qualitative and descriptive research that depends on making comparisons and analyzing them, where the competitiveness of Aden container terminal was analyzed through using SWOT analysis matrix.

Gap Analysis and Contribution:

Previous studies conclude that in general, they focused on the necessity of having strategic plans, and studies enhancing the role of human resources, improving management, using the specialized private sector, and working in a partnership aimed to improve the quality of services of the Aden Port in its all facilities and sectors and to deal with them. The previous studies were also distinguished by their limitations and timeliness because of the constant revolutions and the constant internal conflicts, which led to the lack of interest of the concerned authorities in developing and raising the competitiveness of the Aden container Terminal.

The conflict in Yemen has displaced more than one million people and given rise to cholera outbreaks, medicine shortages, and threats of famine. The United Nations calls the humanitarian crisis in Yemen "the worst in the world.". On 26 April 2021 a key report, Damage, and Capacity Assessment: Port of Aden was released by the United Nations Development Programme (UNDP) in Yemen that outlines urgent capacity and infrastructure needs of the Port in Aden to help keep the world's potentially largest famine in 40 years at bay.

All these lead to the result that very few scientific papers discussing the competitiveness of the Aden container terminal due to the negative effect on Yemeni ports generally and the Port of Aden especially.

RESEARCH PROBLEM

The comprehensive concept of smart ports depends on its strategic importance on the ability and the efficiency of operation and the optimal use of the information and the energy as well as improving the competitiveness but the application of smart ports requires concerted efforts and capabilities that contribute to achieve and to apply the concept of the smart ports. Adopting the smart approach and developing the port infrastructure leads to enhance the competitiveness of ports through excellence in the services provided and reducing costs. Hence the idea of the research is to identify the requirements for applying the concept of smart ports and test their ability to enhance the competitiveness capabilities of the Aden container terminal. We can highlight the study problem in the following question:

What is the effect of applying the concept of smart ports on increasing the competitiveness of the Aden container terminal? The main question is divided into the following sub-questions:

1. What is the possibility of the application of the smart port concept in the Aden container terminal?
2. What is the level of competitiveness at the Aden container terminal?

RESEARCH METHODOLOGY

In achieving the goals of this study, the researcher will depend on the descriptive and the analytical approach as the main method, as it is the consistent and appropriate approach to achieve the objectives of the study as it is a descriptive and analytical study. To, achieve the desired goals of this study a questionnaire is used to apply modern technology, and the questionnaire is distributed and transmitted by the SPSS program to reach the requirements for applying modern technology and follow statistical methods to draw conclusions and recommendations (Neuman, 2014).

EMPIRICAL ANALYSIS AND DISCUSSION:

Cronbach's alpha coefficient is used to measure the reliability of the questionnaires in the scientific papers. Credibility and reliability are among the most important topics of concern to the researchers in terms of their impact on the relevance of the research results and their ability to publish the results. Reliability and consistency are related to the tools used in the research, and their ability to accurately measure the readings taken from these instruments. (Cronbach's alpha) is used to calculate reliability coefficients for the survey tools that use response groups of the Likert scale type, whether it is triple, pentagonal or heptagonal, the Cronbach's alpha value ranges from zero to one with higher values indicating that the elements measure the same dimension. Conversely, if Cronbach's alpha is low (near 0) then, that means that some or all of the elements are not measured in the same dimension. There may be negative numbers as well, where a negative number indicates that there is something wrong with the data. Acceptable Cronbach's alpha values are 0.70 and above which is good.

An electronic survey was conducted as shown in attachment No. (1), and 228 electronic surveys were responded to. The necessary analyzes were made, and according to the analysis of the research, the Cronbach alpha analysis in all dimensions used in the questionnaire was close to the correct number. There are no negative numbers and it is higher than 0.5. As shown in the following table No. (1):

Table No. (1) Cronbach alpha analysis

Cronbach alpha analysis	
0.835	The general direction of the management of the Aden container terminal
0.826	The impact of implementing the concept of smart ports on meeting the needs of customers in the Aden container terminal
0.721	The impact of applying the concept of smart ports in the Aden container terminal on sustainable development
0.827	The impact of implementing the concept of the smart port on the marketing aspect of Aden container terminal
0.833	The impact of implementing the concept of smart ports of Aden container terminal on the economic side
0.808	The complete questionnaire

When analyzing the years of experience, it becomes clear that the percentage of the categories of less than five years concerning the years of experience was 25%, the percentage of the categories from five to ten years concerning the years of experience was 15%, the percentage of the categories from ten years to fifteen years concerning the years of experience was 15 %, The percentage of the categories from fifteen years to twenty years concerning the years of experience was 25%, the percentage of the categories of more than twenty years concerning the years of experience was 20%.

When, analyzing the employers who answered the questionnaire it was found that the most percentage of the questionnaires that were answered was in the category of port management by 45%, followed by the category of workers at the port by 31%, followed by external customers by 11%, and shipping agents by 10%. While the lowest percentage of customs brokers at a rate of 3%. As for, the analysis of the percentage of holders of higher degrees and the knowledge of the certificates obtained by all respondents to the questionnaire the following shows that the most percentage of the questionnaires that were answered were those with a bachelor's degree by 55%, followed by those who obtained a master's degree at a rate of 20%, followed by the recipients. With a doctorate by 9%, and finally those with a diploma or any other certificates by 16%.

When, analyzing the general trend of the port administration it was found that the percentage of respondents strongly agree with the first question 72.81% while, the percentage of respondents who do not agree 3 reached 1.32%. The percentage of respondents who strongly agree with the second question is 69.30%, while the percentage of respondents who do not agree is 1.32%. The percentage of respondents who strongly agree with the third question is 79.82% while, the percentage of respondents who do not agree is 1.75%. The percentage of respondents who strongly agree with the fourth question is 73.25% while, the percentage of respondents who do not agree is 2.19%. The percentage of respondents who strongly agree with the fifth question is 78.07% while, the percentage of respondents who do not agree is 1.32%. The percentage of respondents who strongly agree with the sixth and last question is 77.63% while, the percentage of respondents who do not agree is 0.88%.

When analyzing the impact of applying the concept of smart ports on meeting the needs of customers, it was found that the percentage of respondents strongly agreeing to the first question is 76.32% while, the percentage of respondents who do not agree was 1.32%. The percentage of respondents who strongly agree with the second question is 72.81%, while the percentage of respondents who do not agree is 0.88%. The percentage of respondents who strongly agree with the third question is 77.19% while, the percentage of respondents who do not agree is 0.88%. The percentage of respondents who strongly agree with the fourth question is 71.05%, while the percentage of respondents who do not agree with 2 is 0.88%. The percentage of respondents who strongly agree with the fifth question is 76.75%, while the percentage of respondents who do not agree is 0.88%. The percentage of respondents who strongly agree with the sixth and last question is 77.63%, while the percentage of respondents who do not agree is 1.32%.

When analyzing the impact of implementing the concept of smart ports, applying the concept of sustainability, it was found that the percentage of respondents who strongly agree to the first question is 80.70%, while the percentage of respondents who do not agree is 1.32%. The percentage of respondents who strongly agree with the second question is 73.25%, while the percentage of respondents who do not agree is 0.88%. The percentage of respondents who strongly agree with the third question is 76.75%, while the percentage of respondents who do not agree is 0.88%. The percentage of respondents who strongly agree with the fourth question is 74.12%, while the percentage of respondents who do not agree is 0.88%. The percentage of respondents who strongly agree with the fifth question is 76.75%, while the percentage of respondents who do not agree is 0.88%. The percentage of respondents who strongly agree with the sixth and final question is 77.63%, while the percentage of respondents who do not agree is 0.88%.

As revealed from the analysis of the impact of applying the concept of the smart port on the marketing side, the percentage of respondents who strongly agree to the first question is 77.19%, while the percentage of respondents who do not agree is 1.32%. The percentage of respondents who strongly agree with the second question is 78.51%, while the percentage of respondents who do not agree is 0.88%. The percentage of respondents who strongly agree with the third question is 80.70%, while the percentage of respondents who do not agree is 0.88%. The percentage of respondents who strongly agree with the fourth question is 79.82%, while the percentage of respondents who do not agree is 1.32%. The percentage of respondents who strongly agree with the fifth question is 79.82%, while the percentage of respondents who do not agree is 0.88%. The percentage of respondents who strongly agree with the sixth and last question is 84.21%, while the percentage of respondents who do not agree is 1.32%.

The analysis of the concept of smart ports on the economic side revealed that the percentage of respondents who strongly agree with the question is 75.44%, while the percentage of respondents who do not agree is 1.32%. The percentage of respondents who strongly agree with the second question is 74.56%, while the percentage of respondents who do not agree is 0.88%. The percentage of respondents who strongly agree with the third question is 77.63%, while the percentage of respondents who do not agree 2 reached 0.88%. The percentage of respondents who strongly agree with the fourth question is 80.26%, while the percentage of respondents who do not agree is 0.88%. The percentage of respondents who strongly agree with the fifth question is 80.26%, while the percentage of respondents who do not agree is 0.88%. The percentage of respondents who strongly agree with the sixth and last question is 78.07%, while the percentage of respondents who do not agree is 1.32%.

CONCLUSION:

When analyzing the general trend of the port administration toward applying smart port concept we found that it takes the first value according to Cronbach alpha analysis, but the impact of applying the concept of smart ports in the Aden container terminal on sustainable development takes the least value the Aden container terminal management should develop the port executing expansion projects in the storage area of the container terminal supplying the terminal with advanced and high-tech equipment capable of serving giant container ships and thus raising handling rates, global marketing of container terminal services giving intensive training and qualification courses for local workers to reach their place in which they will be able to operate and market the activities of the container terminal in a regionally competitive manner necessity to search for funding for the port's development projects, the first and most important of which is the deepening and expansion of the shipping channel which has become one of the obstacles and the most prominent of which is to receive giant ships for the container terminal in the Aden port. For further research, it should analyze the impact of participating private sector. Also, there should be studies to find out how to increase the competitiveness area of the Aden container port.

REFERENCE:

Adam, C. (2019) "Architectures in the IoT Civilization", https://www.netburner.com/learn/architectural-frameworks-in-the-iot-civilization.

Alix, Y. (2017). "What is a smart port, Paris Innovation Review", http://parisinnovationreview.com/articles-en/what-is-a-smart-port

EL-SAKTY, K. (2016) "Smart Seaports Logistics Roadmap, College of International Transport and Logistics", Arab Academy for Science, Technology and Maritime Transport.

Elsayeh, M. (2015) "The impact of port technical efficiency on Mediterranean container port competitiveness", Ph.D. Thesis. University of Huddersfield.

Ismail, A. (2019) Benchmarking the Efficiency of the Egyptian Container Terminals, Ph.D. Thesis. Arab Academy for Science Technology and Maritime Transport.

UNCTAD (2019) "*Review of Maritime Transport*", United Nations. New York.

Saxon, S. and Stone, M. (2017) Container shipping: The next 50 years, Travel, Transport & Logistics, pp. 1-36.

Neuman, W. L. (2014) "Social Research Methods: Qualitative and Quantitative Approaches", 7th ed. Pearson.

Kang, D. and Kim, S. (2017) "Conceptual Model Development of Sustainability Practices", The Case of Port Operations for Collaboration and Governance. Sustainability, 9.

Leonard, H, Silvia, S., and Stefan, Vo. (2017) " An Analysis of Digital Transformation in the History and Future of Modern Ports", Proceedings of the 50th Hawaii International Conference on System Sciences.

A simulation model for analyzing and optimizing container-terminal operations

Mohamed M. Faragalla
Ph.D. of applied statistics, Port Said University.
Computer operator at West Port Said Container Terminal (PSCCHC).
Faragalla2018@gmail.com

ABSTRACT:

Generally, the main objectives of container terminals are decreasing the operating duration of vessels and achieving the maximum possible usage of resources to decrease the operating costs in parallel. Somewhere between these conflicting objectives, a compromise point need to obtained. This research aims at creating a discrete event simulation model to mimic the equipment deployment optimization problem of Port Said Cargo and Container Handling Company (PSCCHC) in short-term planning. This optimization problem looks like a closed network queueing system. The virtual vessel Princess of Port Said (PPSD) is assumed as a heavy workload case study. ARENA software is used in modeling this problem under the storage rules in (PSCCHC). Experimental results revealed the distinguished abilities of the proposed discrete event simulation model in exploring the details of the mentioned problem and obtaining the optimal solution.

KEYWORDS:

Container terminals, Discrete event simulation modeling, arena package, PSCCHC, deployment optimization problem, Planning in container terminals.

INTRODUCTION:

Container terminals consist of three main parts berth, yards, and gates where each of them has its subsystem, where a set of operations in those subsystems are performed daily. These operations can be container handling operations from vessels or from outside through gates toward the storage areas and vice versa or others. On the quayside, containers are loaded/unloaded from vessels. After unloading, containers are stacked in temporary buffers which are divided into several blocks called yards. Special storage areas, yards, are reserved for reefer containers, which are supported by electrical supplies for cooling, another area for containers that contain hazardous. Truck and train lines link the terminal to outside through the gates. When containers reach the terminal, they are classified and registered in the computer database, picked up using handling equipment, and distributed to storage points in the yards according to a predesigned storing plan [6, 12] (see Figure 1).

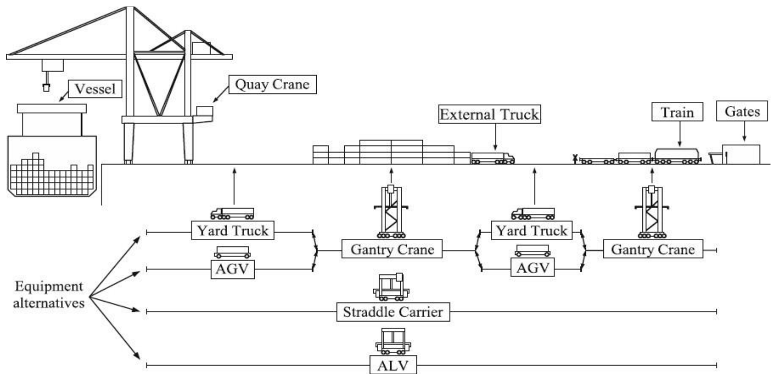


Figure (1) Subsystems in container terminals

Source [14]

Figure (1) generally shows the basic schema of container terminals and details the subsystems in each part of the container terminal. Indeed, the main targets in any container terminal are to (1) use a minimum number of facilities in each operating cycle as a way to reduce the idle time of each piece of equipment separately as much as possible, consequently achieving the maximum benefit from using that equipment through its working life in the terminal, and then reducing operating costs, in parallel to (2) achieve the lowest possible operating time as a way to obtain vessels' owner satisfaction, and then attract more customers and gain more profits [14, 13].

In this paper, if the mentioned system is seen as a closed queueing network system where quay cranes, yard cranes are considered servers and tractors are customers, there will be a chance to control the basic variables and simulate this system using ARENA simulation software. Accordingly, many benefits can be gained from simulating that system such as predicting (a) bottlenecks points, (b) the needed time to finish a handling mission, (c) equipment utilization percentages, and (d) the effect of pumping more tractors in the working cycle and other benefits. Consequently, by adjusting these variables in the discrete event simulation schema, the main objectives of PSCCHC can be achieved gradually, as much as possible.

SIMULATING THE DEPLOYMENT OPTIMIZATION PROBLEM:

The deployment optimization problem is considered one of the optimization problems which could be applied in many industrial and service fields. In container terminals, the deployment optimization problem is the problem that relates to the optimal decision of distributing handling equipment in quayside, gates, and yards, where it is believed that the key to successful handling missions is fulfilled through the wise equipment deployment decision.

The most famous of these equipment are quay cranes, yard cranes, and tractors. On the other hand, the equipment deployment method can be seen as a tool that controls the tradeoffs between the two main interwoven objectives of any container terminal [11, 9]. hence, the importance of optimal equipment deployment decision becomes clear where it must be taken by terminals' administrators to overcome problems that may occur during real-time operating. Those operating problems might be congestion, equipment low utilization percentages, long queues in front of cranes, and others [8]. In reality, the equipment deployment optimization problem gets more complicated in conjunction with the continuous development of container vessels of larger capacities [14]. Thus, it is becoming an urgent need to support planning systems in the container terminal by one of the recent effective scientific methods.

Logically, in container terminals, vessels' operating duration is inverse proportion to the existing number of handling equipment in the system. But, with more additions of this equipment, the system is expected to reach saturation case. Furthermore, this uncontrolled amount of equipment will increase dramatically the operating cost without realizing a real benefit in reducing the operating time of the vessel. On the other hand, the intensifying workload on specific yard cranes leads the system to disruption in a bottleneck that is represented in long queues in front of these mentioned cranes and consequently traffic congestion in certain points in yards. Thus, the equipment deployment optimization problem is designed to get the optimal quantities of equipment in each working point which does not bring the system to the saturation case, long queues, or traffic congestion.

Note, in the closed queueing network system, there are a fixed number of customers move between some servers. At each server, a service is provided that takes some time. customers approach the servers and processing immediately if the server is idle. Otherwise, customers line up in front of the server and wait to receive service as seen in (figure 2) [7].

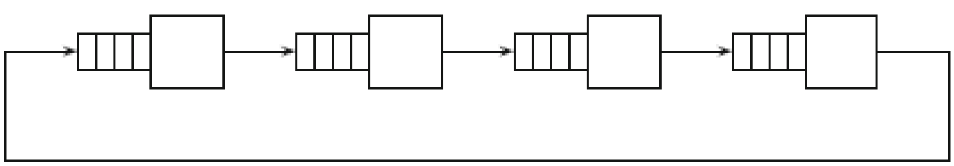


Figure (2) Schematic of closed queueing network system

Source [7]

Figure (2) shows the schema of closed queueing network and customers accumulation locations in such a system. The discrete event system is considered one of the most famous methods that are used to study the behavior of complex systems that have discreet variables such as the closed queueing network. So, if the container terminal system is seen as a closed queueing network system, the simulation technique will be done by modeling the system using computer software such as ARENA for adjusting the system variables and thus studying how changes of values affect the outcomes [1, 17, 15].

PROBLEM OF THE STUDY:

Actually, in PSCCHC, there are fixed rules in storing the discharged container from vessels, the basic parameter of the simulation model, where the containers are classified. Local containers are stored in five main areas called (EXT, YD1, HM2, YD2, and HML), this classification is conducted according to the kind of goods and customs procedures. Also, specific yards for transit containers are called (OLD YARD, MULTI, and NEW). Empty, reefers, and hazardous containers are stored in other equipped yards. In addition to the storage rules, another parameter must be taken into account, PSCCHC has an irregular layout which sometimes needs a long distance to be crossed by tractors, that might reach up to 2.2 K.M, to reach sprawling locations such as EXT, YD1, and HM2 yards compared with other yards. After vessels dock the berth, each container is conducted to a specific storage yard according to the mentioned storage rule. But unfortunately, sometimes, quay cranes are seen idle waiting of tractors while such tractors waiting in a long queue in front of a specific yard crane. Other times, a lot of tractors are seen in queues in the system or the system at all idle because of the little number of tractors in it and other cases. Finally, it's believed that the equipment deployment system of PSCCHC lacks a scientific rule to distribute yard cranes and tractors, and thus it needs a solution for such an equipment deployment optimization problem.

Therefore, this paper utilized a discrete event simulation technique to design a deployment plan of yard cranes and tractors depending on the number of containers that are planned to be stored in each yard according to the mentioned storage rules in PSCCHC. This designed plan aims at performing the discharge mission with the lowest amount of equipment to save operating costs in parallel with obtaining the fastest possible operational performance to satisfy customers. ARENA software is used for modeling the mentioned deployment optimization problem.

Literature Review:

1. The study conducted by Dragović, Tzannatos, and Park (2017) presented a review of the available research that addressed simulation models in ports. The review covered published journal papers that are relevant to simulation modeling in a period of 54 years (1961–2015) with a focus on container terminals. It was found that most of the research in such a field addressed operations research especially simulation modeling because of its

capabilities of offering integrated solutions in sector-specific transport and maritime. It was noted that more than 20 % of simulation models were built in ARENA [3].

2. The study conducted by Rusca, Rusca, Popa, and Rusca (2018) focused on the problem of designing a new port taking into account the non-uniform arrival rate of vessels and in-land tractors. Discrete event simulation was used for investigating the berthing capacity of the terminal. If the storage buffers were seen as a queuing system, the quality serving attributes would be evaluated. The discrete simulation model was developed in ARENA software. The results confirmed the abilities of the designed models in decision-making [16].
3. The study conducted by León, Angeles, Muñoz, and Samaniego (2020) addressed constructing a discrete event simulation model for evaluating the expansion of a container terminal. The expansion plan involved adding a new berth and new storage space. The results showed the new berth may increase the workload. Accordingly, the terminal must add new storage space either in the terminal or at an external facility for expected demands of over 140% [10].
4. The study conducted by Clausen, Kaffka, and Meier (2012) examined the outcome of the flow of the operations in container terminals where different scenarios were simulated. Changes in different inputs were performed to measure their impact on the outputs which are throughput, resource utilization, and waiting times. A discrete event simulation model was developed using Arena 14.0 to model the system taking into account the incoming and outgoing number of vessels, trucks, trains, and containers. The aim was to model the path of containers from arrival to departure [2].
5. The study conducted by Faragalla (2012) addressed the problem of discharging the containers in transit yards in PSCCHC. A multi-objective optimization problem was used to model the problem. A large stochastic process was conducted to find out the Pareto optimal line using genetic algorithms. Visual basic package with access databases was used to investigate the Pareto line. The results revealed the success of the model in optimizing such problems [4].
6. The study conducted by Faragalla (2017) focused on the optimization problem of yard crane deployment in storage yards in PSCCHC. A closed queueing network system was used to model the problem. Operational laws were used to solve the model using the visual basic.net package. The results showed the distinguished benefits of the proposed model in optimizing the problem [5].

The previous literature review showed the importance of using scientific methods in all planning levels, long, tactical and operational in container terminals which have been divided into three main parts (quay, yard, and gate). Indeed, many optimization problems are analyzed and solved to improve the performance in each part of the container terminal using operation research methods which are widely featured in this field research for decades. In long-term planning, the research addressed constructing new container terminals (Rusca, Rusca, Popa, and Rusca 2018) or extending existing (León, Angeles, Muñoz, and Samaniego 2020). In tactical planning, the path of the container inside the terminal was concerned (Clausen, Kaffka, and Meier 2012). In operational planning, the most frequent question was how to decrease the operating time of vessels as much as possible (Faragalla 2017). The discrete event simulation technique was used many times in literature to simulate problems and the problems were often modeled to be mimicked using the ARENA package. According to the author's knowledge, this research addresses the deployment optimization problem in the PSCCHC which has unusual details as mentioned previously. On the other hand, the human element has merged in the optimization process by adjusting variables manually to observe the effects of each change on results, as a way to more understanding the infrastructure parameters and the working variables in the PSCCHC.

THE PROPOSED MODEL:

As mentioned above the main targets in the container terminal are to recruit a minimum number of facilities to reduce costs, and to achieve the lowest possible operating time to satisfy customers, both in parallel. In the case of this study, a virtual vessel called the Princess of Port Said (PPSD) is designed with a heavy workload to prove the efficiency of the proposed simulation model. 920 containers are planned to be discharged in PSCCHC from the PPSD vessel and are stored in 6 storage blocks, according to storage rules in PSCCHC, as seen in (Table-1). Recruiting three quay cranes, to discharge the mentioned 920 from PPSD, is important to finish the work in an acceptable time without overlapping between quay cranes' missions, as seen in (Table-2). According to PSCCHC rules, the distance is evaluated at about 40 feet between the nearest two quay cranes.

TABLE (1) THE NAMES OF **storage blocks and the number of containers that will be stored in them**

BLOCK NAME	Container number
EXT	327
HM2	66
MLT	147
NEW	86
YD1	139
YRD	155
SUM	920

Source: Original

Table (2) the number of containers that will be discharged by each quay crane

QUAY CRANE NAME	Container number
QC10	304
QC11	316
QC12	300
SUM	920

Source: Original

Table (1) shows the names of the chosen blocks and the assigned number of containers that will be stored in them. Table (2) shows the names of quay cranes and the number of containers that will be discharged by each one, from the PPSD. From here, the objectives and constraints of the proposed model can be summarized as

Objectives

(1) Minimizing the average idle percentages of quay cranes, to ensure the lowest operating time for the vessel PPSD in PSCCHC.

(2) Minimizing the recruited number of handling equipment in the operating processes to ensure the lowest operating cost.

Constraints

(1) Respecting the storage rules in PSCCHC.

(2) overcome all bottlenecks in the system.

The Simulation Model Algorithm:

1. Identifying and classifying the discharged containers from PPSD data. Accordingly, the target yards with the number of containers that are required to be stacked in it will be known, according to storing strategy in PSCCHC. (Satisfying the first constraint).
2. Determining the required logical working time that is needed to finish operations at PPSD.
3. Starting the simulation model by adding only a one-yard crane at each storage yard and a very little number of tractors. (Achieving the second objective).
4. While the simulation is conducted (25 iterations) the results, especially utilization percentages and queues in front of yard cranes in the yards, are monitored. If a bottleneck appears in the system add one more yard crane in the bottleneck point and repeating step4. (Satisfying the second constraint).

5. If the required working time and little average idle percentages of quay cranes are satisfied, (Achieving the first objective), the simulator exits from the system and adopts the last results, otherwise adds one more tractor to decrease working time and moves step 4. If more results are needed to investigate more facts about the system in the PSCCHC add more tractors to the simulation model.

RESULTS:

1. the test of fit for quay cranes, yard craned, and tractors

The input analyzer package, using the Kolmogorov-Smirnov test and also the Chi-Square test, is used to perform the test of fit for the working rates of the quay cranes (QC10, QC11, and QC12) at PSCCHC. The result showed the triangular probability distribution TRIA (2.45, 2.84, 3) as shown in (Figure-3). Another test of fit is performed for the working rates of the yard cranes in PSCCHC. Results showed the triangular probability distribution TRIA (4.11, 4.9, 6) as shown in (Figure-4).

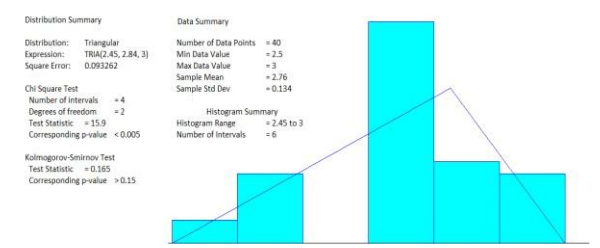


Figure (3) Result of the test of fit for working rates of quay cranes

Source: the input analyzer package

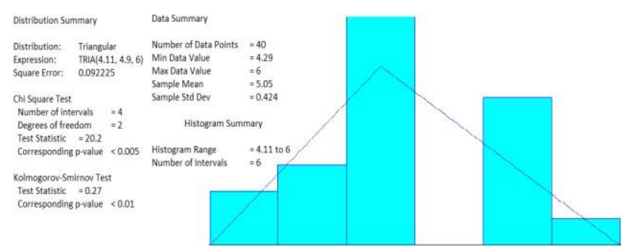


Figure (4) Result of the test of fit for working rates of yard cranes

Source: the input analyzer package

Figure (3) and figure (4) show the resulting graph for the test of fit which investigates that both working rates of quay cranes and yard cranes belong to triangular probability distribution respectively. After that, the tractor speeds in the PSCCHC are sampled by counting how many minutes are needed by a tractor to cross 1 km. These observations were carried out when the tractors were carrying containers and again without where 40 observations are collected in both cases separately. The test of fit shows that the tractor speed probability distribution followed Long-Normal Probability Distribution. 3.4 + LOGN (0.857, 0.511) and 1.7 + LOGN (0.417, 0.238) when tractor is loaded or empty as shown in the following (Figure 5) respectively.

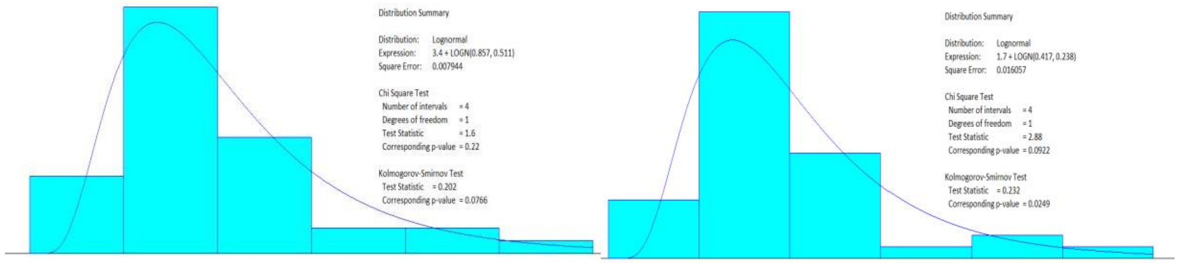


Figure (5) Result of the test of fit for working rates of loaded and unloaded tractors respectively

Source: the input analyzer package

Figure (5) shows the graph for the results of the test of fit for the working rate of loaded and unloaded tractors respectively where Long-Normal Probability Distribution is investigated in both cases.

2. Simulation Results

The discrete event simulation model is performed where 25 iterations are run for each try. The target addressed investigating the most possible facts about discharging 920 containers in PSCCHC from the virtual heavy workload vessel PPSD. It is already noted from the first try, 3 tractors only, the yard crane in the EXT yard had a significantly higher utilization percentage compared with others. 327 containers which represented 35.5% of total discharge are planned to store in EXT only, according to storage strategies in the PSCCHC.

This notice predicted a large bottleneck in the EXT yard by injecting more tractors into the system. Thus, another yard crane is assigned in the EXT yard. Therefore, the equipment deployment decision was amended to continue the simulation with a pair of yard cranes in the EXT yard instead of one. After that, the experiment continued with adding one tractor in each new try and the operating time is decreased gradually until 24 tractors been in the system. In this point, it is noted that the system became saturated with tractors, where adding more tractors will not either decrease the work time or average idle percentage of quay cranes concretely, the author's opinion. This situation caused congestion and queues in the system. The results of the experiment can be summarized in (Table-3) and the graph of the two main interwoven targets of PSCCHC can be shown in (Figure-6).

Table (3) Simulation results

TRACTORS	TIME	IDLE PERCENTAGE	TRACTORS	TIME	IDLE PERCENTAGE
30	15:19:00	6.93%	**16**	16:45:39	15.71%
29	15:18:30	6.97%	**15**	16:58:20	16.76%
28	15:21:30	7.66%	**14**	17:20:42	18.59%
27	15:22:10	7.99%	**13**	17:56:55	21.34%
26	15:24:40	8.04%	**12**	18:56:53	23.74%
25	15:29:21	8.86%	**11**	19:22:00	27.09%
24	15:32:35	9.16%	**10**	20:31:50	31.16%
23	15:39:12	9.48%	**9**	21:59:58	35.76%
22	15:44:33	9.81%	**8**	23:56:49	41.00%
21	15:53:2	10.68%	**7**	26:52:00	47.43%
20	15:55:45	11.06%	**6**	30:35:59	53.86%
19	16:01:12	11.82%	**5**	36:00:30	60.77%
18	16:12:36	12.48%	**4**	44:24:20	68.19%
17	16:22:32	13.74%	**3**	58:29:25	75.86%

Source: Original

Table (3) shows the decreasing of average idle percentages of quay cranes and total expected working time with increasing of tractors number in the working cycle.

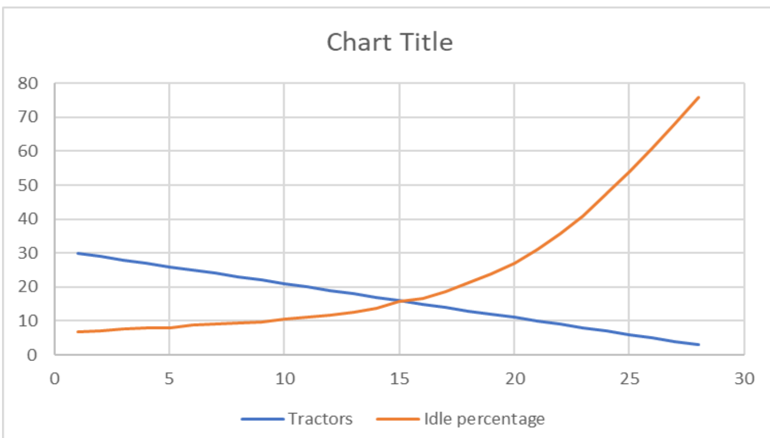


Figure (6) The graph of two main targets in PSCCHC

Source: Original

Figure (6) summarizes the presented data in table (3) and shows that the intersection point of objectives is in 15 tractors, 3 quay cranes, and 7 yard cranes with16.76% of average idle percentages for quay cranes. Sometimes, in the PSCCHC the lowest working time is preferred than any other considerations due to the crossing operations in the Suez Canal and the opposite case when time is not important. In those cases, the decision-maker can adopt any other plan listed in table (3) where 28 equipment deployment plans are presented with different results. The utilization percentages of each crane of the optimal solution can be summarized in (Figure-7).

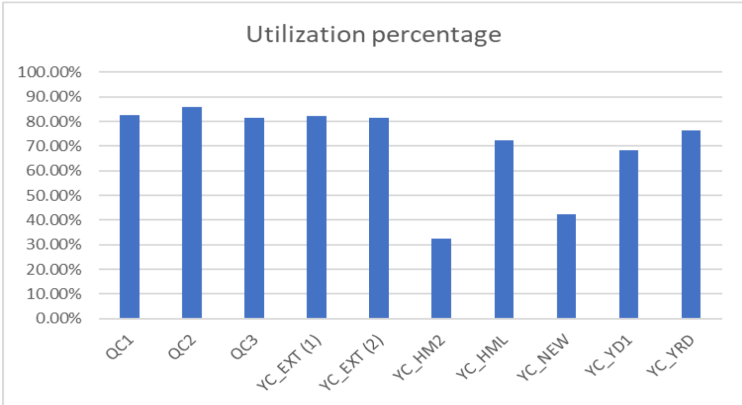


Figure (7) The utilization percentages of the contributed cranes in the optimal solution

Source: Original

Figure (7) show the utilization percentages of all quay and yard cranes if the plan of 15 tractors, 3 quay cranes, and 7 yard cranes is adopted in the case of PPSD.

CONCLUSION:

This paper used the discrete event simulation technique to provide a scientific solution related to the equipment deployment problem in (PSCCHC). The container's discharge system was analyzed, and it was seen as a large closed queueing network system. Through this vision, both yard and quay cranes were considered as servers, and tractors were customers in the closed queue network system. Thus, two main conflicting objectives appeared and were studied in the short-term planning area (1- using the lowest possible equipment number vs 2- achieving the lowest idle times of quay cranes). The constraints in the proposed model worked under the respect of the storage rules in (PSCCHC) and commitment to overcoming bottlenecks with the lowest possible number of yard cranes. Arena simulation package was used in modeling the mentioned complex optimization problem.

A virtual vessel (PPSD) with a heavy workload (920 containers) was assumed to test the proposed simulation model. Tests of fit were performed to investigate the working rates of equipment in the (PSCCHC). Thereafter, 28 experiments were performed by adding one tractor in each trial to decrease the working time on the (PPSD), but under the set constraints. Experimental results showed the efficiency of the proposed discrete event simulation model in getting a logical solutions space for the equipment deployment problem that related to the discharged containers from the virtual vessel (PPSD). The intersection point of the two conflicting objectives in (PSCCHC) was determined which decided 15 tractors and 16.76% average idle percentages of quay cranes. In addition, one bottleneck was discovered and solved by adding one more yard crane in the determined crowded yard.

Recommendation:

1- Apply the proposed system in the short-term planning process in the PSCCHC.

2- Use statistical data to reevaluate the un/load vessels and gate operations rules periodically to adjust the suitability of these rules with the continuous changes in the number of vessels and changeable workload in the PSCCHC.

3- use statistical data to support planning in the PSCCHC, this to performing new research that concentrates on the quay cranes deployment problem in the form of a working timetable for each vessel.

References:

[1] Bandyopadhyay, S., & Bhattacharya, R. (2014). *Discrete and continuous simulation: theory and practice*. CRC Press.

[2] Clausen, U., Kaffka, J., & Meier, F. (2012). CONTSIM–container terminal management with simulation. *Procedia-Social and Behavioral Sciences, 54*, 332-340.

[3] Dragović, B., Tzannatos, E., & Park, N. K. (2017). Simulation modelling in ports and container terminals: literature overview and analysis by research field, application area and tool. *Flexible Services and Manufacturing Journal*, *29*(1), 4-34.

[4] Faragalla, m. (2012). *Using multi-objective programming to optimize the container handling in port-said west port container terminal*. Master thesis, Faculty of commerce, Port said university

[5] Faragalla, m. (2017). *An Optimization Model for Transport-Storage Logistics "An Applied Study"*. Doctoral dissertation, Faculty of commerce, Port said university

[6] Kim, K.H. & Gunther, H.O. (2007). *Container terminals and cargo systems: design, operations management, and logistics control issues*. Berlin (DE): Springer-Verlag Berlin.

[7] Lagershausen, S. (2013). Closed Queueing Networks. In *Performance Analysis of Closed Queueing Networks* (pp. 5-13). Springer, Berlin, Heidelberg.

[8] Lee, P. T., and Z. Yang. 2018. *Multi-Criteria Decision Making in Maritime Studies and Logistics*. New York: Springer.

[9] Li, W., Y. Wu and M. Goh, Eds. (2015). *Planning and Scheduling for Maritime Container Yards*. Heidelberg, Springer.

[10] López-González, A., Medina-León, S. V., González-Angeles, A., Mendoza-Muñoz, I., & Gil-Samaniego-Ramos, M. (2020). Assessment of a container terminal expansion using simulation. *Dyna*, *87*(214), 129-138.

[11] Ma, N. L. (2008). *Optimal Planning of Container Terminal Operations*. Doctoral dissertation, Imperial College London, United Kingdom.

[12] Meisel, F. (2009) *Seaside operations planning in container terminals*. Berlin: Physica-Verlag.

[13] Park, N. K., & Dragović, B. (2009). A study of container terminal planning. *FME transactions*, *37*(4), 203-209.

[14] Park, N.K.; Suh, S.C. (2019) Tendency toward mega containerships and the constraints of container terminals. *Journal of Marine Science and Engineering*, 7, 131.

[15] Rossetti, M. D. (2015). *Simulation modeling and Arena*. John Wiley & Sons.

[16] Rusca, F., Popa, M., Rosca, E., & Rusca, A. (2018). Simulation model for maritime container terminal. *Transport Problems*, *13*.

[17] Zeigler, B. P., Muzy, A., & Kofman, E. (2018). *Theory of modeling and simulation: discrete event & iterative system computational foundations*. Academic press.

Container Market Concentration in the Era of Digitalization: Evidence from North African Sea Ports

Author: Dr. Ahmed Ismail yaseenahmedismail@gmail.com Deanery of Admission and Registration, AASTMT, Alexandria
Co- Author1: Cap. Abdulla Wanis nouraw@gmail.com PhD candidate, AASTMT, Alexandria
Co- Author2: Dr. Arbia Hlali arbiaarbiahlali@yahoo.fr Department of economics, Faculty of economics and management science of Sfax

ABSTRACT:

This paper aims to analyze concentration and de-concentration tendencies of North African container market through quantitative approaches between 2009 and 2018. In doing so, container market structure was analyzed followed by container market concentration analysis using the HHI index and BCG matrix in order to determine the market leader and the most profitable port in the region. The main outcomes of this study revealed that total container throughput in North Africa area has experienced a moderate growth during the period of study, while the HHI analysis showed that the stated market is highly concentrated and tends to increase overtime. The BCG Matrix analysis, on the other hand, shows that ports of Damietta, West Port Said and Algiers are the market leaders, with Algiers port being the most profitable one. Accordingly, all these indicators clarify that there is a lack of competition between North African container ports and terminals.

Key words: North Africa, Container port, TEUs, digitalization, market share, market concentration, HHI and BCG.

INTRODUCTION:

Nowadays, containers have moved through intermodal transport network on a global scale. The maritime container shipping network and land transport network often used as a complementary function to intermodal network. However, seaports have been playing an increasingly important role for trading system. Added to this, trade liberalization and development of land infrastructure resulted in access to the remote areas, as well as, the abolition of national (economic) borders, which obliges ports to compete strongly, especially goods transported in containers via marine terminals (Hussain, 2010).

In fact, seaports supposed to function in an ever-changing environment. The dynamics of changes and challenges are expanding overtime due to the global trade trends, socio-economic aspects and industry developments. Thus, seaports are expected to stay innovative to keep up with these changes and actively participate in the era of the Fourth Industrial Revolution (4.0 I.R.). Containerization of marine cargoes, on the other hand, was introduced in 1956, aiming to cut down total costs of maritime transport especially cargo handling costs, instead of loading/unloading each piece of transport item to or from a ship in a labor-intensive manner. It also increased transport pace and efficiency through reducing packing requirements and handling processes at all transfer points (Levinson, 2006).

Both of positive and negative factors are explain the slow or rapid growth of containerization. On the positive side, there is organic, induced and technological growth. An example of the possible current and future impulse of containerization caused by technological change, is attraction of using of containers for agricultural commodities transport. The proportion of shipments of certain bulk cargoes transported by containers is increasing and can already be observed in some cases (Rodrigue et al., 2020).

Hussain (2010) clarified that digitalization is a technical infiltration of all social and economic sectors and digitalization and 4.0 I.R. are frequently used terms today. In this regard, although the maritime industry has started later and slower than other industries, and its current applications and digital trends are including cloud infrastructure, block chain, Artificial Intelligence (AI), Internet of Things (IoT) and automation (ISLI, 2018), whereas among these trends, block chain aiming to secure and trace goods from door to door and also to keep run paperless some maritime documentation is the most promising technology for the maritime industry (ISLI, 2018). Rodrigue et al. (2020) explained that automotive industry will be greatly impacted with the Three Dimensions (3D) impressions. In addition to the 3D impressions, shipment of motor vehicles by containers offering direct competition with RO-RO vessels is another factor that can contribute to the rise and fall of containerization.

The drastic increase of international trade in the past few years has reshaped global maritime industry, bringing new developments to the scene, deregulations and liberalization, as well as increased competition. Thus, there is an extensive acknowledgment within today's maritime industry that it should move towards a technological transformation to increase its efficiency, visibility and customer service, such as AI, IoT, big data, and block chain that constitute great opportunities to improve overall efficiency, productivity and can drive profitability and economic growth (Ismail and Wanis, 2020). However, the current trends of digitalization increased attention towards integration and sustainability call for a higher efficiency in port operations.

Although the bigger companies, such as major shipping lines, are digitized they still use old standards of digitization. Moreover, the maritime industry is dominated by some very big companies (concentration), and due to their size, it is harder for these companies to innovate. Concentration in container port industry could be defined as a polarization of total volume of container throughput in only a few container ports (Nguyen et al., 2020). Furthermore, the workforce in maritime industry is aging and it is harder to convince older or more experienced people to do things in a new way.

This paper aims to review the literature related to container ports concentration through assessing the concentration ratios and to outline competitiveness level of major North African container ports and terminals using the BCG and HHI analysis and panel data for the 10-year period between 2009 and 2018. However, selection of container ports is based on their geographic position, since they generally share the same foreland.

It is important to note that this paper is considered as the first attempt to analyze concentration degree of North African container ports and terminals all together, and to identify the faster and the most profitable container ports in the stated area. Thus, in order to achieve the study aim, the paper will answer the following two questions:

Q1- What are concentration and de-concentration tendencies of major North African container ports?
Q2- What is the fastest growing container port and the most profitable one?

To do so, this paper is divided to five main sections that are well arranged in a coherent manner. After this introductory section, the second section will review the literature on seaports market concentration, while Section Three will present the study methodology and techniques. Section Four is devoted to describe study results and main findings, while the study conclusion will be drawn in the fifth and final section.

LITERATURE REVIEW:

Seaport is at the core for many business activities and constitutes a vital component of the socio-economic activity within port's region. However, management and operation of seaport are complex tasks and facing many challenges. Container shipping, on the other hand, is a cyclical market where under and overcapacity succeed each other following economic cycles and all such firms make great efforts to recognize these shipping cycles and predict future demand (Stopford, 2009; Sanchez, 2017). In fact, there are several megatrends are affecting seaport industry, in particular container port segment. These trends include consolidation in the liner shipping market and the growing concentration (UNCTAD, 2017)

Most studies on container ports were centered on the advanced and emerging markets in North America, Europe and North East Asia, while measuring of container market structure and efficiency in South Mediterranean Sea and North Africa region is very limited through the global academic research network (Wanis and Ismail, 2019; Ismail et al., 2020). Although this, the major drawback of available literature was due to focusing on technical efficiency and also due to difficulty of obtaining port costs/ price data which is required to measure allocative and economic efficiencies (Bichou, 2018). On the other hand, there has been a remarkable development in North Africa region container ports over the past few years, due to trade flows and their geographical location.

To this end, innovations in shipping industry through steamships and longitudinal frames of ship's hull followed by containerization are the main drivers of the first and second phases of world trade development during last two centuries. Since 2000 the globe enters into a third stage of world trade development regularly referred as the age of digitally enabled trade that driven by further reductions in coordination and transport costs. It is coupled with a considerable cost fall through data transfer (WTO, 2018). Share of containerized commodities has increased from 2 to 16.5% between 1970 and 2019 (UNCTAD, 2020).

Technology is used to enhance organizations performance which including management, operations and assets. Technological development has proceeded very rapidly in the Twenty-First Century thus far. However, the major challenge is to know which technology to invest in, and which technology will has an impact on maritime transport. Similar to other sectors of economy, maritime industry has been impacted by digital transformation because new technologies transformed traditional containers. Now a days, container itself is object of digitalization and diffusion of a "smart container" which allows for additional information, that available to carriers, terminal operators and cargo owners (Rodrigue et al., 2020).

Recently, digital transformation implies a cultural change requires organizations to continually challenge the status quo and to experiment (Rodrigue et al., 2020). There has been a growing concern about emerged markets trend around the globe that to become less competitive and more concentrated. However, this sometimes attributed to increasingly digital and globalized nature of many markets and firms that operate within them (OECD, 2018). Figure-1 illustrates the relationship between market concentration and enterprise competitiveness.

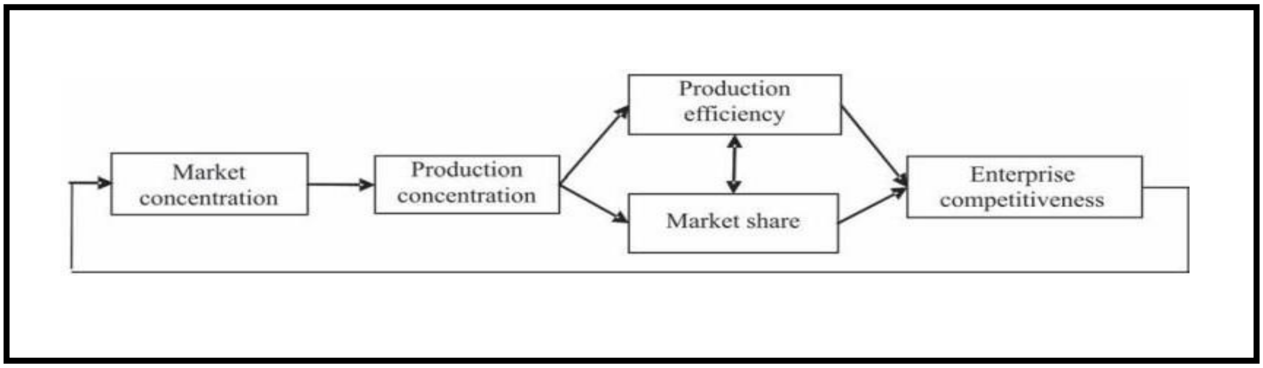


Figure-1. Relationship between enterprise competitiveness and market concentration.
(Source: Ginevičius and Čirba, 2007).

Market concentration is an endogenous inexorable law corresponding to economic development, and it is beneficial to improving economic efficiency. However, market concentration measures can be divided into two groups or units; discrete and cumulative. The former which is not ideal is based on concentration curve accounting only for a limited number of attribute carriers. The later, the cumulative values cannot adequately describe market situation (Ginevičius and Čirba, 2007).

As shown in the Appendix-1, this study reviews 17 studies on seaports concentration. However, the performed literature review indicates that most studies were focused on the advanced and emerging markets, while none of them evaluates North African container ports as a whole.

Regarding the HHI index, it is an economic concept that widely applied. It measure degree of concentration in an industry. It named after economists Orris C. Herfindahl and Albert O. Hirschman. However, the index has a theoretical value ranging from close to zero to 10000. A low HHI value indicates a high level of competition and vice versa. While the BCG matrix, it is created by BCG's founder " Bruce Henderson" in 1968. However, it evaluates growth share in order to help corporations and integration to make investment or to disinvestment decisions related to their business units/seaports or product portfolios.

In accordance with above clarification, Varan and Cerit, (2014) explained concentration between ports and container ports competition in Turkey through measuring outcomes of the privatization process of Turkish ports using HHI, SSA, and CR. The statistical feedback suggest that recent port privatization is successful in stimulating the private investments and competition as well.

Elsayeh (2015) analyzed competitive position of top 22 container ports in Mediterranean basin, for fifteen years period, from 1998 to 2012 using HHI index and BCG matrix, as well as to visualize the dynamics between ports in the defined market. While Elbayoumi and Dawood (2016) provided a satisfactory understanding of competition level and market share of 24 container ports in 12 countries from Middle East region using HHI index. The empirical results show that only five terminals among 24 terminals in the stated region are growing constantly. These ports are Dubai included Jebel Ali, East Port Said, Ambarli, Salalah and Jeddah, while Aden terminal shows the lowest market share.

Recently, El-Haddad et al., (2017) analyzed Eastern Mediterranean container market structure during the period from 1995 to 2014 using CR, HHI and SSA methods. They found the stated market was concentrated. Further, it tends a monopoly in 2014, along with a continued growth rate of ports of Piraeus and Ambarli.

As services provider, seaports mostly combine a few digital technologies that are implemented in different segments of seaport operations, such as; infrastructure and superstructure, safety and security, and cargo handling, which lead to customer satisfactory. Thus, implementation of these digital technologies should upgrade and adjust seaport services according to stay productive, user friendly, efficient and competitive (Ines and Adrijana, 2020).

So far, it is important to note that, this study is limited to North African container ports between 2009 and 2018, and it is not related to container transport between ports. Although this, the IMF report (2021) indicated that there was a sharp decline in the global economic growth at - 4.5% in 2020, this is due to spread of COVID-19 pandemic. It has affected all economic performance and markets especially in a number of emerging markets MENA region and developing Europe that are under macroeconomic strain.

Due to spread of COVID-19 pandemic which is inflicting high and rising human costs worldwide, there is a subsequent shortage of empty containers observed. Thus, several months will likely pass before this disruption can be absorbed across the maritime supply chain. In fact, there are three steps to be carried out by policy makers; first, trade facilitation and digitalization for resilient supply chains. Second, tracking and tracing of containers. Third, more competition is needed in the maritime transport industry, as the carriers have earned high rates of return during the pandemic (UNCTAD, 2021)

METHODOLOGY:

This paper used number of quantitative analysis approaches. Among all growth rate and concentration degree tools, this paper only used the BCG matrix and HHI index due to their suitability with container port industry and market size. In this vein, relative market share of each port can be calculated in terms of market share or revenues. It calculated through dividing own brand's/port's market share by market share of largest competitor in the industry. The relative market share formula is given as following:

$$\text{Relative Market Share} = \frac{\text{Your firm's market share (or revenues)}}{\text{Largest competitor's market share (or revenues)}} \quad (1)$$

For container ports, concentration is a phenomenon of polarization of container traffic in a few number of ports and de-concentration is a phenomenon of spread of container traffic from a small number of ports to a wider set of ports (El-Haddad et al., 2017). Alternatively, concentration is defined as a phenomenon of polarizing container traffic in big load centers in the expense at small ports (Roll and Hayuth, 1993).
In fact, market concentration in any industry or sector can be measured in different methods or indicators, for instance; Concentration Ratio (CR), The Lorenz curve, Gini coefficient (GC) and Herfindahl-Hirschman Index (HHI). This paper, however, is limited to HHI index as an indicator to estimate competition degree between firms in the stated market, and to provide further elaboration for any changes in market share with relation to total market throughput.

In comparison with the K-CR, it is supposed that HHI index is more precise measure, this is because it takes into account all companies/ports (Salem, 2020), as well as, the simplicity of the calculation necessary to determine. Although HHI index is provided useful information on the number and size distribution of competitors, it takes long time to collect and publish, as well as, it fails to take into account the complexities of various markets and should only use in case of all firms/ports involved in the same market competition (Hayden, 2021).

Concerning the HHI index, Hirata (2017) defined the HHI index as "the sum of the squares of each carrier's market share". Higher value of HHI means more industry concentrated and greater potential for market power. Although, HHI index fails to measure distribution of firm's output, it beholds all firms/ports in the industry. In addition, it gives extra weight for a single firm or port which particularly has a wide market share (Colander, 2008). Thus, for purpose of this study, the HHI index is known as the sum of squared values of each container port in the North Africa container market share.

In accordance with above discussion, HHI value reaches a maximum value of 10000 when a monopoly exists in which one firm has 100 per cent of market. In contrast, HHI value takes on a very small value (theoretically approaching zero) means the market is a purely competitive. Usually, the market in which many firms with small market shares. The US Department of Justice considers that a market in which HHI value is less than 100, means a highly competitive market, and if HHI value is between 100 and 1000, the market is not concentrated, while HHI value is between 1000 and 1800, the market is moderately concentrated. The market is highly concentrated when HHI value is above 1800 (Medda and Liu, 2013; Piplica et al., 2016).The formula is given as following:

$$HHI = \sum_{i=1}^{n} S_i^2, \qquad \frac{10000}{n} \le HHI \le 10000 \qquad \textbf{(2)}$$

Where *Si* is the market shares of port in North African container market and *n* is total number of selected ports in the market. Table-1 provides a description for markets concentration measures using HHI index.

The HHI considers the entire size distribution of ports in the market through assigning a weight of both numbers of ports in market and inequality of market shares. It is necessary to note that HHI index is used to measure concentration of market shares. The assumption behind HHI in measuring competition is that a low or high level of concentration is expected to be accompanied by a high or low degree of competition. However, this assumption is particularly true for inter-port competition (Cullinane et al., 2005).

Table-1 Markets Concentration Measures using HHI

Concentration level	Type of market	HHI value
Non-concentrated market	Efficient competition, Part of monopolistic	>100-1000
Moderately concentrated	Part of monopolistic	1000-1800
Highly concentrated market	Tight oligopoly, dominant firm	>1800

Source: Piplica et al., 2016

Regarding the BCG matrix, it used to visualize the dynamics between ports in the defined market and to assess the ports' competitive position. It consists of four categories in order to identify four market positions. The process of BCG Matrix follows number of steps; in the first step one: unit or port choice, while in the second step defining the market, this is because incorrectly defined market may lead to poor classification. In the third step, market growth rate to be calculated, whereas the final step includes drawing the circles on a matrix and to plot brands on the matrix.

In this way, Figure 2 shown that the stars come first, which means port is operating in a high growth industry that take a significant part in high market share. Stars are cash generators and cash users. Second, the cash cow, which considered as the most profitable brands, and should be "milked" to provide as much cash as possible. In order to support their further growth, the cash gained from "cow" should be invested into stars (Mohajan, 2018).

Figure-2. Boston Consulting Group (BCG) matrix
(Source: Mohajan, 2018)

The question mark comes third, as a brand it requires much closer consideration. It holds a low market share in fast growing markets consuming large amount of cash and incurring losses, while, the dogs come fourth that hold a lower market share in comparison with other competitors, and is operating in a slowly growing market. Dogs are not worth to investing in because they generate low or negative cash returns (Mohajan, 2018).

The BCG Matrix establishes a model for allocating resources among various business units and compares many business units at the same time. Although this, the true nature of business may not be indicated, and high market share does not always lead to high profits, as well as, market is not well defined in this matrix (Elsayeh, 2015).

Regarding data collection for this paper which is annual container throughput in TEUs, it were collected from various sources. It mainly collected from ports websites, as well as through direct contact with the port managers and operators of the stated ports in Egypt, Libya, Tunisia, Algerian and Tanger Med port as the only port from Morocco under this study.

EMPIRICAL RESULTS AND POLICY IMPLICATION

North Africa container market structure

Market share of each port in this study was calculated as percentage from total throughput of ports, as presented in the Table-2. The empirical results shown that there is a significant shift in ports ranking under this study.

Table 2. Development of Market Share of North African Container Ports (2009-2018).

Port	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Rank
PORT SAID	14.30%	12.33%	12.92%	13.06%	11.05%	6.77%	7.75%	5.50%	5.96%	5.59%	4
DAMIETTA	18.81%	18.45%	14.57%	12.06%	10.95%	9.80%	8.32%	8.78%	9.77%	12.64%	3
ALEXANDRIA	21.60%	20.24%	18.42%	18.45%	21.18%	19.95%	19.40%	20.60%	19.77%	19.10%	2
KHOMS	0.41%	0.90%	0.76%	0.26%	1.05%	1.05%	0.95%	0.88%	0.65%	0.73%	14
TRIPOLI	1.65%	1.25%	1.16%	0.63%	1.07%	1.18%	1.16%	0.79%	0.50%	0.40%	12
MISURATA	3.37%	4.17%	3.48%	2.73%	3.76%	4.02%	3.53%	3.65%	3.00%	2.39%	7
TOBRUCK	0.04%	0.01%	0.02%	0.03%	0.09%	0.12%	0.07%	0.19%	0.18%	0.13%	16
RADES	6.60%	6.11%	5.76%	5.95%	4.74%	4.57%	3.65%	3.70%	3.70%	3.26%	6
SOUSSE	0.03%	0.03%	0.03%	0.04%	0.43%	0.37%	0.37%	0.41%	0.60%	0.65%	15
SFAX	0.54%	0.54%	0.53%	0.56%	0.93%	0.91%	0.98%	0.96%	1.00%	0.94%	13
La Goulette	0.19%	0.10%	0.01%	0.01%	0.10%	0.03%	0.09%	0.04%	0.12%	0.10%	17
ALGIERS	10.56%	10.39%	8.73%	9.80%	10.20%	9.68%	10.06%	10.39%	10.83%	10.06%	5
ANNABA	0.22%	0.16%	0.68%	1.32%	1.87%	1.89%	1.85%	1.95%	1.93%	1.80%	10
BEJAIA	2.03%	2.45%	2.24%	2.70%	3.32%	3.27%	2.77%	3.07%	3.22%	2.64%	8
SKIKDA	1.88%	1.80%	1.48%	1.63%	1.60%	1.74%	1.74%	1.95%	2.04%	1.81%	9
ORAN	1.74%	1.37%	1.22%	1.13%	1.16%	1.05%	0.94%	0.97%	0.96%	0.78%	11
TANGER M.	16.03%	19.70%	27.99%	29.64%	26.50%	33.61%	36.37%	36.17%	35.77%	36.98%	1
TOTAL	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	

(Source: Authors own calculation derived from many sources).

In 2009 and 2010 Alexandria port was the market leader. Since then, Tanger Med port was the market leader which increased its market share year by year from 27, 99% in 2011 to 36,98 % in 2018, followed by Egyptian ports of Alexandria, Damietta and Port Said.

Market share for the dominant four ports was rising over the remaining period. It was about 70% between 2009 and 2014, and raised to about 71% between 2015 and 2017. In 2018, market share of the four dominant ports was increased to more than 74%. Although Libyan, Tunisian and Algerian container ports have an insignificant share in North Africa container market, they gained a negligible market growth over the period of study due to political instability and governance structure of these ports.

It is important to note that container port structure in North Africa is considered as a part of Mediterranean basin which mirror structure of liner shipping industry on a worldwide level with hubs and gateway ports (Elsayeh, 2015). However, establishment of hub transshipment ports in North Africa and south bank of Mediterranean has benefited some ports over others especially in Egypt and Morocco which changing the competitive landscape.

Hirschman-Herfindahl Index (HHI) Analysis

Based on ports market share that already shown in Table-2, the empirical results indicate that in 2009, the average value of HHI was at 1461.973, which indicates that the stated market is moderately concentrated. Therefore, ports of Damietta, Alexandria, Tanger Med and West Port Said are the dominants when they account more than 71 % of market share as a whole.

Table-3. HHI index for North African Container Market 2009-2018

Port	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
W.PORT SAID	203.900	151.7138	166.9268	170.5016	122.2508	45.91584	60.14486	30.21031	35.54363	31.24875
DAMIETTA	356.716	339.9028	212.4494	145.535	120.2221	96.28384	69.21133	77.08857	95.6338	159.9526
ALEXANDRIA	465.040	408.7947	339.2204	340.4326	448.7945	398.206	377.7055	424.3961	390.8651	365.4979
KHOMS	0.166	0.827114	0.581384	0.070287	1.106486	1.106667	0.904872	0.772028	0.433138	0.538719
TRIPOLI	2.713	1.558943	1.358247	0.398296	1.161021	1.406694	1.362241	0.635473	0.259919	0.166132
MISURATA	11.371	17.36113	12.1002	7.453734	14.15828	16.18778	12.56953	13.32419	9.071929	5.722933
TOBRUCK	0.001	0.0001	0.000324	0.000895	0.008447	0.013255	0.005539	0.038863	0.03288	0.01776
RADES	43.696	37.23278	33.19556	35.3576	22.65111	20.89491	13.35462	13.68751	13.72112	10.66889
SOUSSE	0.001	0.001042	0.001136	0.001804	0.189489	0.135269	0.141387	0.171078	0.393502	0.36128
SFAX	0.292	0.287201	0.281196	0.320704	0.889546	0.821448	0.974247	0.928506	1.035865	0.91811
LA GOULETTE	0.0380	0.0105	0,0001	0.0002	0.0103	0.0007	0.0088	0.0014	0.0149	0.0090
ALGIERS	111.077	107.7305	76.36041	95.60156	104.0336	93.78257	101.3122	108.0162	117.3618	101.2459
ANNABA	0.055	0.0262	0.462023	1.751733	3.558185	3.555746	3.407626	3.811638	3.728618	3.539123
BEJAIA	4.097	5.993314	5.041068	7.281118	11.01586	10.69608	7.690148	9.454644	10.41237	6.973112
SKIKDA	3.573	3.173026	2.173814	2.664342	2.578006	3.019507	3.037498	3.822604	4.190167	3.274094
ORAN	3.023	1.892916	1.496953	1.282815	1.347478	1.104236	0.883671	0.952909	0.932155	0.612475
TANGER MED	256.213	391.4101	783.0608	878.4067	702.2847	1129.348	1322.611	1308.347	1279.811	1367.221
MEAN	**1461.973**	**1467.746**	**1634.475**	**1687.061**	**1553.103**	**1821.521**	**1971.616**	**1994.162**	**1958.653**	**2054.059**

(Source: Authors own calculations)

This means these ports were in an oligopolistic situation. Between 2010 and 2012, HHI value increased slightly to 1687.06. Such increase in HHI value reveals a decrease in competition level between North Africa market players.

In contrast, in 2013 average value of HHI decreased to 1553.103, this indicates the stated market still moderately concentrated, and competition level between ports was increased, which driven by region's leader container ports. For the same year, dominant ports account more than 73 % of total market share. Since 2014, the defined market was become highly concentrated market, where average values of HHI were increased year by year as the following; 1821.521 in 2014, 1971.616 in 2015, 1994.16 in 2016, 1958,653 in 2017 and 2054.059 in 2018.

To Sum up, and as shown in the Table-3, the average (mean) values of HHI between years of 2009 and 2013 clarify that the defined market was a moderate concentrated. Since then, the market was highly concentrated. The mean (average) value of HHI index for North African container market during period of study was 1760.437. Hence, competition level of North Africa container market that measured through HHI index reveals decreasing competition trend during period of the study, which means competition between North African container ports is shrinking.

Boston Consulting Group Matrix

As shown in Figure-3, the vertical axis of the matrix presents the annual average rate of growth of North African container ports, while the average market share of the same market is presented by the horizontal axis. After calculating relative market share and market growth rate; using Microsoft Excel; a scatter chart is calculated automatically and distribute ports according to their relative market share and market growth rate; as shown in appendix-2.

Based on market share of the stated ports in the years of 2017 and 2018 which already shown in Table-2. Figure-3 revealed results of the BCG matrix analysis. Ports of Damietta, West Port Said and Algiers were the market leaders or stars. These ports are operating at a high growth and maintain their market share. These ports have high future potential. Although, it stays between stars and cash cow, port of Algiers is the most profitable brand (port) and should be "milked" to provide as much cash as possible.

On the other hand, ports of Khoms, Sfax, Annaba and Sousse were question marks which require more consideration, because they hold low market share in a fast-growing market, and consuming large amount of cash and incurring losses also. Thus, potential of these ports in future is uncertain. The dogs were; Tripoli, Misurata, Tobruck, Rades, La Goulette, Bejaia, Skikda, Oran, Alexandria and Tanger Med ports. These ports hold the lowest market share matched to other ports and operating in a slowly way or their market share and growth rates are reduced, this is because they often generate a low or negative cash returns. Despite this, some dogs are profitable but for long period of time.

Overall, BCG matrix shows that competitive positions of North African container ports are not changed. This is because North African container market tendency towards more concentration.

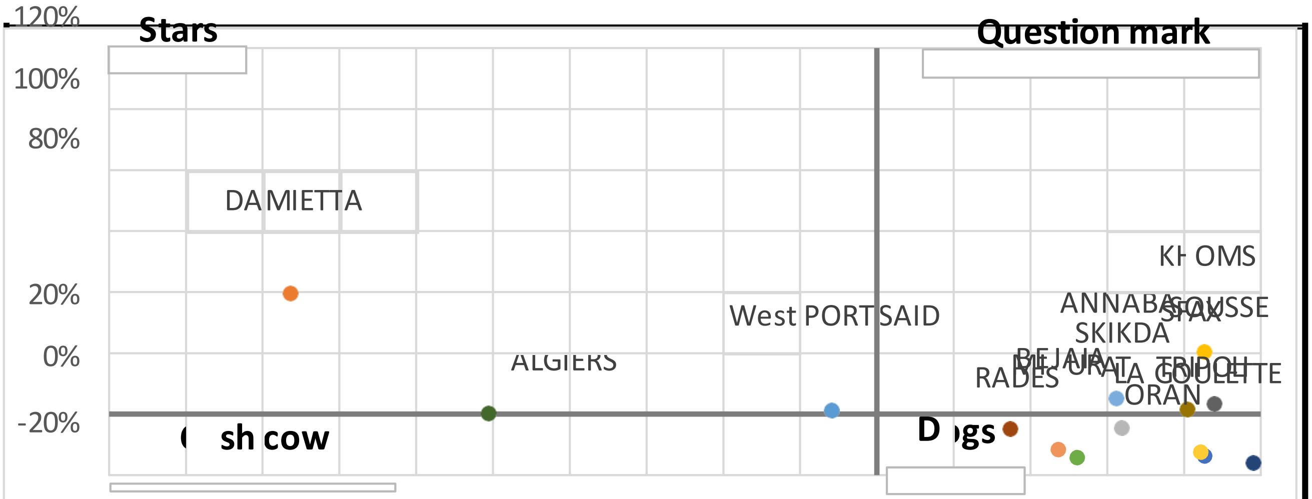


Figure-3: North African container ports BCG matrix
(Source: Authors own calculations)

Concerning policy implication by managers and operators of North African container ports and terminals, thus in order to reduce concentration degree among study ports which lead to enhance competitiveness level, cooperation rather than competitiveness is needed, while integration as a further step also is needed in the med or long range. Investment in the digital technology is needed also, but the major challenge is to know which digital technology to invest in and which one will has a positive impact on the port and its services quality.

CONCLUSION:

Market growth and concentration and de-concentration tendencies of North African container market have been analyzed through quantitative analysis approaches between 2009 and 2018. This is, most probably, the first attempt to analyze market structure, growth and concentration degrees of North Africa container market using the HHI index and BCG matrix.

At first, market structure was analyzed through market share and inequality. The study results revealed that total container throughput in North Africa region has experienced a moderate growth between 2009 and 2018, respectively from 5,751,404 TEUs to 8,952,957 TEUs. Although there has been a significant growth in container traffic cross the entire region, a remarkable drop in terms of TEUs has occurred in 2012 to 7,063,304 TEUs, due to oil prices collapse, as well as political instability in each of Egypt, Tunisia and Libya.

Secondly, average value of HHI index of North African container market has reached 1760.437, indicating that the stated market is highly concentrated, more specifically from 2013 until the end of study, following discernable rising from the moderate concentration that was reached between 2009 and 2013. Increasing

HHI trend over time indicates that competition level between North African container ports and terminals is shrinking.

Thirdly, BCG Matrix analysis has shown that ports of Damietta, West Port Said and Algiers are the market leaders, while ports of Khoms, Sfax, Annaba and Sousse hold low market share in a fast growing market, and require more consideration. Port of Algiers, moreover, is the most profitable port. Other remaining ports under this study hold the lowest market share and operate in a slowly growing environment.

It is important to note that dynamic motion of maritime industry towards digitalization and innovation is another important factor for container ports future demand. The ability of digitalization and innovation, such as big data, AI, IoT and smart containers, tend to reduce maritime transport and coordination costs, and could reinforce the competitiveness level of maritime industry.

Accordingly, cooperation, rather than competitiveness, among ports of study in proximity represents a prime way for enhancing competitiveness level. Also, an effective planning for transport infrastructure, such as ports and their connections to railways, roads, and inland waterways, requires a foresight of what a potential future flow of maritime trade could look like. Added to this, enabling the participation of the private sector in North African container port operations should be considered.

Last but not the least, the importance of digitalization in maritime container industry should be considered, which includes redefining the seaport service quality factors. Thus, introducing additional digital technologies in providing quality seaport services and investing in their implementation represent an important task for policy makers and port managers to elaborate.

REFERENCES:

Bichou, K., (2018): Port Efficiency and Performance Benchmarking. John Wiley & Sons

Boston Consulting Group website; https://www.bcg.com/about/our-history/growth-share-matrix

Cariou, P., (2020): Changing demand for maritime trades. Port Economics. https://www.porteconomics.eu/2020/05/28/portreport-4-changing-demand-for-maritime-trades/

Colander D., (2008): The Making of a Global European Economist, Kyklos, *Vol 61(2)*, pp. 215-236

Cullinane, K., Wang, T., and Song, D., (2005): A Theory of Container Port Production and its Empirical Validation. Springer

Elbayoumi O. and Dawood A., (2016): Analysis of the Competition of Ports in the Middle East Container Ports Using HHI, *Journal of Shipping and Ocean Engineering*, *Vol. (6)*, pp. 339-347

Elhadad E., Hanafy N., Labib A. and Eman A.,(2017): Analytical approach to the market of the container ports in the east Mediterranean region using the concentration ratio, HHI, SSA, *The Business and Management Review*, *Vol 8 (5)*, pp.192-199

Elsayeh M., (2015): The Impact of Port Technical Efficiency on Mediterranean Container Port Competitiveness. PhD thesis, The University of Huddersfield. UK

Ginevičius, R. and Čirba S., (2007): Determining market concentration. JBEM, Vol. (8), pp.3−10.

Hayden (2021): Limitations of concentration ratios and HHI information. Available online at: https://www.rhayden.us/managerial-economics/limitations-of-concentration-ratios-and-hhi-information.html (Accessed 02 June 2021)

Hirata E., (2017): Contestability of Container Liner Shipping Market in Alliance Era, Elsevier, *Vol 33(1)*, pp. 27-32. On line at: https://www.itf-oecd.org/sites/default/files/docs/changing-demand-maritime-trade_0.pdf (18 April 2021)

Hussain A., (2010): A new approach in benchmarking seaport efficiency and technological change. *International Journal of Transport Economics. Vol. 37*(1), pp. 77-96

Ines K. and Adrijana A., (2020): Improving the seaport service quality by implementing digital echnologies. *Scientific Journal of Maritime Research, Vol (34),* pp. 93-101

International Monetary Fund (IMF, 2021): World Economic Outlook Report. Washington. Online at https://www.imf.org/en/Publications/WEO (Accessed 01 June 2021)

ISLI Forum (2018): Digitalization of maritime supply chains. White paper. In proceeding of 28 Global Supply Chain Forum – KEDGE Business School

Ismail A. Wanis, A., (2020): Evaluating the Competitiveness Level of North African Container Ports: An empirical study on the Egyptian and Libyan container ports using FAHP. MARLOG9. Alexandria

Levinson M., (2006): The box: How the shipping container made the world smaller and the world economy bigger. Princeton: Princeton University Press.

Medda F., and Liu Q., (2013): Determinants and strategies for the development of container terminals. Journal of Productivity Analysis, *Vol. 40 (1)*, pp. 83-98

Mohajan, K. (2018) "An Analysis on BCG Growth Sharing Matrix", Noble International Journal of Business and Management Research. *Vol. 20* (1). pp: 01-06.

Nguyen H., Woo S., Bereford A., and Pettit S., (2020): Competition, market concentration, and relative efficiency of major container ports in Southeast *Asia. Journal of transport geography, Vol. (83*), pp1-10

OECD (2018): Market concentration; an issues paper for the hearing on market concentration taking place at the 129th meeting of OECD Competition Committee on 6-8 June 2018. Available online at: https://www.oecd.org/competition/market-concentration.html (Accessed on 4 April. 2021)

OECD (2019): Changing demand for maritime trade. Discussion paper. Available online at:
Piplica D., Fran G. and Pavic I., (2016): Similarities and Differences between the CR and HHI as an Indicator of Market Concentration and Market Power, British Journal of Economics, Management & Trade, *Vol 13(1)*, pp. 1-8.

Rodrigue JP. Notteboom, T. and Pallis A. (2020): Port Economics, Management and Policy, New York: Routledge.

Roll Y. and Hayuth Y., (1993): Port performance comparison applying data envelopment analysis (DEA). *The flagship journal of international shipping and port research, Vol.20 (2*), pp.153-161.

Salem, K., Ismail, A., Elbishi, A. and Gamil, M. (2020) "The dynamics of the Mediterranean container terminals' market", *AIN Journal*, Egypt. July 2020. ISSN (2090-8202).

Sanchez, R., Wilmsmeier G. and Tovar B.,(2013): The evolution of container terminal productivity and efficiency under changing economic environments, *Research in Transportation Business & Management, Vol.(8),* pp. 50-66

Stopford M., (2009): Maritime Economics, Second Edition. Routledge.

UNCTAD (2018). 50 Years of Review of Maritime transport 1968-2018: Reflecting on the past, exploring the future. UNCTAD publication. https://unctad.org/en/PublicationsLibrary/dtl2018d1_en.pdf (15 April 2021)

UNCTAD (2020). World Maritime review. UNCTAD publication. Geneva

UNCTAD (2021): container shipping in times of COVID-19: why freight rates have surged, and implications for policymakers. Policy Brief-84. Geneva.

Varan, S. and Güldem A., (2014): Concentration and Competition of Container Ports in Turkey: a Statistical Analysis, DENİZCİLİK FAKÜLTESİ DERGİSİ, *Vol.6 (1),* pp: 91-109

Wanis, A. and Ismail A., (2019): Benchmarking the technical efficiency of the Egyptian and Libyan Container ports using DEA. MARLOG8. Alexandria

WTO (2018). The future of world trade: How digital technologies are transforming global commerce. WTO publications. https://www.wto.org/english/res_e/publications_e/wtr18_e.htm

Appendix-1 The Previous Studies on Concentration in Seaports

Author(s) / year	Concentration indicators used	Study area / field	Study results
Hayuth (1981)	Market structure	Market structure of the US container ports system	Theoretical study
Fageda, (2000)	GC, HHI, SSA	Mediterranean container port (1990-1998)	Load centers will have to face a very competitive environment. Consolidation of load centers in the region becoming as maritime hubs.
Notteboom et al., (2007)	SSA	The European container ports system	Routing flexibility is a keystone for attractiveness in the stated region.
Fageda (2011)	HHI, SSA	The Mediterranean container ports system	GC can produce incorrect results especially when examine port system within small number of ports.
Liu et al., (2011)	HHI, SSA	Concentration and competition level of Shanghai international shipping hub within 2 neighboring ports	Concentration degree of a port depends on natural condition and developed hinterland

Li et al., (2012)	HHI	Container port systems in China (1979-2009) and the USA (1970-2009)	Concentration levels of container port systems in both countries seem to be decrease
Martin (2012)	SSA	Competitive relationship among East-Southern Florida ports	The competition was fierce due to geographical position and port structure
Varan and Guldem (2014)	CR, HHI, SSA	Turkish container ports system	There is a necessity to reconstruct port policies in order to achieve competitive advantage for the stated ports
Elsayeh (2015)	CR, HHI, GC, SSA	Mediterranean container ports	Market tends to de-concentrated
Li et al., (2015)	CR	Coastal ports in China (1982-2012)	Concentration ratio decreased continuously since 1982 which means the stated ports are de-concentrated.
Elbayoumi et al., (2016)	HHI, SSA	24 container terminals in 12 MENA countries	5 out of 24 terminals were growing constantly
Pham et al., (2016)	CR1, CR3 GC SSA	North Vietnamese port system (2005-2014)	The market experienced de-concentration trend due to perfect competition.
Liu et al., (2016)	BCG, HHI, SSA	Trade traffic in major northern China ports (2004-2014)	The market is oligopoly.
El-Haddad et al., (2017)	CR3, CR5, HHI and SSA	East–Mediterranean region container market 1995-2014	Piraeus & Ambarli ports tend monopoly
Ismail A., (2019)	CR, HHI	Top 10 Mediterranean container ports (2013-2017)	The empirical results show that the market is low concentrated
Constantinos and Theodore (2019)	CR4, CR8, HHI	The U.S West and East Coast ports (2005-2015)	Ports have evolved from being de-concentrated towards a high and moderate concentration levels respectively
Nguyen et al., (2020)	GC, CR, HHI	Top 10 SE Asia container ports between 2007-2017	SE Asia ports become moderately concentrated in 2017, contrasting from highly concentrated in 2007, which indicating a tendency towards de-concentration.

(Source: Authors own elaboration).

Appendix-2 Market Share and Growth Rate of North African Container Ports 2017-2018

Port	**Market share**	**Growth rate**
West PORT SAID	5.6%	1.2%
DAMIETTA	12.6%	39.6%
ALEXANDRIA	19.1%	4.4%
KHOMS	0.7%	20.4%
TRIPOLI	0.4%	-13.7%
MISURATA	2.4%	-14.3%

TOBRUCK	0.1%	-20.7%
RADES	3.3%	-4.8%
SOUSSE	0.6%	3.4%
SFAX	1.0%	1.6%
LA GOULETTE	0.1%	-16.0%
ALGIERS	10.1%	0.3%
ANNABA	1.9%	5.2%
BEJAIA	2.6%	-11.7%
SKIKDA	1.8%	-4.6%
ORAN	0.8%	-12.5%
TANGER MED	36.9%	11.6%

(Source: Authors own calculation)

Appendix-3 North African Container Throughput 2009-2018.

Port	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Alexandria	1,240,323	1,249,125	1,354,813	1,303,237	1,460,000	1,519,193	1,653,946	1,688,301	1,638,172	1,710,000
Damietta	1,086,303	1,139,018	1,072,176	852,102	755,651	747,026	708,000	719,547	810,311	1,131,226
Port Said	821,292	760,967	950,389	922,300	762,000	515,870	660,000	450,445	494,000	500,000
Khoms	23,450	56,187	56,088	8,726	72,494	80,954	66,319	72,008	54,533	65,650
Tripoli	94,739	77,138	85,729	44,577	90,294	99,328	71,622	65,330	42,244	36,457
Misurata	193,953	259,319	255,879	306,304	306,304	192,839	342,466	299,147	249,572	213,975
Tobruck	2,080	0,358	0,527	2,113	8,765	6,334	2,445	16,156	15,025	11,920
Rades	380,200	376,978	423,817	420,000	328,000	303,198	311,163	309,136	306,931	286,005
Sfax	31,060	33,109	39,007	40,000	65,000	34,800	83,772	78,969	84,333	85,704
La Goulette	11, 187	6,324	728	1,000	7,000	2,000	8,000	3,077	10,123	8,506
Sousse	1,622	1,994	2,479	3,000	30,000	28,000	32,000	33,897	51,978	53,762
Alger	606,181	641,243	642,795	690,622	702,936	737,259	856,595	851,743	897,655	900,357
Skikda	108,717	110,050	108,455	115,293	110,655	132,290	148,321	160,230	169,614	161,845
Bejaia	116, 423	151, 247	165,158	190,593	228,738	248,984	236,000	251,992	267,375	236,193
Annaba	13,440	10,000	50,000	93,485	130,000	143,557	157,098	159,900	160,754	168,268
Oran	100,000	85,000	90,000	80,000	80,000	80,000	80,000	80,000	80,000	70,000
Tanger Med	920,640	1,222,276	2,058,430	2,093,417	1,826,357	2,558,426	3,077,750	2,964,324	2,964,278	3,312,409
TOTAL	**5,751,610**	**6,178,076**	**7,355,943**	**7,063,304**	**6,898,743**	**7,615,056**	**8,518,296**	**8,198,364**	**8,296,144**	**8,952,957**

(Source: Authors own elaboration).

Role of Digitalization and Internet of Things (IoT) in Fostering Ports Security.

Mohamed Abdelfattah [1], Ahmed Moh y IBRAHYM[2]

Vice Dean of Regional Maritime Security Institute, Arab Academy for Science, Technology and Maritime Transport (AASTMT), Alexandria, Egypt,
mlmf_001@yahoo.com.
Head of Quality Assurance Unit at Regional Maritime Security Institute, Arab Academy for Science, Technology and Maritime Transport (AASTMT), Alexandria, Egypt,
ahmedmohyy@gmail.com.

Abstract:

Maritime transportation is the utmost economical mode meant for mobilizing raw and finished products in bulk. The effectual governance and security of port facilities are habitually the key to managing such challenges. Integrating Digitalization, the Internet of Things (IoT), and other digital technology approaches into port environments makes the task of detecting threats more predictable. Digitalization and IoT in ports have also been adopted in the industry to boost safety and security. Furthermore, despite quantum rises in advances to shipping and maritime security technology, the threat to natural life and property remains tangible. Effective and optimal deployment of these technologies can assist in fostering maritime security manifold. This study followed the descriptive analytical approach to achieve its main aim by demonstrates these technologies with an analytical view of the most important distinguishing features and evaluating their effective use. Finally, the study proposed and discussed the possibility of integrating the usage of many of these technologies and their impact on enhancing port security.

Keywords: Ports Security, Digitalization, Internet of Things, New Technologies.

1. Introduction:

Shipping has been the highest economical means of transportation since ancient times and today it is also one of the enormous means of transportation (Rodrigue, 2020). In a true signification, shipping is the solitary international industry that has made globalization with an essential role in global sustainability as one of the crucial stakeholders (Benamara et al., 2019; Wang et al., 2020; Yuen et al., 2018). Statistics specify that 90% of the global trade is done by maritime transportations (CTAD, 2018). This corresponds to an impressive 1.5

tons/person established on the existing universal population. Shipping‟s ability to relocate materials and goods from where they are manufactured to where they will be eventually consumed. In 2019, the entire value of the annual world shipping trade had extended more than 14 trillion US Dollars (Hemmings, 2021).

Ports are district multimodal connections of universal supply chains. They work in complex infrastructure, commercial, regulatory, and transactional systems. Maritime shipping is in high demand throughout the world's economy, ports have encountered increasing burdens toenhance their performance in terms of security, energy, environmental, economic, and functional challenges which affect their sustainability. (Yap, 2020).

The port industry is always developing and this progress brings challenges in several areas. Some of these areas are administrative frameworks, governance models, operational and infrastructure capabilities, the introduction of new smart technologies, industry alliances, and changes in business strategies. Currently, one of the key drivers of transformations in the ports area is digital transformation (Shaw et al., 2017). The level of integration between the smart devices, activities, and agents, with the increase of connectivity between several ports, has formed a new operating system in which novel risks have appeared. The challenges of the industry and legislators should work together with the private sector to make sure these critical infrastructures are sufficiently protected while assisting the full development of new smart technologies in a sector that has relatively lagged behind other industries in transitioning to the new smarter „4.0 world‟ (de la Peña Zarzuelo et al., 2020).

According to The International Convention for the Safety of Life at Sea (SOLAS) amendments (2002), containing a new Ch. XI-2 on maritime security with the International Ship and Port Facility Security (ISPS) code. According to ISPS Code, port security responsibilities are obviously outlined. Those responsibilities to protect the port facility, ships within ports (while berthing or docking), individuals, cargo handling equipment, cargo and ship's stores from the threats and vulnerabilities of the security incidents. The Port Facility Security Officer (PFSO) and the port facility security crew can recognize, observe, and react appropriately to mitigate these threats and vulnerabilities upon their ability. Most of the world ports have created port security committees to harmonize and adapt the framework for identifying the new smart technologies to enhance maritime security measures (Suppiah, 2009).

Key elements and related port operations concerns include delays, congestion, lack of information sharing, and operating errors (Molavi et al., 2020). Moreover, traditional and new security threads include unlawful acts, the use of ports as a channel for relocating weapons of mass destruction, terrorist-attacks drug smuggling, armed robbery, cyber-security and stowaways. (Biobaku et al., 2016; Lim et al., 2018; Molavi et al., 2020). These concerns may still be around if corrective and preventive measures are not performed and organized within a well-timed manner. As a reaction to the foreseeable and existing challenges, ports adopt and implements technology-based options, along with innovative methodologies to port operations planning, development, and management. Enforcement of such solutions to mitigate these challenges are identified to be substituting to smart digitalized and Internet of things (IoT) ports (Molavi et al., 2020).

According to the ISPS Code responsibilities, PFSO is responsible to preserve physical borders for the port facility. As well, on behalf of the Contracting Government, ports security administration‟s or a duly authorized organization is accountable to maintain security measures as required to extend beyond the physical borders of the port, such as data storage domains or facilities (Suppiah, 2009). This is because the impacts of digitalization and IoT technologies often go beyond previously understood borders, posing a threat to the convergence of port linkages in order to support port facility protection and be able to meet their high tend security levels when requested. In the same context, digitalization and IoT, booming the dependency on the new smart technologies to support maritime security through the interfacing process between the vessels and port facilities with updated techniques used to eliminate or mitigate the security incidents (Sirimanne et al., 2019). The knowledge andskills required to maintain traditional operational technologies, such as early industrial control systems differ from those with real-time data exchange through digitalization, IoT, Artificial intelligence, 5G, and 6G connection network which predictable to integrate the aerial, terrestrial, and maritime communications into a robust network which could be more fast, reliable, and can support a massive quantity of devices with ultra-low latency requirements. In addition, there is a need to understand the capacity of all port users and security equipment‟s to deliver, as outlined within the procedures, the due diligence each actor has to shoulder. As the responsibility for systems moves beyond the physical boundaries of the ports, recognizing who is accountable for upholding the maintenance of systems is crucial for the maritime security digitalized equipment (Lesniewska et al., 2021; Liu et al., 2020; Padhi & Charrua-Santos, 2021).

At the present time, security responsibilities are outlined in legislation and the ISPS Code. However, each attribution of responsibility with the digitalization and IoT needs to be reviewed on a rolling basis as the process of identifying accountable parties will be fluid as the system becomes more complex. The transfer of security data and security analysis to centralized systems can obscure attribution for problems with integrity and security. Shared platforms such as the Port Community System‟s, Marine Traffic web platforms and Electronic Data Interchange reports should be continually maintained to avoid unauthorized access to or destruction of critical information (Lesniewska et al., 2021). This study was a sincere method to demonstrate the role that new smart technologies can perform in fostering port security. This study tracked the descriptive-analytical method to accomplish its principal aim by demonstrating these new smart technologies with an analytical standpoint of the most significant identifying features and evaluating their effectiveness. Finally, the study discussed the possibility of integrating the usage of many of these innovations and their effects on enhancing port security.

2. Concept of digitalization and IoT in maritime domain and port security:

Digitalization and digitization are combined to provide digital data and information that can be interpreted by computers. Digitalization defined as text, images, or sound is converted into a digital format that can be interpreted by a computer. Digitization is the procedure of transforming information into a digital form to be read by computers. Consequently, the analog signal representing an image, object, sound, or document by creating sequences of numbers that describe a separate set of points or samples. The outcome is known as a digital demonstration or, further explicitly, a digital image, to an object, also digital form, for the signal. In recent times, digitized data is in the type of binary numbers, which makes it easier to process by modern computers and do other tasks, but, firmly declaring, digitizing in simple terms means the transformation of analog material into a numerical structure. Digitization is critical for data collection, storage, and dissemination because it requires all types of information in all formats to be carried efficiently and intermingled. This combination is a favored way of maintaining information for numerous port administrations around the globe (Gray & Rumpe, 2015).

On the other hand, IoT refers to the network of physical entities "things" that are implanted with software, sensors, and other technologies for the aim of linking and exchanging data using other systems and devices through the Internet. Both digitalization and IoT are commonly used in intelligent transportation, government work, environmental protection,intelligent fire protection, safety, industrial monitoring, lighting control, environmental monitoring, intruder detection systems, security monitoring systems, and intelligence gathering (Li et al., 2015).

From a digitalization and IoT viewpoint, maritime transport can be divided into two linked main domains. The first domain is the seaborne sector which refers to the operation of the vessels and the second domain is the operation of ports supported with a shore-based level of technologies. Furthermore, vessels have become complex computer-controlled implementations, somewhere the operators have partial physical charge over critical systems. The use of wireless communications to link seaborne networks to shore-based applications, as well as digitalization and IoT, means that ships are now part of a hyper-connected environment dominated by the Internet, as well as the Internet's adequacy in fulfilling port protection requirements (Xiao et al., 2021; Zhang et al., 2020).

Currently, there are many activities and initiatives aimed at supporting the security of seaports, and, in particular, the emergence of what is often referred to as Maritime Domain Security Awareness (MDSA), Maritime Situational Security Awareness (MSSA), or Security Cloud Database (SCD) initiatives. MDSA, MSSA, or SCD initiatives as a result of attempts to change mariners‟ security alertness with the digitalization and IoT of current and imminent security threats and vulnerabilities. However, in order to do so, a wide range of data, with the (voluntary) tracing of vessels activities by way of information-gathering systems for example the Automated Identification System (AIS), aerial drone‟s exploration, active surveillance for naval patrols, radar systems, and satellite imaging, and data from national and foreign bodies are collected and analyzed with a role in maritime security, such as port authorities, law enforcement, and customs (Daxecker & Prins, 2021). MDSA, MSSA, or SCD with the digitalization and IoT aims to deliver a valuable database of information, regularly in real-time, against which maritime security actions together with inspections and interceptions of ships at sea, can be scheduled and aimed, through centralized data-mining that is described as a process operated to extract valid data from a huger set of any raw data. Data mining is regarded as one of the most important technologies that make digitalization and IoT process smarter (Buklagin & Goltyapin, 2021; Del Giudice et al., 2021; Kapkaeva et al., 2021).

Other programs, meanwhile, take advantage of the opportunities provided by digitalization and IoT to open up new avenues of intelligence sharing between civil and military actors, as well as between navies or vessels of nations that would otherwise be hesitant to cooperate. Such as, international efforts and activities against piracy along the Somalian coast have been assisted by the information-sharing framework Mercury, which encourages different stakeholders to participate - as well as national navies, international operations, and civil information-sharing domains - to communicate with one another through synchronous text-based conversation, with a live stream on piracy incidents and naval operations affording real-time data to all actors who took part. At the corporate level, similar developments are taking place with maritime security governance and coordination. The maritime security agenda is fostering several of the new operational frameworks with the aim of coordinating activity with the smart maritime industry's digitalization and IoT (Bueger & Edmunds, 2017).

To effectively accommodate the growing number of passengers and trade, as well as to have suitable border security, Digitalization and IoT are widely used in ports. The arrangementsused in a port could include security systems such as (i) Access control for sensitive or restricted areas with the use of identification card systems or the designated security crew members. (ii) CCTV cameras are used to track perimeters and access to vulnerable areas. (iii) Access to the site by cars and road haulage vehicles is regulated using Automatic
Number Plate Recognition (ANPR). (iv) The autonomous surface vessel's intelligent control device. (v) As the port handles passenger traffic, such as cruise liners, the access control systems can also be used by customs and border enforcement officials (Boyes, 2014).

3. Development of Technology Transformation for Fostering Port Security:

Container scanning and tracking:

The volume of cargo transported in containers, along with the need for quick transportation and complex transport processes, pose a significant security threat to security systems. Due to the vast amount of container traffic, it is practically not acceptable to carry out visual checks to verify all containers by customs officials or inspectors (Alop, 2019). To meet this challenge, many non-intrusive cargo screening equipment‟s such as X-ray scanner, Radiation Portal Monitors (RPM), Radio Isotope Identification Device (RIID), Pulsed Photonuclear Assessment (PPA) inspection technology, Neutron Elemental Inspection Systems (NELIS), Tagged Neutron Inspection Systems (TNIS), vital signs detection systems, neutron interrogation techniques, fast neutron radiography, and cosmic ray Muon Radiography (MR) can be used. Of these multiple inspection tools, the X-ray scanner is one of the most widely used, providing and indicating a digital image, that can be used in the MDSA, MSSA, or SCD with the digitalization and IoT technologies (Min et al., 2016).

In the context of the necessity of prior notification of the shipment data, and similar to many security initiatives to secure the handling of containers and ensuing security measures, the importance of using paperless bills of lading, will enhance port security. A fully electronic Bill of Lading is currently obtainable on the eBusiness platforms on different companies globally. Managing such an essential document has never been this easy before. There is no need for the shipper to physically send the bill of lading to the concerning parties, this transfer can be done in just one click through companies account on MDSA, MSSA, or SCD depending on digitalization and IoT (Haliantych et al., 2021).

From a container tracking perspective, one of the most remarkable techniques used in tracking containers is the use of Radio Frequency Identification (RFID) label Tags. A microchip is connected to a radio antenna in a plain RFID tag. The microchip contains details such as cargo type, serial number, manufacturer, and so on. An RFID interrogation unit for smart containers may be integrated into the machine mounted within the container. Results

from the tags will be sent to the outside globe by the integration of an in-container transmitter through the MDSA, MSSA, or SCD. In the same context, nanotechnology has proven to be a game-changer in this area, allowing for the advancement of NANO-scale devices such as sensors. Containers may be tagged with nanotechnology to map their passage through the supply chain and have their current location. Seals with NANO sensors may be used on container door systems to keep the doors locked electronically. The sensor would send a warning if the container was opened in an inappropriate manner, which can reflect a securityincident immediately to all accountable parties connected to the MDSA, MSSA, or SCD
depending on the digitalization and IoT technologies (Tian, 2016).

Screening and identification of personnel:

The human interrelationship with port facilities and ships has grown considerably in response to the rising development in the maritime sector. Therefore, it is important to have an accurate system for controlling access and verifying the identity cards of the individuals. The US government's Transportation Worker Identification Credential (TWIC) ID card program is an appropriate move forward in maritime protection (White, 2020). The updated Seafarers' Identity Documents (SID) were introduced by the International Labour Organization (ILO) to deter acts of terrorism that challenge the security of passengers and crews, as well as the safety of ships. Biometric processing, which is commonly used for critical and important matters, is included in the SID. Workstation, domain control, and network, data protection, program logon, transaction security, and site security are all examples of its usefulness. Nevertheless, MDSA, MSSA, or SCD through the digitalization and IoT technologies, will innovate the integration of authentication process and indicates the headcounts, crew, or visitors in each place (Ntungwe, 2018).

Safety of navigation and traffic services:

Vessel Traffic System (VTS) is described by Charles W. Koburger Jr. (1986) as an "assembly of personnel, operating processes, facilities, and regulations organized for the purpose of marine traffic control, surveillance, and can be effectively used for improving maritime security in the area of control." VTS is located in a high-traffic area with restricted waterways and narrow channels. Such areas are thought to have a high chance of casualties. As a result, traffic in certain areas must be constantly monitored. Computers with appropriate software for producing a surface image of traffic in the region, as well as navigational sensors such as DGPS and AIS, are among the infrastructure and other resources needed to achieve its goals. VTS will be able to share information on sea traffic more effectively according to digitalization and the IoT. As a result, electronic instruments onboard ships and protocols between ship traffic networks must be standardized. A global standard for e-Navigation, a new concept of the ship navigation system, is being developed with the aim of ensuring safe ship navigation and including security-related capabilities in maritime interactions through the exchange of data and knowledge within the MDSA, MSSA, or SCD (Park & Bang, 2016).

Acoustic threat detection:

Remote Operated Vehicle (ROV) systems have been used for underwater detection, mine countermeasures, and industrial activities such as rescue support duties, as well as for observation, testing, and survey operations by coastal and inshore operators. This technology would be effective in improving maritime protection by providing underwater surveillance for high-profile strategic targets. Improvements in digitalization and IoT and underwater maritime technologies ROVs, as well as the Internet of Underwater Things (IoUT), known as a network of interconnected smart underwater items (Berlian et al., 2016), have enabled a broad range of applications, including ship and port facilities security, underwater observations, disasterwarning systems, and military applications which could be integrated within the MDSA, MSSA
or SCD for easily accessible information by the authorized parties.

Port perimeter and channel surveillance (monitoring):

The assaults on the USS Cole in the port of Aden and the French VLCC Limburg in Yemen demonstrated how vulnerable narrow channels and port areas are for shipping. As a result, maintaining port perimeter and channel monitoring is important. Radars are used to conduct monitoring in the majority of situations. Furthermore, since radar equipment is limited in its ability to acquire and detect small targets in port and channel zones, an attack by small rubberized high-speed boats is a distinct possibility. As a consequence, port and channel surveillance will use a variety of emerging technology to supplement and resolve technical deficiencies, such as virtual fences, drones, and thermal infrared cameras which will significantly enhance maritime security, through the integrated MDSA, MSSA, or SCD, depending on the digitalization and IoT (Daxecker & Prins, 2021).

The virtual fence was constructed in some ports and port facilities to harden vulnerable assets such as rail tracks and pipelines over long distances. The virtual fence is made up of optical video recorders, an adaptive sensor detection suite that combines fixed and Pan/Tilt/Zoom, high definition, color, day/night cameras, radio frequency identification, active scanners, and other sensor types installed at strategic positions along the asset's line of sight, whether it is like pipelines or rail lines (Attia, 2016; Peckham, 2012). Data is encoded and transmitted via wireless or wired communication either through a chain of satellites, WiFi radio transmitters, and fiber optic or hard-wire connectivity to local and control centers and remotely located command.

In the same way, harbors, waiting areas, and waterways are critical maritime facilities that may be targeted by terrorists. Thus, it is significant to sustain a great level of surveillance in these zones. Harbor, waiting areas, and channel patrol are all carried out by manned vessels in most nations. Due to fatigue, patrolling for long periods of time on these vessels is difficult, nevertheless the exposure to a certain degree of risk as well. Unmanned Surface Vessels (USV) that can be remotely controlled with drones for hours of surveillance and anti-piracy patrol with no risk to human life, increasing the extent of observation and identification, and integrating with the MDSA, MSSA, or SCD by digitalization and IoT technologies. Depending on the requirements of the security forces, the vessel may be run using a satellite system, microwave guidance, or cellular technology (Johnston & Poole, 2017).

On the other hand, another approach toward the renovation of technological security phases represented in the aerial drones that have had a lot of coverage in recent years, being able to reduce the necessary manpower commitment and exhaustion, as well as the associated costs, in the maritime industry. Because of its tiny scale, it is easier to navigate, adapt to thermal exposition, and hold lightweight thermos and laser scanning cameras. Through the reliance on digitalization and IoT between all associated parties within the ports, aerial drones improve the protection, security, and reduces the vulnerability of dangerous operations. Thousands of laser pulses fired per second by devices aboard an autonomous drone, obtained by MDSA, MSSA, or SCD, and accessed by control centers via digitalization and IoT for risk evaluation at a later time. In the same context, a Light Detection and Ranging(LiDAR) method could be used to determine the authenticity of the observed pulses. These LiDAR data succeed to outline some unrivaled security capacities for visionary (Matteoli et al., 2017).

One of the latest technologies that can be used in this context, Laser Detection and Ranging (LADAR). Essentially, LADAR is a laser-based navigational aid that blends long-range target tracking with high-accuracy calculation, providing users with a complete 2D/3D/4D (3D plus time) perspective for optimum maritime visibility. With over 100 readings per second, the laser pulse scans a small region or target. LADAR is now focusing on integrating drone technologies into the device. There is optimism that as this technology becomes more widely used, new technologies will emerge that were previously undiscovered as a result of the digitalization and IoT revolution for the smart maritime industry (Mathew, 2019).

4. Discussion:

Port authorities and managers can now look for the possibility of additional integration of sensors installed in the different sectors of the port despite the information being processed separately. The aim of this discussion is to present the possibility of integrating the information obtained to form a picture of the port's various activities and the integration required to secure them. In the same context, port managers can study the possibility of using drones practically and effectively, taking into account that the aspects of the study must include many features, whether in terms of technical feasibility, operations, and potential legal blocks. Today"s primary port security technologies are radars, cameras, thermal imagers, and sonar, a combination of electromagnetic and acoustic spectrums (Henderson, 2020). A port or perimeter area, also would have a physical wall or fence line. All of the sensor systems ultimately link into a command and control center that allows the port security team to set up alert zones on the mapping system. Enhancements to all of those, along with the deployment of new or advanced technologies still under development, will improve coastal and port security significantly in the next years. The key driver which port security officials should see is the move from individual single-function sensors, such as coastal protection or ground radars, and combining them into one radar system. We can now do mixed sea and ground sensing, as well as low-flying Unmanned Arial Vehicles (UAVs), which have changed the challenge from 2D to 3D.

The ports are considered by many to be the most vulnerable to terrorist attacks. As natural formations, often used for centuries, they are more defined by the land enclosing them, making them more difficult to protect in a cost-effective manner. Natural curves in their environment create shadows and large areas that are unprotected because local authorities cannot afford the additional radars that would be required. Smaller, less expensive short-range radars can create a day/night, all-weather defense to enhance harbor protection significantly, especially when combined with other mechanisms, such as Unmanned Underwater Vehicles (UUVs) and electronic fences.

Globally, several port facilities have been targets of thousands of aggressive UAV operations in recent years (Ferrando et al., 2021). It is possible now and in the future to propose a system that merges Electro-optical (EO) tracking/classification, electronic-scanning radartarget detection, and directional RF inhibition ability. Monitor water and land activities, surveillance capabilities, flying drones, monitoring air, land, and sea simultaneously really need to be integrated with other system sensors. Their use to provide MDSA, MSSA, or SCD in port and harbor security may include:

- creation of an over-water virtual fence to detect small boats and swimmers before they reach the port/harbor boundary;
- creation of an overland virtual fence to detect land outsider before they arrive at the barriers;
- observation of intruders detected by other means;
- identification and tracking of intruders and direction of security forces;
- scanning of waters within the port/harbor boundaries for unauthorized activities;
- surveillance of all ships and boats within the protected area; and
- surveillance of all land fences within the protected area

A consolidated approach to port security is fundamental in an open port area. The establishment of a physically robust guarded overall port area is almost impracticable in many ports, considering the nature of its extent. A community of port facilities, roads, residential areas, and lots of open water creates the need for innovation and collaboration. The port security operational features can be dealt with and support through technical renovations but more importantly, a smart collaboration between officials is required.

MDSA, MSSA, or SCD through the digitalization and IoT technologies will assure the prompt action on time, insurance, and detection of the security breach. Furthermore, will enhance the linkage between marine command centers for security measures within the ports, port facilities, and other related parties associated with maritime security. The subsequent linkage technicalities must have sufficient details to serve as a planning and implementing the port security daily operations. These technicalities through the great use of digitalization and IoT will include outcome-based goals and measures of impacts, other than the weak individual integrations for the flow of the security data and information before that. This can enhance the security team's ability to perform port security risk management tasks and measure the impact and effectiveness of security measures in place at the port. These integrations through MDSA, MSSA, or SCD, which are depending on digitalization and (IoT), will be expected to address and enhance both the physical and operational security of the ports. This cloud of information and subsequent technical development by the digitalization and IoT are aimed to be dynamic, and therefore resilient enough to be refined so that they may remain modern and beneficial to all parties. Also, this cloud will provide the time with updated information, instruction, and procedures that can be chosen, integrated, and acclimatized to meet the particular needs of port security and its port facilities. Figure (1) shows the proposed flow chart of information before and after using digitalization and (IoT).

In this way, harmonious port security aims can be maintained, empowering the government and the maritime industry to achieve it regardless of changes in conditions and technology. This cloud will be produced by the Maritime Authority under the supervision of the relevant security agencies in each contracting government. In developing this cloud, input and contributions were received from the maritime security community and other security agencies duly authorized on behalf of the contracting government. Finally, the importancemust be emphasized in an advanced and efficient, Security Management Software (SMS) application which will allow the following integration needs: (i) Integration between various security sub-systems at the local level. (ii) Multi-site Integration. (iii) Integration with external databases used by other departments at the seaport. (iv) Integration between the various response forces.

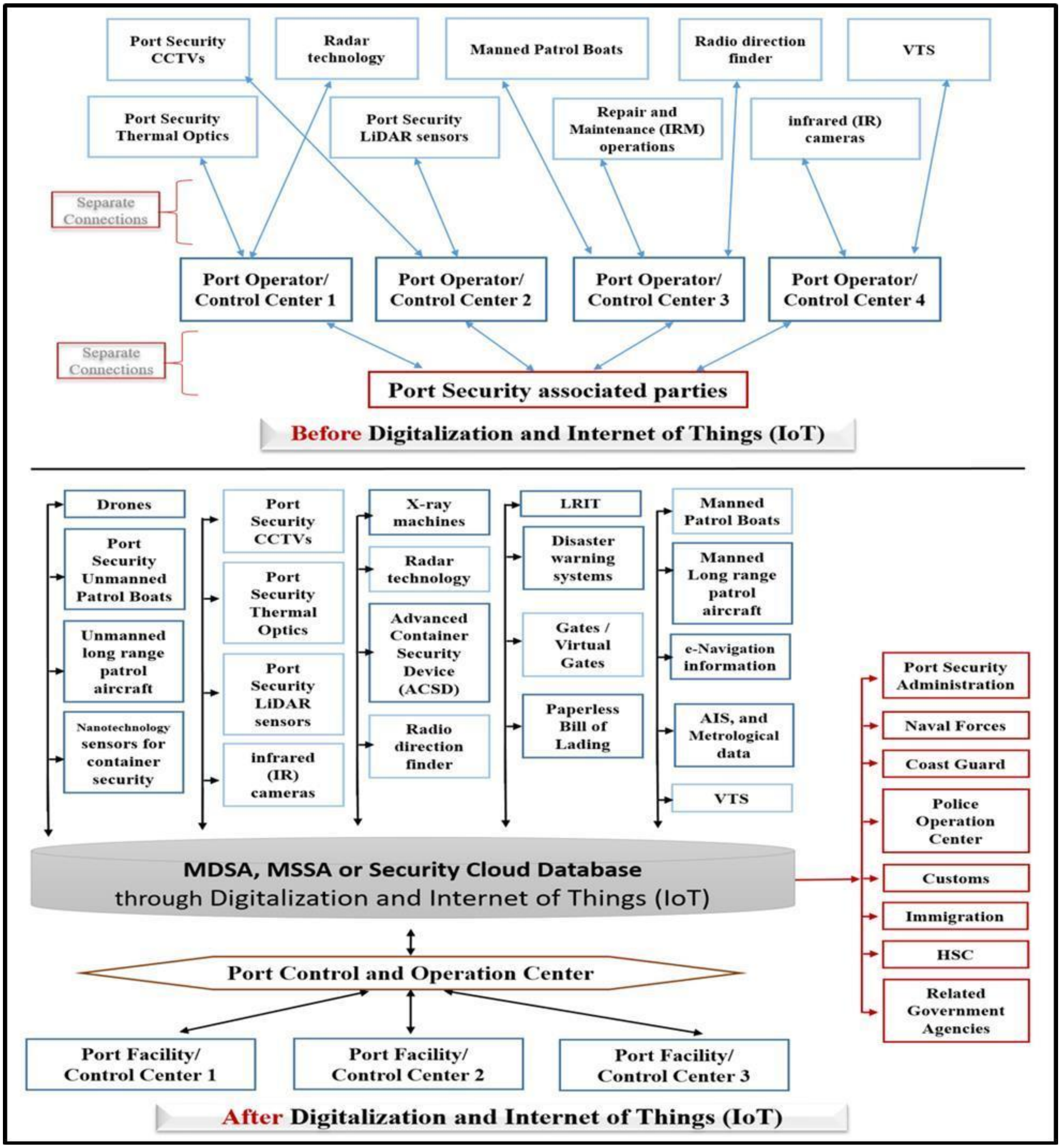


Figure (1): The proposed flow chart of information before and after using Digitalization and (IoT).

Source: Prepared by authors

5. Conclusion:

Ports operate in a very competitive market and face advanced security challenges due to their critical infrastructure with multiple supply chains. These aspects create a natural request for creative approaches to providing developed operational applicability. High-performing ports are implementing smart technologies to best manage operations facing new challenges in maintaining safe and secure facilities which provide the best environment for port operations. Considering the above from a technology viewpoint especially digitalization and IoT there are a number of challenges to improve port security: (i) Need for national and international standards with how maritime-related risks are at the port level, defined, evaluated, and contrasted; (ii) Need for further exploration and further development of port security technologies; (iii) Need for turn-key port security solutions, which address administrative and technological interoperability; and (iv) Need for greater inclusion in the development and application of port security technologies of leading, distinguished, non-national shipping companies and international seafarers. This study suggested the significance of provides MDSA, MSSA, or SCD as a tool for port authorities through digitalization and IoT to develop their port security strategies and assess their smartness, in addition to providing a proposed comprehensive framework for supplying information from various available sensors and linking it either with port control and operations center or to the different security agencies charged in dealing with security threats considering it as an added value for ports security.

6. Reference:

1. Alop, A. (2019). The main challenges and barriers to the successful "smart shipping".
    a. *TransNav: International Journal on Marine Navigation and Safety of Sea*
    b. *Transportation*, *13*(3), 521-528.
2. Attia, T. M. (2016). Importance of communication and information technology and its applications in the development and integration of performance in seaports. *Renewable Energy and Sustainable Development*, *2*(2), 137-146.
3. Benamara, H., Hoffmann, J., & Youssef, F. (2019). Maritime transport: The sustainability imperative. In *Sustainable Shipping* (pp. 1-31). Springer.
4. Berlian, M. H., Sahputra, T. E. R., Ardi, B. J. W., Dzatmika, L. W., Besari, A. R. A., Sudibyo, R. W., & Sukaridhoto, S. (2016). Design and implementation of smart environment
    a. monitoring and analytics in real-time system framework based on internet of
    b. underwater things and big data. 2016 International Electronics Symposium (IES), Biobaku, T., Lim, G. J., Bora, S., Cho, J., & Parsaei, H. (2016). An optimal sonar placement
    c. approach for detecting underwater threats under budget limitations. *Journal of*
    d. *transportation security*, *9*(1-2), 17-34.
5. Boyes, H. (2014). Maritime Cyber Security-Securing the Digital Seaways [J].
    a. *Engineering&Teclmology Reference*, *1*(1), 56- 63.
6. Bueger, C., & Edmunds, T. (2017). Beyond seablindness: a new agenda for maritime security studies. *International Affairs*, *93*(6), 1293-1311.Buklagin, D. S., & Goltyapin, V. Y. (2021). Digitalization of crop production: development trends. IOP Conference Series: Earth and Environmental Science,
7. CTAD, U. (2018). Review of maritime transport 2018. *United Nations New York*.
8. Daxecker, U., & Prins, B. (2021). *Pirate Lands: Governance and Maritime Piracy*. Oxford
    a. University Press.
9. de la Peña Zarzuelo, I., Soeane, M. J. F., & Bermúdez, B. L. (2020). Industry 4.0 in the port and maritime industry: A literature review. *Journal of Industrial Information Integration*,
    a. 100173.
10. Del Giudice, M., Di Vaio, A., Hassan, R., & Palladino, R. (2021). Digitalization and new technologies for sustainable business models at the ship-port interface: a bibliometric analysis. *Maritime Policy & Management*, 1-37.
11. Ferrando, I., Brandolini, P., Federici, B., Lucarelli, A., Sguerso, D., Morelli, D., & Corradi, N. (2021). Coastal Modification in Relation to Sea Storm Effects: Application of 3D Remote Sensing Survey in Sanremo Marina (Liguria, NW Italy). Water 2021, 13, 1040. In: s Note: MDPI stays neutral with regard to jurisdictional claims in published ....
12. Gray, J., & Rumpe, B. (2015). Models for digitalization. In: Springer.

13. Haliantych, M. K., Kostruba, A. V., & Maydanyk, N. I. (2021). Legal Aspects of the Implementation of a Pledge of a Bill of Lading as a Security: National Legal Realities. *International Journal of Criminology and Sociology*, *10*, 363-367.
14. Hemmings, J. (2021). The Sino-Russian Approach to the Maritime: A Mare Clausem System?
    a. *DKI APCSS, 22 - 2021*.
15. Henderson, K. T. (2020). *Non-Line-of-Sight Visualization and Imaging for Dynamic Scenes*
    a. *Using Sensor Fusion and Light Transport* University of Florida].
16. Johnston, P., & Poole, M. (2017). Marine surveillance capabilities of the AutoNaut wave- propelled unmanned surface vessel (USV). OCEANS 2017-Aberdeen,
17. Kapkaeva, N., Gurzhiy, A., Maydanova, S., & Levina, A. (2021). Digital Platform for Maritime
    a. Port Ecosystem: Port of Hamburg Case. *Transportation Research Procedia*, *54*, 909-
    b. 917.
18. Lesniewska, F., Ani, U. D., Watson, J. M., & Carr, M. (2021). The Internet of Things in Ports: Six Key Security and Governance Challenges for the UK (Policy Brief). *arXiv preprint arXiv:2101.08812*.
19. Li, S., Da Xu, L., & Zhao, S. (2015). The internet of things: a survey. *Information Systems*
    a. *Frontiers*, *17*(2), 243-259.
20. Lim, G. J., Cho, J., Bora, S., Biobaku, T., & Parsaei, H. (2018). Models and computational algorithms for maritime risk analysis: a review. *Annals of Operations Research*,
    a. *271*(2), 765-786.
21. Liu, R. W., Nie, J., Garg, S., Xiong, Z., Zhang, Y., & Hossain, M. S. (2020). Data-driven trajectory quality improvement for promoting intelligent vessel traffic services in 6G- enabled maritime IoT systems. *IEEE Internet of Things Journal*, *8*(7), 5374 - 5385.
22. Mathew, E. (2019). Intelligent Transport Systems and Its Challenges. International
    a. Conference on Advanced Intelligent Systems and Informatics,
23. Matteoli, S., Zotta, L., Diani, M., & Corsini, G. (2017). A framework for predicting underwater object recognition performance with fluorescence LIDAR. 2017 IEEE International
    a. Geoscience and Remote Sensing Symposium (IGARSS),
24. Min, H., Park, J.-W., Lim, Y.-K., So, A., & Cho, Y. K. (2016). Challenges and opportunities for implementing X-ray scanning technology at the Korean hub ports. *International Journal of Logistics Systems and Management*, *25*(4), 513-531.
25. Molavi, A., Lim, G. J., & Race, B. (2020). A framework for building a smart port and smart port index. *International journal of sustainable transportation*, *14*(9), 686-700.

26. Ntungwe, V. N. (2018). ILO Convention 185 on seafarers' identity document thirteen years after entering into force: analysing implementation challenges and future outlook. WORLD MARITIME UNIVERSITY DISSERTATIONS.
27. Padhi, P. K., & Charrua-Santos, F. (2021). 6G Enabled Industrial Internet of Everything: Towards a Theoretical Framework. Applied System Innovation, 4(1), 11.
28. Park, N., & Bang, H. C. (2016). Mobile middleware platform for secure vessel traffic system in IoT service environment. Security and Communication Networks, 9(6), 500-512.
29. Peckham, C. (2012). An overview of maritime and port security. 2012 IEEE Conference on
30. Technologies for Homeland Security (HST),
31. Rodrigue, J.-P. (2020). The geography of transport systems. Routledge.
32. Shaw, D. R., Grainger, A., & Achuthan, K. (2017). Multi-level port resilience planning in the UK: how can information sharing be made easier? Technological Forecasting and Social Change, 121, 126-138.
33. Sirimanne, S. N., Hoffman, J., Juan, W., Asariotis, R., Assaf, M., Ayala, G., Benamara, H., Chantrel, D., Hoffmann, J., & Premti, A. (2019). Review of maritime transport, 2019.
34. Suppiah, R. (2009). International Ship and Port Facility Security (ISPS) Code and Crew
35. Welfare. Maritime Affairs: Journal of the National Maritime Foundation of India, 5(1),
36. 57-72.
37. Tian, F. (2016). An agri-food supply chain traceability system for China based on RFID & blockchain technology. 2016 13th international conference on service systems and service management (ICSSSM),
38. Wang, X., Yuen, K. F., Wong, Y. D., & Li, K. X. (2020). How can the maritime industry meet Sustainable Development Goals? An analysis of sustainability reports from the social entrepreneurship perspective. Transportation Research Part D: Transport and Environment, 78, 102173.
39. White, M. M. (2020). Problems with the Transportation Identification Workers Credential and the 100 Percent Scanning Requirement Found in the US Container Security Initiative
40. Northcentral University].
41. Xiao, Y., Chen, Z., & McNeil, L. (2021). Digital empowerment for shipping development: a framework for establishing a smart shipping index system. Maritime Policy & Management, 1-14.
42. Yap, W. Y. (2020). Business and Economics of Port Management: An Insider"s Perspective.
43. Routledge.
44. Yuen, K. F., Thai, V. V., Wong, Y. D., & Wang, X. (2018). Interaction impacts of corporate social responsibility and service quality on shipping firms" performance. Transportation Research Part A: Policy and Practice, 113, 397-409.
45. Zhang, J., Wang, M. M., Xia, T., & Wang, L. (2020). Maritime IoT: An architectural and radio spectrum perspective. IEEE Access, 8, 93109-93122.

Innovative Navigation Role of ECDIS in Decision Support System

Ahmed Khalil Tawfik Barghash
Senior Marine instructor, integrated simulators complex, (AAST),Alexandria.
***Email:* seamasterkhila@hotmail.com**
Dr. Saleh Mesbah
Head of Remote Sensing and GIS Unit, Arab Academy(AAST),Alexandria,
***Email:* saleh.mesbah@aast.edu**
Dr. Nafea Shaban
Head of Marine Simultors,Integrated simulators complex, Arab Academy(AAST), Alexandria
,***Email:* nafea_24@yahoo.com**

ABSTRACT:

Navigational decision making in maritime transport becomes increasingly important nowadays with the increase of technological development, as it causes a direct increase in marine traffic, as well as having various types of ships with different specifications and different dynamic behavior. Thus, a reliable navigational decision support system is important to help officers in the process to achieving the best mode of navigation using a well-defined model structure according to the area of operation, maritime traffic, ships types, specifications and behavior. Despite the benefits obtained from ECDIS (Electronic Chart Display and Information System) as a tool of navigational decision-making, there are several challenges that are still facing ECDIS as a decision support system for navigation. The research aims to develop a new decision support system for maritime navigation to determine the best modes of ECDIS through an optimum model structure, which is capable of achieving an adequate level of ECDIS performance through a model software. The study followed a quantitative approach through a questionnaire to collect data from officers. Results showed a significant impact of Collision Avoidance, Under Keel Clearance Weather and Navigation Warning on officers' situational awareness in case of ECDIS integrated bridge system, implying the fact that there is an urgent need to devices and programs providing the Collision Avoidance, Under Keel Clearance Weather and Navigation Warning. These devices could be defined as the AIS, ARPA and NAVTEX as well as the programs of Tide and Sailing Direction. This research provides an insight to the importance of the five sensors; AIS (Automatic Identification System), ARPA (Automatic Radar Plotting Aid), NAVTEX (navigation telex), Tide and Sailing Direction and shows that these sensors are not optional for the ECDIS system. Instead, they should be considered as the minimum requirements of IMO (International Maritime Organization) to ECDIS navigation system as they boost the situational awareness for the officers using the ECDIS.

Keywords: ECDIS, E-Navigation, Risk Assessment, Situational Awareness, Collision Avoidance, Weather Conditions, under keel Clearance.

1. INTRODUCTION:

Navigational decision making in maritime transport becomes increasingly important nowadays with the increase of technological development, as it causes a direct increase in marine traffic, as well as having various types of ships with different specifications and different dynamic behavior. To increase the accuracy of decision-making process, much and qualified information should be obtained through a model structure using highly customized and developed model software to be able to possess the right data and reach the best decision which can improve maritime safety. This is not that easy to achieve and it might cause confusion to officers with much information that may not be always useful according to the sea state and many other factors (Besseris, 2011).

Since its inception, the International Maritime Organization has been concerned with securing maritime safety in all its elements and the safety of navigation in particular, so it issued many decisions whose aim was to improve the level of maritime safety and prevent maritime accidents, and with the increase in the many accidents, which was the responsible human element In most cases, the importance of taking advantage of the rapid development in the field of electronic equipment technology appeared to reduce the factors causing these accidents. The new instructions have been released for the installation of the electronic map system (EDIS) according to the type and tonnage of each ship, and with for ships to gradually start relying on ECDIS systems as a basic means of navigation, this has led to the emergence of fundamental defects in the systems that have a direct impact on the safety of maritime navigation. Therefore, the World Hydrographic Organization has issued a set of tests in order to be able to list these faults and study them so that they can be covered. With scientific methods and methods with the manufacturers of those systems so that the degree of reliability is raised to them in order to increase the level of safety of maritime navigation and the preservation of the marine environment, and the entry of (ECDIS) system into force, as well as the adoption of many ships on electronic maps instead of paper maps for the sake of the safety of maritime navigation (Weintrit and Neumann, 2015).

Despite the benefits obtained from ECDIS as a tool of navigational decision making, there are several challenges that are still facing ECDIS as a decision support system for navigation (Robinson, 2014). One of these challenges is having too much information on the screen which may be distracting to officers and decrease maritime safety. Also, ECDIS can be very complex and the size of chart displayed on the screen monitor is very much reduced compared with the paper chart. In addition, some symbols may be misinterpreted due to unfamiliarity. Besides, automatic plotting of position can lead to complacency concerning the vessel’s position and proximity to dangers. Finally, confusion with Electronic Chart System (ECS), which is an unauthorized use for primary navigation, may decrease maritime safety as well.

Accordingly, this research comes to introduce a model structure through a wider model application, which is capable to develop the performance of ECDIS as a decision support system to be able to provide the best mode of navigation in the optimum way of minimizing collisions and achieving safe distance, speed and course without causing confusion to officers with much information present on the device. Therefore, the researcher develops a new decision support system to determine the best modes of ECDIS through an optimum model structure, which is capable of achieving an adequate level of ECDIS performance through a model software. The different disciplines are introduced for ECDIS as best navigation modes, which are not available recently. A system must be established to support the ship master decision-making, by computer-based system to enhance ECDIS roll. The system shall be able to predict and optimize the best mode of operation (Bemley et al., 2013).

The Researcher methodology in development of the new Decision Support System is through examining the importance and significant of AIS (Automatic Identification System) ARPA *(Automatic Radar Plotting Aid*),NAVTEX (navigation telex) and Tide and Sailing Direction through questionnaire from officers.

2. LITERATURE REVIEWS:

It has been mentioned that the research aims to develop a new decision support system for maritime navigation to determine the best modes of ECDIS through an optimum model structure that is capable of achieving an adequate level of ECDIS performance through model software.

2.1 Literature Reviews for The relationship between Risk Assessment Parameters and Situational Awareness using ECDIS Decision Support System.

Maritime Transportation Systems (MTSs) are facing rapid changes. It is happening mainly due to crew shortage, increasing sizes of ships being operated, and progressive automation of modern merchant vessels. Continuous expansion of the global fleet and intensification of carrying goods by the sea trigger economical profits on the market, prompting further development of the shipping. Consequently, such a process can lead to a greater number of maritime accidents caused by heavy traffic (Chen et al., 2019; Ożoga and Montewka, 2018). These factors contribute to intensified scientific production in systems designed to support navigators, as well as ship operators in decision-making related to accident prevention.

There is no strict definition of the Decision Support System (DSS), due to the development of the concept over the years (Ożoga and Montewka, 2018). Its general aim is to support the decision-making process through improving human and system performance, e.g. by reducing mental workload. This is achieved not always through a process of automation but also merely by the facilitation of the decision-making. Therefore, many various approaches can be used in such systems, which are not limited to computer-based only. These methods can utilize paperwork, engage graphical representation of data, as well as handling and processing experts' knowledge (Bolman et al., 2018).

However, Decision Support System (DSS) is a computer-based information system that supports business or organizational decision-making activities. DSS can be either fully computerized, human or a combination of both (Stróżyna and Abramowicz, 2015). Decision-making requires access to best quality information on key environmental quality parameters. However, current data resources possess varying uncertainty. Therefore, management of environmental risks in coastal and marine waters is increasingly important (Chen et al., 2019).

In general, decision support means the use of various models and scenarios which help users to assess how their decisions may influence the state of the system. Decision Support Systems (DSS) are very complex systems which require the integration of data management, metadata systems, models, geographical information systems (GIS) and other components like image processing or data fusion (Martinussen et al., 2017). A decision support system had been designed for threats, vulnerabilities and consequences which facilitate the development and implementation of shipboard and seaport security plans through enabling the maximum flexibility in matching the demand of security control to the anticipated level of security risk. This system was not sufficient to provide the required level of security needed nowadays (Rønningen and Øvergård, 2017).

It has been mentioned before that the research aims to develop a new decision support system for maritime navigation to determine the best modes of ECDIS through an optimum model structure which is capable of achieving an adequate level of ECDIS performance through model software. Thus, this chapter defines the terms Risk Assessment, Decision Support System and ECDIS, discusses their shapes, clarifies the dimensions of each one, explores barriers to ECDIS as a navigational tool, evaluates guidelines and models on ECDIS in relation to providing support for Decision Making Process and justifies the need for empirical data on best navigational mode (Ożoga and Montewka, 2018).

Moreover, a Designed Navigator's Decision Support System (NDSS) was proposed. The system proposed consists of two subsystems - Navigational Situation Display System (NSDS) and Determining Safe Trajectory System (DSTS). The first one collects input data from ARPA system and displays current navigational situation. The second subsystem is responsible for the performance of anti-collision calculations (Chen et al., 2020). Also, a navigational decision support system called NAVDEC was introduced, which represents an example of how information systems are gradually transformed into decision support systems. The NAVDEC also analyzes and assesses the present navigational situation considering the COLREGs, generates safe maneuvers in collision situations (new courses, speeds, trajectories) and justifies its proposals

(Awan and Al Ghamdi, 2019). Despite their high performance, the mentioned systems were limited only to prevent collisions, which is not the only benefit of ECDIS presence on board.

Furthermore, it was claimed that ECDIS will be a central system that would enable integration with devices and information sharing to improve maritime safety by best navigating the maritime traffic in each scenario. This system was able to include new and different situations of ECDIS challenges but did not provide a clear vision of ECDIS best modes of navigation (Ożoga and Montewka, 2018). In addition, the risk modeling approach was introduced for cargo ships as a decision support system, which provide the individual risk index based on some risk factors (Łushnikow and Pleskacz, 2018). The same problem is still present that there are no sufficient studies of an adequate application of ECDIS best modes of navigation.

It has been noted that maritime situation is, therefore, understood to represent a set of parameters which directly or indirectly, defined status of the monitored maritime object at the moment. Maritime situation awareness is an instrument for analysis of specific characteristics and parameters of the monitored maritime object for the purpose the obtained information about its current status and forecasting its status in the near future (Giannozzi et al., 2020). In turn, the term maritime situation management implies focused influence on navigation safety decision support system in order to improve the quality of decision making. This improvement is in large part attributable to the changing of properties, characteristics and parameters of the system. Initial data for maritime situation awareness process are information about vessels (vessel type, draught, stability, flood-ability), location of areas with solid ice cover, hydro-meteorological conditions, location of the closed areas for navigation, location of the environmentally vulnerable areas and others (Başhan et al., 2020)

Decision support studies provide a lot of benefits through effective management of knowledge (Giannozzi et al., 2020), because management practices are going back to the business mental models proposed by Newton and Descartes. The proposed models were based on complex behavior where the relationship between the stimulus and the response was not predictable. Such behavior was considered as complex one and computed as the product of the process of estimated parameters. In these models, ambiguity and uncertainty are to be reduced or ignored (Ożoga and Montewka, 2018).

Accordingly, the objective is to simultaneously minimize costs and maximize output. This is not that easy, especially in the case of the information revolution taking place nowadays. Such revolution is causing fundamental changes in the business-operating environment, culture, and business conceptual models (Acomi, 2020). As navigational tools are developed to have ECDIS as an innovative navigational tool in maritime nowadays, the researcher will suggest using ECDIS as a decision support system to apply safety assessment in maritime and minimize cost.

Thus, the ECDIS is used as a navigational tool in maritime and it is very effective for assessing risk and as a decision supporting system. In commercial maritime operations, the ECDIS and integrated ship Navigation systems (eg. ECPINS) have become more common place over the last years for safety, risk assessment, economic reasons, and for decision supporting system. Meanwhile the military has been adopting the same technology for arguably higher risk and more dynamic military operations planning for surface and now sub-surface applications. The drive for integrated automation and error reduction has also extended to join the digital dots between the source of the Navigation and operations planning data and the users. Thus, the hypothesis of this paper could be developed as follows:

H_1: There is a significant relationship between risk assessment and experts' situational awareness due to modes of ECDIS as a decision support system.

2.2 Related Concepts of ECDIS (Electronic Chart Display and Information System)

The electronic map system is a computer-based navigation system that complies with international standards issued by the International Maritime Organization (IMO) and can be used as an alternative to paper maps. It includes electronic navigation maps that have been defined through the International Maritime Organization in the database that contains all the data on the map that are used for the safety of navigation. The ECDIS system can receive the information issued by the navigational devices such as the electric compass, the automatic identification device, the satellite positioning device, the speedometer and the distance device, and the wind speed measuring device, and the system can also display the relevant navigation information in the navigation books (Łushnikow and Pleskacz, 2018).

After many ships relied on electronic maps as a main source for maritime navigation, as well as a large number of ships replacing electronic maps from paper maps, and due to the multiplicity of companies that manufacture these systems, a set of defects in some of these systems have been discovered that have a great impact on the safety of maritime navigation. In light of this, the International Hydrographic Organization (IHO) has identified defects in electronic map systems including, for example (Kamahara et al., 2019):

- The absence of the navigational areas newly defined by the International Maritime Organization, which are, Archipelagic Sea Lane, Environmentally Sensitive Sea Area and Particularly Sensitive Sea Area.
- The complete illumination features of the navigation aids are not apparent
- Isolated hazards do not appear.
- The system does not have the ability to detect hazards affecting the safety of sailing ship when using the itinerary test feature of the itinerary before departure.

- The system does not have the ability to display some warnings in the correct way that maintains the safety of sailing ships.

3. RESEARCH METHODOLOGY:

It is aimed to develop a new decision support system for maritime navigation to determine the best modes of ECDIS through an optimum model structure. This model structure should be capable of achieving an adequate level of ECDIS performance through a model software. Thus, the best modes are defined, which are useful for different onboard cases and scenarios. The current paper is an explanatory research with quantitative approach using unstructured questionnaire survey (quantitative tool) to collect data from officers to examine the impact of such challenges and propose solutions for solving them. Figure 1 illustrates the research framework, where the independent variable is the risk assessment, the dependent variable is the situational awareness.

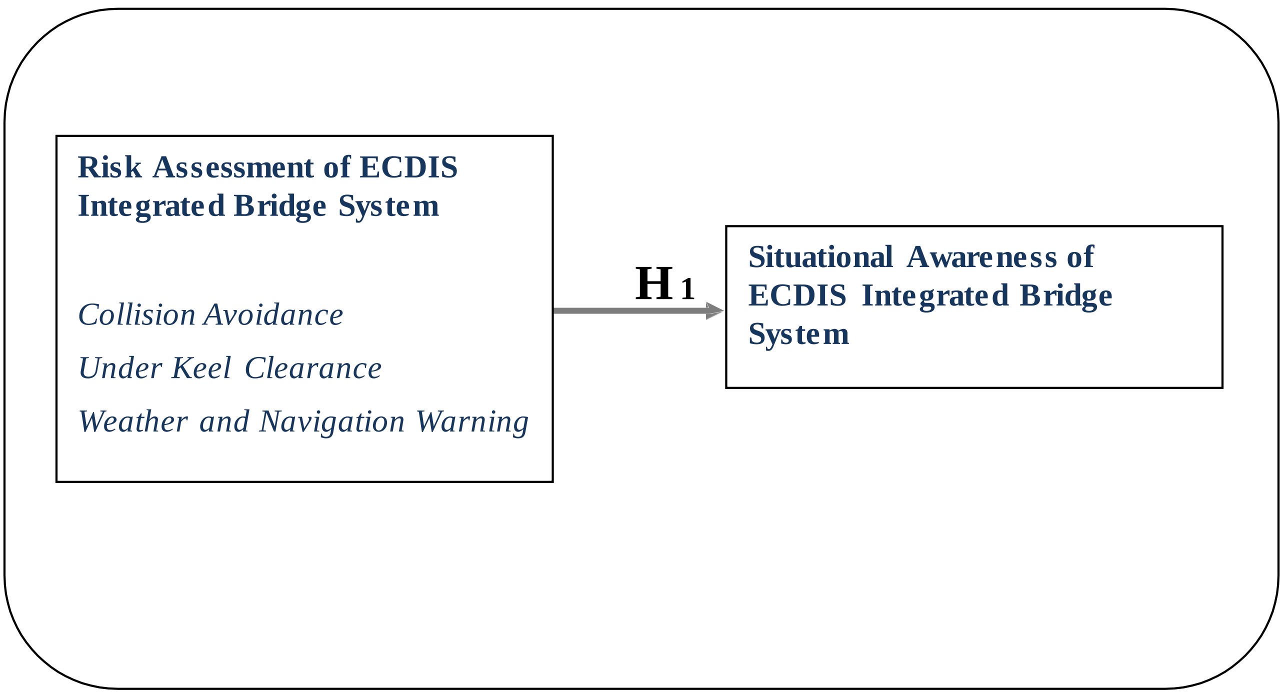


Figure 1: Proposed Paper Framework

The research hypothesis could be stated as follows:

H_1: There is a significant positive relationship between Risk Assessment Parameters and Situational Awareness in case of ECDIS as a decision support system.

4. EMPRICAL STUDIES and FINDINGS:

The current paper is an explanatory research with quantitative approach using unstructured questionnaire survey for collecting primary data from officers to examine the impact of such challenges and propose solutions for solving them. A descriptive analysis of the research variables is presented, followed by testing the research hypothesis using structural equation modeling.

Descriptive Analysis for Data Obtained for ECDIS Integrated System

Descriptive analysis provides summary statistics about the research variables, including the mean, and standard deviations. Table 1 shows the descriptive analysis for the research variables, where it was observed that the mean of Collision Avoidance, Under Keel Clearance, Weather and Navigation Warning, and Situational Awareness are 3.7401, 3.5573, 3.8414 and 3.5683 respectively. This means that the average values of research values are above average. In addition, it could be noticed that a relatively higher responses were shown in the zone of neutral (corresponding to 3) to the agreement zones (corresponding to 4 and 5).

Table 1: Descriptive Analysis for the Research Variables

				Frequency				
	N	**Mean**	**Std. Deviation**	**1**	**2**	**3**	**4**	**5**
Collision Avoidance	454	3.7401	.68945	0	0	182	208	64
Under Keel Clearance	454	3.5573	.76342	0	0	277	101	76
Weather and Navigation Warning	454	3.8414	.76712	0	0	175	176	103
Situational Awareness	454	3.5683	.73599	0	0	263	124	67

Table 2 shows the SEM (Structural Equation Modeling) analysis of Risk Assessment dimensions; Collision Avoidance, Under Keel Clearance, Weather and Navigation Warning on Situational Awareness in case of ECDIS integrated bridge system. It could be observed that there is a positive significant influence of Risk Assessment; Collision Avoidance, Under Keel Clearance, Weather and Navigation Warning, as the corresponding estimates are 0.379, 0.355, and 0.362 respectively as well as p-values are less than 0.05. In addition, the R square is 0.728, which means that Risk Assessment dimensions; Collision Avoidance, Under Keel Clearance, Weather and Navigation Warning explain 72.8% of the variation in Situational Awareness.

Table 2: SEM Analysis of Risk Assessment on Situational Awareness

			Estimate	P-value	R Square
Situational Awareness	**<---**	Under Keel Clearance / Collision Avoidance	.375 / .359	*** / ***	0.728
Situational Awareness	<---	Weather and Navigation Warning	.362	***	

Table 3 shows the model fit indices; CMIN/df = 1.119, GFI = 0.972, CFI = 0.996, AGFI= 0.960, and RMSEA = 0.016 are all within their acceptable levels. All of these values are referring to the fit indices and how the data fit the model to be tested.

Table 3: Fit Indices and Thresholds for Risk Assessment on Situational Awareness

Measure	Results	Threshold
CMIN/df (chi-square fit statistics/degree of freedom)	1.119	< 2 excellent; < 3 good; < 5 sometimes permissible
GFI (goodness-of-fit index)	0.972	> 0.80
AGFI (adjusted goodness of fit index)	0.960	> 0.80
CFI (comparative fix index)	0.996	> 0.95 great; > 0.90 traditional; > 0.80 sometimes permissible
RMSEA (root mean square error of approximation)	0.016	< 0.05 good; 0.05-0.10 moderate; > 0.10 bad
PCLOSE (significance Level)	0.956	> 0.05

The SEM (structural Equation Modeling) model conducted for the effect of Risk Assessment dimensions; Collision Avoidance, Under Keel Clearance, Weather and Navigation Warning on Officers Situational Awareness in case of ECDIS integrated bridge system is illustrated in Figure 2 where, the model fit indices; CMIN/df = 1.119, GFI = 0.972, CFI = 0.996, AGFI= 0.960, and RMSEA = 0.016 are all within their acceptable levels.

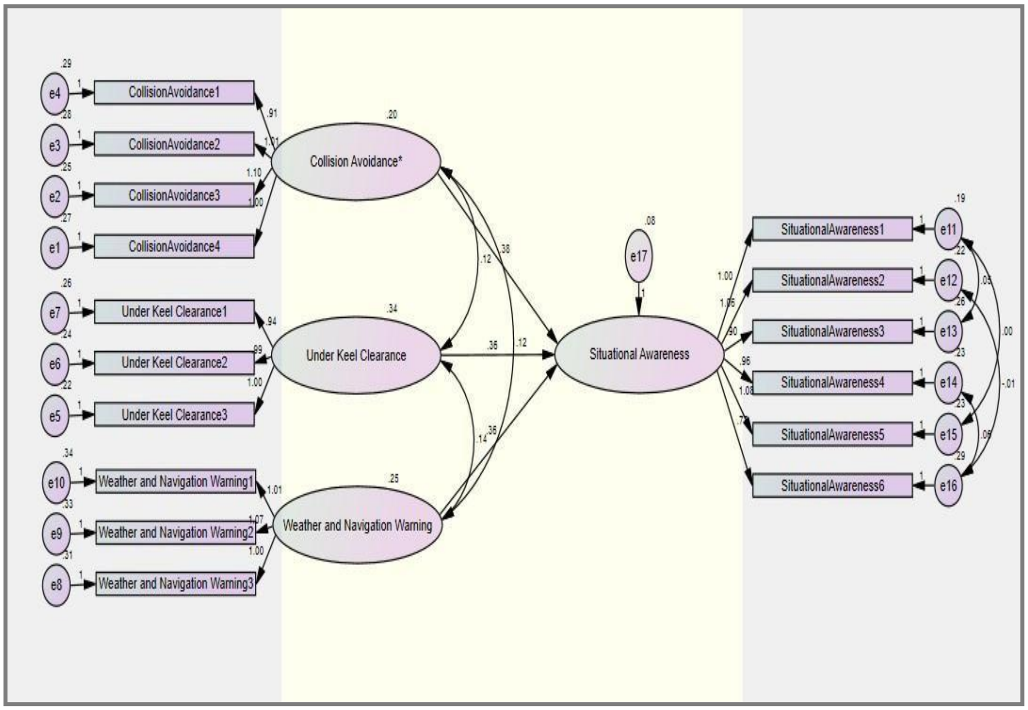


Figure 2: SEM Model

Source: AMOS (Analysis of a Moment Structures)

5. CONCLUSION, RECOMMENDATION and LIMITATIONS:

The results of the analysis showed a significant impact of Collision Avoidance, Under Keel Clearance Weather and Navigation Warning on officers' situational awareness in case of ECDIS integrated bridge system, implying the fact that there is an urgent need to devices and programs providing the Collision Avoidance, Under Keel Clearance Weather and Navigation Warning. These devices could be defined as the AIS, ARPA and NAVTEX as well as the programs of Tide and Sailing Direction.

The officers must be aware of the Risk assessment themes, which are Collision Avoidance, Under Keel Clearance, Weather and Navigation Warning and should learn that an ECDIS integrated bridge system should be used to increase the situational awareness. In addition, Officers must be aware that in order to avoid the challenges faced on board, the five sensors should be connected to the ECDIS primary to navigation and that these sensors should not be viewed as an option but rather a necessity. Further, more researchers should shed the light on increasing the situational awareness through connecting various sensors to the ECDIS.
Moreover, officers should be aware of the ECDIS system they are using and whether it is stand alone or integrated system, as this directly affect their situational awareness.

There are some limitations to this research that if prevented, results that are more accurate will be obtained and the results could be generalized. For example, the sampling technique is convenient sampling and the sample size is relatively small. This limitation could be solved by using random technique through making an online interview or questionnaire to be able to reach more officers and thus enlarging the sample size and making it more suitable for generalizing.

References:

Acomi, N., 2020. Impact of chart data accuracy on the Safety of Navigation. TransNav: International Journal on Marine Navigation and Safety of Sea Transportation, 14(2).

Amirhossein, T., Agrawal, R.R., Chatterjee, R., Negri, M. and Turchi, M., 2018. Multi-source transformer with combined losses for automatic post editing. In Third Conference on Machine Translation (WMT) (pp. 859-865). The Association for Computational Linguistics.

Awan, M.S.K. and Al Ghamdi, M.A., 2019. Understanding the vulnerabilities in digital components of an integrated bridge system (IBS). Journal of Marine Science and Engineering, 7(10), p.350.

Bemley, J.L., Davis, L.B. and Brock III, L.G., 2013. Pre-positioning commodities to repair maritime navigational aids. Journal of Humanitarian Logistics and Supply Chain Management, 3(1), pp.65-89.

Bistrović, M. and Komorčec, D., 2015. Impact of E-Navigation on ECDIS Development as a Decision Support System. NAŠE MORE: znanstveno-stručni časopis za more i pomorstvo, 62(1), pp.30-39.

Bolman, B., Jak, R.G. and van Hoof, L., 2018. Unravelling the myth–the use of decisions support systems in marine management. Marine Policy, 87, pp.241-249.

Chen, P., Huang, Y., Mou, J. and van Gelder, P.H.A.J.M., 2019. Probabilistic risk analysis for ship-ship collision: State-of-the-art. Safety science, 117, pp.108-122.

Chen, Z., Lv, N., Liu, P., Fang, Y., Chen, K. and Pan, W., 2020. Intrusion Detection for Wireless Edge Networks Based on Federated Learning. IEEE Access, 8, pp.217463-217472.

Engler, E., Baldauf, M., Banyś, P., Heymann, F., Gucma, M. and Sill Torres, F., 2020. Situation Assessment—An Essential Functionality for Resilient Navigation Systems. Journal of Marine Science and Engineering, 8(1), p.17.

Giannozzi, P., Baseggio, O., Bonfà, P., Brunato, D., Car, R., Carnimeo, I., Cavazzoni, C., De Gironcoli, S., Delugas, P., Ferrari Ruffino, F. and Ferretti, A., 2020. Quantum ESPRESSO toward the exascale. The Journal of chemical physics, 152(15), p.154105.

Kavallieratos, G., Diamantopoulou, V. and Katsikas, S.K., 2020. Shipping 4.0: Security requirements for the cyber-enabled ship. IEEE Transactions on Industrial Informatics, 16(10), pp.6617-6625.

Martinussen, M., Friborg, O., Schmierer, P., Kaiser, S., Øvergård, K.T., Neunhoeffer, A.L., Martinsen, E.W. and Rosenvinge, J.H., 2017. The comorbidity of personality disorders in eating disorders: a meta-analysis. Eating and Weight Disorders-Studies on Anorexia, Bulimia and Obesity, 22(2), pp.201-209.

Miciuła, I., Stępień, P. and Zakrzewska, M., 2020. Model of the geospatial situation of the decision support system for automatic determination of inland vessel movement. Procedia Computer Science, 176, pp.3153-3162.

Ożoga, B. and Montewka, J., 2018. Towards a decision support system for maritime navigation on heavily trafficked basins. Ocean Engineering, 159, pp.88-97.
Ozturk, U., Birbil, S.I. and Cicek, K., 2019. Evaluating navigational risk of port approach manoeuvrings with expert assessments and machine learning. Ocean Engineering, 192, p.106558.
Prill, K. and Szymczak, M., 2016. Methodology for identification of potential threats and ship operations as a part of ship security assessment. Zeszyty Naukowe Akademii Morskiej w Szczecinie.
Stankov, U., Filimonau, V. and Vujičić, M.D., 2020. A mindful shift: an opportunity for mindfulness-driven tourism in a post-pandemic world. Tourism Geographies, 22(3), pp.703-712.
Stróżyna, M. and Abramowicz, W., 2015. A dynamic risk assessment for decision support systems in the maritime domain. Studia Ekonomiczne, 243, pp.295-307.
Svilicic, B., Kamahara, J., Celic, J. and Bolmsten, J., 2019. Assessing ship cyber risks: a framework and case study of ECDIS security. WMU Journal of Maritime Affairs, 18(3), pp.509-520.
Weintrit, A. and Neumann, T., 2015. Safety of Marine Transport: Marine Navigation and Safety of Sea Transportation. CRC Press.
Svilicic, B., Kamahara, J., Celic, J. and Bolmsten, J., 2019. Assessing ship cyber risks: a framework and case study of ECDIS security. WMU Journal of Maritime Affairs, 18(3), pp.509-520.

The Readiness of the Maritime Education for the Autonomous Shipping Operations

Karim Mohamed Aboul-Dahab

National Telecom Regulatory Authority (NTRA), Egypt, kmohamed@tra.gov.eg

ABSTRACT:

Technological advancement in the maritime industry is progressing in a rapid pace and needs continuous development of seafarer's education to cope with this development. In the area of automation, unmanned shipping is expected to offer more effective way of moving freight in a way that reduce costs and accidents caused by human errors ,moreover the autonomous operations supports the transition towards sustainable and eco- friendly transportation MO is reviewing the existing IMO adopted conventions to perceive how they may apply to ships with differing levels of automation , to establish a regulatory framework for Maritime Autonomous Surface Ships (MASS).The current version of STCW 1978 (as amended) has 19 competence themes consisting of 66 Knowledge, Understanding & Proficiency items (KUPs), which specifies the minimum standard of competence for officers in charge of a navigational watch on ships of 500 gross tonnage or more ,The curriculums in maritime education and training (MET) university education must react and adjust to the upcoming changes within the maritime industry which demand raising the awareness among all industry stakeholders on the essential Competencies for Autonomous Maritime Operation. This paper will review the readiness of the existing STCW framework for the implementation of the different degrees of the Autonomous vessels, further to investigate the seafarer training needs for Operating Autonomous Ships, in particular degree 1 and degree 2 Autonomous Ships.

Keywords: Maritime Autonomous Surface Ships (MASS), Standards of Training, Certification, and Watch keeping (STCW), International Maritime Organization(IMO), maritime education and training (MET), Competency Development, competency gap analysis, Internet of things (IoT), Maritime human factors

INTRODUCTION:

Shipping has experienced big changes over the past 20 years. Ship sizes have increased and crew numbers have decreased. New technologies on the bridge and innovation in the engine room mean that the skills required onboard have changed significantly.

The progress towards digitalization and computerization is accelerating in the shipping industry, digitalization activities has influenced various business activities within the marine industry,, This will create significant new demand for a range of occupations, including; Ship Automation Specialist, Cyber Security Specialist and Data Protection Specialist.[14]

The advancement of the maritime shipping business towards unmanned vessels has made great progress . The change towards digitalization and computerization is accelerating in the shipping industry more than ever before, further the advancement towards unmanned shipping would come at a cost, the shipping industry stakeholders needs to get ready to confront the upcoming challenges associated with the technological progress. the automation development can be seen effectively all around in regular day to day activities , for instance the wide utilization of drones, self-driving vehicles and in the advanced cargo handling solutions.

As a result of technological developments over time and the more systematic approach for managing ship operations, many standard ship operations, as currently experienced and everything considered, are performed and managed without the direct day to day involvement of the shipmaster. When irregularities representing threats to the safety of the ship, her cargo, threats to the environment or others at sea occur, the master will intervene and give orders as necessary, such that the safety and integrity of the ship and her cargoes is maintained or a fail-safe mode established.

The European Technology Platform describes the autonomous ship as a next generation modular control and communications technology system of systems which will "enable wireless monitoring and control functions both on and off board. These will include advanced decision support systems to provide a capability to operate ships remotely under semi or fully autonomous control .[3]

Embedding smart ship equipment into an existing vessel is the first step on the Rolls-Royce roadmap to a fully autonomous and intelligent ship. The company hopes to have a remotely operated vessel in operation on international waters by 2025.as it appears in figure-1[18], On the other hand , some reports presumed that the implementation of a fully autonomous ships on a significant scale won't happen in the coming decades, however the maritime industry will observe an increasing number of autonomous functions on a ship. For example, optimum routing considering weather conditions and collision avoidance algorithms. Such systems will require complex human-machine interactions and in-depth system understanding is needed. [4]

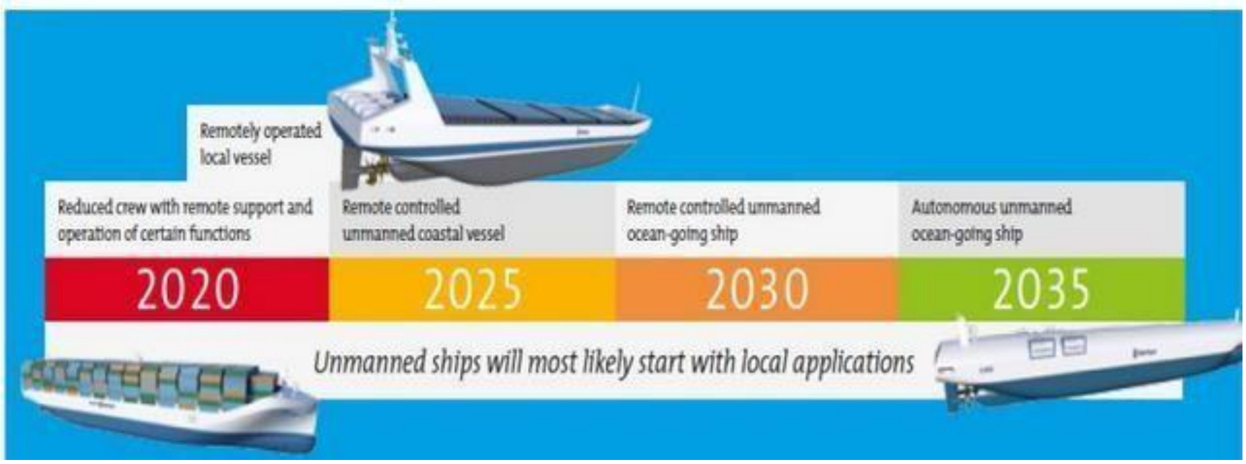


Figure 1

The IMO has formally initiated work to investigate the feasibility of the Autonomous Surface Ships (MASS) implementation taking in to consideration the associated challenges as the safety , security and the environmental concerns, The Maritime Safety Committee (MSC) supported an updated regulatory framework for the administrative checking , as work in progress, includes a plenary definition of MASS and the varying degrees of autonomy. MASS operations has been classified in to several degrees that varies according to the nature of human involvement in the operation process , in this respect the IMO recognized four degrees of MASS operations as follows:

• Degree one: vessel with computerized process and decision support system ,Seafarers are on board of vessel to take necessary actions and to interact with the installed systems, A few operations might be automated.

• Degree two: Distantly controlled vessel with crew on board ,most of the main functions are remotely operated , yet the seafarer on board remains necessary for efficient operation

• Degree three: Remotely controlled vessel without a crew on board , the vessel is controlled from a remote control center , the seafarer existence remains important in the control center

• Degree four: A complete autonomous vessel , an Artificial intelligence systems efficiently operate the main functions including taking decisions in many circumstances [11]

The technological change in the maritime industry may render workers' skills obsolete, automation has been gradually replacing employees in many industries , for instance to move from first degree (MASS) to second degree (MASS) means that a less number of seafarers are required on board and a new technical competencies deems necessary to proceed to the next phase of the shipping automation, in this regard advanced training program or specific crew Training is necessary to increase their knowledge, skills and understanding to work in a more digitized shipping environment.

MSC 102/5/21 proposed as for degree of autonomy three, since "master", "crew", "responsible person", etc., are not on board, the meanings of such personnel of the ship should be clarified in SOLAS chapter VII and all the associated codes.

The rest of this paper is presented as follows. section 2 review about the previous research on the topic at hand as well as the studies related to the development of Maritime education and training (MET, The third section analyses the future competence required for seafarers , a competency gap analysis outlined in the fourth section , Our conclusions are drawn in the final section.

BACKGROUND:

automation is the technology by which an interaction or method is performed without human involvement . In other words its the Computerization or programmed control of different systems to sufficiently operates equipment such as Vessel navigation ,Monitoring and identification [14]

The International Convention on Standards of Training, Certification and Watch keeping for Seafarers (STCW) the convention proactively respond to international seafarer training and development needs , the certificates, watch keeping and the essential training of seafarer were previously administered separately by each flag state ,in the absence of a unified standards of seafarer training and development the competency level varies enormously in a global field by nature.[12]

A growing body of literature(Pan, Yushan, et al , 2019, Ekow Manuel, M., 2017) evaluated the different approaches of maritime education, for instance the Vocational ,academic and Simulation-based s maritime education system , with the aim of determining the development needed to cope with the digital trends in the maritime industry .[24,9]

(Komianos, A., 2018) reviewed the different challenges on the implementation of an autonomous vessel , including but not limited to regulatory ,insurance, juridical, safety and the seafarer readiness, moreover the article shed light on the required amendments to the different IMO instruments ,in order to adapt to the operational deployment of such vessels in the future. [15]

in the same manner (Aldauf, M, et al , 2018) addressed the challenges associated with the foreseeable implementation of an autonomous vessel , the research expected that potential conflict will exist when autonomous and conventional vessels operates in common sea areas, moreover based on the research results an experienced seafarers still needed along with the computer experts on the autonomous vessel shore-based control center to attain a safe and efficient marine navigation .[4]

According to (Ju Chae, C,et al , 2020) Increased automation on-board ships will require new standards for the definition of a seafarer, and the clear division of role and responsibilities of staff, remote operators, and the captain, be established.[13]. Relatively several documents have been submitted to the IMO's Maritime Safety Committee (MSC) , for instance the MSC 102/5/21 called for the need for a general, consistent and accepted reinterpretation of previously well-understood terms such as "master" in order that they can be understood in the context of a vessel with no seafarers on board.

Accordingly the MSC 102/5/25 illustrated that regardless of the level of autonomy, people will be involved in the operations of ships. This implies that the formal and informal training needed to match the required competencies for the people associated with the activities and support of MASS. In essence, more attention should be paid to the required competencies in order to manage and control MASS operations.

Bauk, S. and Alop, A., (2020) suggested that as the shipping industry moves toward more automated features on board of vessels , two types of seafarers will be needed, the traditional master on board of vessel and the other seafarers who mainly monitor the smart systems on board of vessels, In this regard the common knowledge between the seafarer offshore and onshore will include but not limited to maritime knowledge.[6]

(Anatoli Alop,2019) assumed that a few or even a considerable amount of the current jobs are probably not going to exist in the foreseeable future , as they will no longer hold the adequate knowledge and competences to confront future challenges, moreover the future educated maritime workers must hold the following competencies; creativity, social interaction, exclusive physical skills, empathy, ingenuity and collaboration. [1]

(Pan, Yushan, et al , 2019) perceived that simulator –based maritime education should be reconfigured in a way that the education providers will act more as a mediator between the trainee and the technology , in this respect the research suggested a more innovative learning environment that deals with the learners as a participant innovators not imitators .[8]

(Erdogan, O. and Demirel, E., 2017)suggested that to improve the quality of maritime education and training (MET) in turkey , maritime universities needs to implement a holistic education and training programmers that meets both vocational and academic requirements, moreover the seafarer needs now more than ever to effectively integrate ICT in their curriculums and training programs , in order to efficiently operate and to safely use automated systems on board of vessels .[10]

MAIN FOCUS OF THE ARTICLE

Issues, Controversies, Problems

Globally speaking the maritime industry and the seafarers working in it are not bound to a single country or nationality. It's an international and multicultural industry, which calls for a unified competency framework that defines the knowledge, skills, and attributes needed for people within this industry ,in this way(Cicek, K., et al , 2019) clustered the main maritime competencies under four categories which are technical, social, methodological and personal, Where in the classification of specialized capabilities, data and programming competencies expected to be a fundamental skills with the increasing digitalization of the maritime industry, consequently the adaptability and flexibility to learn deemed important as well. [7]

All together for Industry 4.0 to succeed, the preparation and capability of qualified workers should meet the new requirements to cope with the digital transformation in the maritime industry, consequently Katarzyna Grzybowska, and Anna Łupicka (2017) defined eight main managerial competencies (Creativity, Entrepreneurial thinking, Problem solving, Conflict solving, Decision making, Analytical skills, Research skills, Efficiency orientation), employees and managers should possess to adopt Industry 4.0 in the automotive and pharmaceutical industry. [16]

On the other hand (Sharma, A, et al , 2019) defined the core competencies for seafarers to operate a degree two autonomous vessels , the research indicated that the ability to take initial actions in emergency situations along with the leadership and team working skills are vitally important in the operation of a semi-autonomous sailing systems. [26]

Maritime capacity building aims to address gaps between the status quo and future requirements for competency development. In this regard, Simmons, E. and McLean, G (2020) assumed that with the progress in automation technology, building the capacity of the seafarer and updating the curriculums of the maritime education and training (MET) institutes are vitally important to cope with the transition towards digitalization and automation in the maritime industry. Changes are required to close these gaps on three main areas: (1) developing a whole of culture appreciation for new cognitive skills (Science, technology, engineering and mathematics (STEM) skills) Maritime Industry 4.0 require more computer knowledge to get acquainted with the advances in maritime technology onshore and offshore (2) creating scientific committees that have a global understanding of the legal and moral consequences of the application of these new technologies , moreover to demonstrate how this transition could benefit the entire marine industry and (3) offering technological solution as e- learning that promotes education to a wider audience, in this case capacity-building programs could provide quality education at a lower cost .[28]

The STCW 2010 amendments pointed out the essential education and training requirements to build up the essential Knowledge, Understanding and Proficiency (KUP) that matches the items included in the convention , In this context Kim, T. and Mallam, S.(2020) examined the degree of importance of six main competencies listed on the Knowledge, Understanding and Proficiency items (KUPs) of the STCW 2010 amendments , the research found that the ability to obtain and maintain situation awareness is perceived

as the most critical leadership competence, indeed the knowledge and ability to acquire, handle and comprehend large amount of system information considered a critical competency to monitor an autonomous vessel via a remote control center, in other words the increased level of shipboard automation suggests that less seafarers are required to efficiently deal with the operating systems onboard y, moreover it requires less personas with high cognitive skills to effectively deal with the normal and abnormal scenarios encountered to effectively operate an autonomous vessel [17]

Accordingly (Wang Deling,et al ,2020) suggested that the improvement of MASS will bring approximately the alteration of seafarer hierarchy . In alignment with the STCW treaty and code, seafarers are essentially classified into three categories: deck team individuals in charge of transport route and cargo transportation (Major of nautical technology); motor room team (Major of marine engineering) individuals responsible for the electrical, electronic installation and control system of the ships.(Major of electrical, electronic and control engineering);. Whereas in higher levels of MASS, the seafarers will not be classified according to the work environments and transport control , in this respect seafarers will be classified in to two categories : "shore-based" staff and "shipboard group". The shore-based team will be responsible for distant operations of the vessels, such as the ship navigation via a remote control center , while the offshore team will be responsible for numerous tasks such as navigation and machine maintenance. [30]

Although digital technologies are creating major new opportunities and jobs in the maritime industry , they also increase the demand for digital skills and competencies, Respectively (Yoshida, M, et al ,2020) considered the basic knowledge of wireless data communication as a main competency for the seafarer involved in the MASS operation, in this respect the research proposed additional competences and possible provisions to the regulatory requirements in the STCW Convention. [32]

In order to identify the main knowledge and skills needed for the future operation of autonomous vessels, (Wang Deling,et al ,2020) have already divided the knowledge and skills needed by navigators in the future to manage and operate MASS into three aspects: Ability, Knowledge and Technology as illustrated in table 1 and table 2,a brief definitions of the competences included in the appendix .

To ensure that the gap between concept and practice is bridged (Zaucha, J. and Gee, K., 2019) emphasized the importance of maritime spatial planning knowledge in the modern maritime education, in a way that raise awareness of environmental issues to create a sustainability approach that intertwined the social ambitions with the ecological and economic dimensions in the sense that economic and ecological dimensions can influence the ability to achieve social sustainability and vice versa.[33]

Pantouvakis, A. and Vlachos, I., 2020 defined leadership as the ability to influence individuals and mobilize organizations to realize a vision of long-term ecological and social sustainability", in other words, Leadership is an important determinant for achieving sustainable development.[23]

According to (M. Yilmaz et al,2020) within the marine industry the implementation of IoT technologies allows the shipping companies to interface via a single system to share the instant vessel data with the maritime stakeholders , .In this regard the IoT technologies are set to reduce redundancy associated with multiple data entry , moreover it reduces costs and enhance communication between different stakeholders , accordingly the IMO created (Global Integrated Shipping Information System) GISIS , and advised all member states to regularly update their data on the GISIS platform , in a way that authenticate the data regarding the Marine Casualties and Incidents, Port Facilities, focal Points, Port Waste Management, licensed vessels to operate radio communications terminals along with the Search and Rescue capacity [20]

(Gauthier, M et al. 2019) suggested that a modern automation and control system is a technologically complex and fully integrated system covering many aspects of the vessel's operation. This includes propulsion, steering, navigation, power management, engines, auxiliary machinery operation and cargo handling.[11]

Table 1 illustrates the core competencies to operate , Degree 1 autonomous vessel , in which "Seafarers are on board of vessel to take necessary actions and to interact with the installed systems, A few operations might be automated",

Aspects	Competencies	Top Manager (Ship Owner)	Middle Manager (Fleet Manager)	Lower Level (Ship Master ,Chief Engineer)
	Leadership and communication	✓	✓	✓
	Environmental/sustainability concerns	✓	✓	✓
Ability	Technical		✓	✓
	Automatic Control Knowledge		✓	
	Critical thinking	✓	✓	
	Data Mining Knowledge	.	✓	✓
Knowledge	Autonomous Navigation		✓	✓
	Fault Diagnosis	✓	✓	✓
	Remote Control			
Technology	Basic Knowledge of wireless communication and data transfer	✓	✓	✓
		✓	✓	✓
	Internet of Things IOT	✓	✓	✓

Table-1

Table 2 illustrates the core competencies to operate a degree two Autonomous ships: The vessels falling within the second degree are remotely controlled ship with seafarers on board.

Aspects	Competencies	Top Manager (Ship Owner)	Shore Based Crew	Ship Board Crew
Ability	Leadership and communication	✓	✓	✓
	Environmental/sustainability concerns	✓	✓	✓
	Technical		✓	✓
Knowledge	Automatic Control Knowledge		✓	✓
	Critical thinking	✓	✓	✓
	Data Mining Knowledge	.	✓	✓
	Autonomous Navigation		✓	✓
	Fault Diagnosis	✓	✓	✓
Technology	Remote Control		✓	
	Basic Knowledge of wireless communication and data transfer	✓	✓	✓
	Internet of Things IOT	✓	✓	✓

Table-2

CONCLUSION:

The development of MASS needs more skilled maritime talents, so the proportion of maritime talents at the levels of technical secondary will continue to shrink, and those of high-vocational and undergraduate level will occupy the mainstream.

Maritime industry is undergoing radical changes with the technological advancement and fast introduction of automation technologies. To cope with increasing industrial demand and accelerated technological development, the global standard of maritime training and certification will also require revision and adaption.

It is acknowledged that education of seafarers must adapt to the changing maritime industry even though, the skills we need now, are not disappearing completely, not at least in the next 20-30 years. The most ships that currently are build and designed are still made for traditional shipping. This doesn´t still mean that educational institutes should not renew planning of the syllabuses and take into account of industry´s needs. MET institutions must have a strategic objective to serve the maritime industry and offer high qualify research to benefit the maritime stakeholders now and in the future so that the maritime transport be executed in safe, secure and efficiently at the same time respecting the nature.

Seafarers should master new knowledge and technology related to marine autonomous surface ship or apply them in practice to different degrees, such as network information knowledge, automation knowledge, information physical system knowledge, big data knowledge, autonomous navigation and collision avoidance technology, remote control knowledge etc, which will have a considerable impact on the future maritime education and training, requiring the future maritime education and training to include the above new knowledge and technology in addition to the traditional maritime knowledge.

The findings of this study illustrated the necessary seafarer competencies to work on board of autonomous ships.

Maritime universities, colleges, training institutions and maritime authorities are suggested to closely track the development of MASS and provide relative new knowledge and improve modes of maritime education in order to produce talents suitable for the development of navigation technology.

REFERENCES:

[1] Anatoli Alop (2019),The Challenges of the Digital Technology Era for Maritime Education and Training Estonian, Proceedings of the European Navigation Conference (ENC) pp.1–5, Maritime Academy (of Tallinn University of Technology) Tallinn, Estonia, 10.1109/EURONAV.2019.8714176

[2] Alessandrini, A., Alvarez, M., Greidanus, H. and Gammieri, V., 2016. 'Mining Vessel Tracking Data for Maritime Domain Applications', , Proceedings of IEEE 16th International Conference on Data Mining Workshops, pp. 361-367.

[3] A. Komianos (2018).The Autonomous Shipping Era. Operational, Regulatory, and Qualit Challenges A. Komianos The Nautical Institute, London, United Kingdom, the International Journal on Marine Navigation and Safety of Sea Transportation, Volume 12 Number 2 June 2018 DOI: 10.12716/1001.12.02.15.

[4] aldauf, M., Kitada, M., Ali Mehdi, R. and Dimitrios, D., (2018). 'E-Navigation, Digitalization and Unmanned Ships: Challenges for Future Maritime Education and Training', Proceedings of the 12th International Technology, Education and Development Conference (INTED2018). pp.9525-9530,Valencia-Spain.

[5] A. Oksavik, H.P. Hildre, Y. Pan, I. Jenkinson, B. Kelly, D. Paraskevadakis, R. Pyne(2020), FUTURE SKILL AND COMPETENCE NEEDS, https://ntnuopen.ntnu.no/ntnu-xmlui/bitstream/handle/11250/2648963/Oksavik.pdf?sequence=4

[6] Bauk, S. and Alop, A., (2020). 'Smart Shipping Needs Smart Maritime Education and Training', Proceedings of the 1st International Conference on Maritime Education and Development, 23-24,November.Springer Nature, pp.131–142.

[7] Cicek, K., Akyuz, E. and Celik, M., 2019. 'Future Skills Requirements Analysis in Maritime Industry', Procedia Computer Science, vol. 158, no. 1, pp. 270-274. https://doi.org/10.1016/j.procs.2019.09.051

[8] Conceição, V., Beatriz Carmo, M., Dahlman, J. and Ferreira, A., 2017. 'Visualization in Maritime Navigation: A Critical Review', Proceedings of Advances in Human Aspects of Transportation, AHFE 2017, pp. 199-212. https://link.springer.com/content/pdf/10.1007%2F978-3-319-60441-1.pdf

[9] Ekow Manuel, M., 2017. 'Vocational and academic approaches to maritime education and training (MET): Trends, challenges and opportunities', WMU Journal of Maritime Affairs, 16(1), 473–483. DOI:10.1007/s13437-017-0130-3

[10] Erdogan, O. and Demirel, E., 2017. 'New Technologies in Maritime Education and Training, Turkish Experiment', Universal Journal of Educational Research, vol. 5, no. 6, pp. 947-952. DOI: 10.13189/ujer.2017.050606

[11] Gauthier, M., Kruithof, G. and Narlis, C., 2019. 'Control and automation systems onboard the vessel: Lessons in human-centered design learned from 20 years of marine occurrences in Canada', Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 1(36), 1-5. https://doi.org/10.1177/1071181319631066

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

[13] Ju Chae, C., Kim, M. and Ju Kim, H., 2020. A Study on Identification of Development Status of MASS Technologies and Directions of Improvement. Applied Sciences, [Online]. 10(4564), 1-18. Available at: https://www.mdpi.com/journal/applsci . https://doi.org/10.3390/app10134564

[14] Jim Covill Michael Klein-Ureña Barry Shepherd, November 27-28, 2019,Autonomous Shipping 2019 and Beyond[presentation] . Workshop on Maritime Autonomous Surface Ships, Convention Centre , Québec City, Canada. http://www.shipfed.ca/data/MarinersWorkshop/2019/Presentations/17-AutonomousShipping-

Covill.pdf, http://cismart.ca/wp-content/uploads/2019/11/CISMaRT-Agenda-Quebec-City-FINAL.pdf

[15] Komianos, A., 2018. The Autonomous Shipping Era. Operational, Regulatory, and Quality Challenges. The International Journal on Marine Navigation and Safety of Sea Transportation, [Online]. 12(2), 335-348. Available at: https://www.transnav.eu/ , DOI: 10.12716/1001.12.02.15

[16] Katarzyna Grzybowska, and Anna Łupicka (2017). Key competencies for Industry 4.0 , Economics & Management Innovations, 1(1) :250-253.

[17] Kim, T. and Mallam, S.(2020). 'A Delphi-AHP study on STCW leadership competence in the age of autonomous maritime operations', WMU Journal of Maritime Affairs, 19(1) 163–181. https://doi.org/10.1007/s13437-020-00203-1

[18] Ngân Nam (2018), Outstanding Features Of Unmanned Cargo Robot. [ONLINE] Available at: https://steemit.com/skyfchain/@minh7296/skyfchain-outstanding-features-of-unmanned-cargo-robot. [Accessed 18 April 2021].

[19] Noe, A., K, S., Gowtham, K. and Kumar, S., 2019. 'Autonomous Ship Navigation Methods: A Review', Conference proceedings of ICMET OMAN 2019 161 , pp. 33-44. http://doi.org/10.24868/icmet.oman.2019.028,

[20] Katranas, G., Rie, A., Manuel Corchado-Rodríguez, J. and Plaza-Hernández, M, . EuroSPI 2020, CCIS 1251, pp. 247–258, 2020. https://doi.org/10.1007/978-3-030-56441-4_18

[21] Mori, Yusuke, " (2014). "An analysis of leadership education and training in maritime education and training institutionsWorldMaritime University Dissertations. 483. http://commons.wmu.se/all_dissertations/.

[22] Odeh Hammoud Alidmat, A. and Ayed Ayassrah, M., 2017. 'Development of Critical Thinking Skills through Writing Tasks: Challenges Facing Maritime English Students at Aqaba College, AlBalqa Applied University, Jordan', International Journal of Higher Education, 6(3), pp. 82-90.

[23] Pantouvakis, A. and Vlachos, I., 2020. 'Talent and leadership effects on sustainable performance in the maritime industry', Transportation Research Part D, 86(4), pp. 1-29. https://doi.org/10.1016/j.trd.2020.102440

[24] Pan, Yushan; Oksavik, Arnfinn; Hildre, Hans Petter. (2019) Foresight Future Skills in Digitalisation Era: The Role of Participatory Design in Simulation-based Maritime Education. Ergoship 2019.

[25] Perwej, Y., K. Omer, M., E. Sheta, O. and Ali M. Harb, H., 2019. 'The Future of Internet of Things (IoT) and Its Empowering Technology', International Journal of Engineering Science and Computing, 9(3) 20192 -20202.

[26] Sharma, A., Kim, T. and Nazir, S., (2019). 'Catching up with time? Examining the STCW competence framework for autonomous shipping', . In *Proceedings of* the third conference on Maritime Human Factors (Ergoship 2019, pp.87-93). Haugesund, Norway.

[27] safety4sea -editorial team (2018). Drivers of the 4th Industrial Revolution in maritime industry. https://safety4sea.com/cm-drivers-of-the-4th-industrial-revolution-in-maritime-industry/

[28] Simmons, E. and McLean, G. (2020), "Understanding the paradigm shift in maritime education: The role of 4th Industrial Revolution technologies: an industry perspective", Worldwide Hospitality and Tourism Themes, Vol. 12 No. 1, pp. 90-97. https://doi.org/10.1108/WHATT-10-2019-0062

[29] Sellberg, C. and Viktorelius, M., (2020). 'From Technical and Non-technical Skills to Hybrid Minds: Reconceptualizing Cognition and Learning in Semi-automated Environments', Proceedings of Advances in Human Factors in Training, Education, and Learning Sciences AHFE 2020,pp.191-197. https://link.springer.com/content/pdf/10.1007%2F978-3-030-50896-8.pdf

[30] Wang Deling, Wu Dongkui, Huang Changhai, Wu Changyue. Marine Autonomous Surface Ship - a Great Challenge to Maritime Education and Training. American Journal of Water Science and Engineering. Vol. 6, No. 1, 2020, pp. 10-16. doi: 10.11648/j.ajwse.20200601.12

[31] Worlu, C., Amri Jamal, A. and Mahiddin, N., 2019. 'Wireless Sensor Networks, Internet of Things, and Their Challenges', International Journal of Innovative Technology and Exploring Engineering (IJITEE), vol. 8, no. 1282, pp. 556-566.

[32] Yoshida, M., Shimizu, E., Sugomori, M. and Umeda, A., (2020). Regulatory Requirements on the Competence of Remote Operator in Maritime Autonomous Surface Ship: Situation Awareness, Ship Sense and Goal-Based Gap Analysis. Applied Sciences, [Online]. 10(8751), 1-27. Available at: https://www.mdpi.com/journal/applsci

[33] Zaucha, J. and Gee, K., 2019. Maritime Spatial Planning past, present, future. 1st ed. Palgrave Macmillan. https://link.springer.com/book/10.1007%2F978-3-319-98696-8.

APPENDIX 1 COMPETENCIES DEFINITION

Aspects	Competencies	Definition	Source
Ability	Leadership and communication	To recognize and demonstrate effective leadership behaviors and how to recognize and apply best practice in communication, and be aware of barriers to communication and how these may adversely affect situational awareness.	Mori, Yusuke, " (2014).
	Environmental/sustainability concerns	The principle of future generations will have access to resources without current operations imposing economic, social and environmental constraints	Pantouvakis, A. and Vlachos, I., 2020

	Technical	Mental structure to be applied through a generic process that can be applied skillfully in resolving problems associated with a domain of knowledge held.	Sellberg, C. and Viktorelius, M., (2020).
Knowledge	Automatic Control Knowledge	The interaction between the agents, which supports self-organization and adaptability, when facing uncertainty or unpredicted constraints	Conceição, V,et al , 2017
	Critical thinking	examination and test of propositions of any kind which are offered for acceptance, in order to find out whether they correspond to reality or not, critical thinking includes analysis, inference and evaluation. From this perspective, analysis involves breaking a concept or an idea into component pieces to understand their inherent relationships.	Odeh Hammoud Alidmat, A. and Ayed Ayassrah, M., 2017.
	Data Mining Knowledge	The knowledge of maritime routes that prolific the understanding of maritime traffic. It also represents key	Alessandrini, A.,et al , 2016

		information to detect unusual patterns or behaviors, moreover the analysis of maritime traffic data to detect maritime events and aggregate them in a georeferenced grid, creating a set of maps that offer visual analytics capabilities.	
	Autonomous Navigation	.Autonomous navigation of ship consists of various sensors to detect the navigating path and environmental and vessel properties to determine safe travel	Noe, A, et al , 2019
	Fault Diagnosis	To understand the influence of a situation and risk assessment in the principles and practice of decision making at an operational level.	Mori, Yusuke, " (2014).
Technology	Remote Control	Remote Operator (RO) is the core of autonomous stage of MASS, the main task is to monitor and supervise the MASS operation and make a final decision of her action. In some cases,	Yoshida, M.,et al , 2020

		RO should immediately take over the operation control from the onboard autonomy computer system to correct its failure.	
	Basic Knowledge of wireless communication and data transfer	The word "wireless" has turned into a nonspecific and widely inclusive word used to portray communications in which electromagnetic waves are utilised to send an indication over part or the whole communication pathway	Worlu, C,et al , 2019
	Internet of Things IOT	is a description for embedded and network cloud technologies that enable remote invigilate and control of sensors and systems. IoT can be used in business, industrial, utility and suburban applications and also IoT remote monitoring and parking lots, shipping departments, control applications in hospital	Perwej, Y.et al ,2019

DIGITAL METHOD FOR REFLOATING A SHIP STRANDING DURING TRANSIT SUEZ CANAL USING ITS OWN MEANS

Abd Elfattah Mohamed Swidan

Assistant Navy Commander for Tug building project, AASTMT, Alexandria, Egypt, abdelfattahswidan@gmail.com

Mohamed Walid Abd Elhamed Ahmed

lecturer, AASTMT, Alexandria, Egypt ,

Mohamed Abass Kotb

Professor, AASTMT, Alexandria, Egypt,

1. ABSTRACT:

Emergency situations strike unexpectedly and prevent the vessel from completing the voyage to transit the Suez Canal. Predict a system for emergency response in Suez Canal become a necessary step to protect the navigation against unexpected action SCERS supports and enables quick actions to mitigate the effect of the incident. The ability to respond immediately to an emergency on the vessels during transit SC and plan for the quickest return to normal operation. The main core of this research is studying the possibility of digital refloating the stranded ship case during transit Suez Canal by its own means using a preliminary trim control step considering Suez Canal applying the ship emergency response system with a proactive step always working in positive active mood to cover Suez Canal. The constrain is the preliminary trim control step not affected the ship maneuvering capability during transit Suez Canal.

This will be achieved through the following strategies:

Focus on the Suez Canal main items (Suez Canal characteristics. operation system, transit regulation, weather, current, types of sea bed, last year's ship stranding cases)

Explain the methods for ground reaction calculation of stranding ship and the effect of refloating the stranded ship tugs bollard pull.

Demonstrate the digital emergency response system as the result of". OPA'90 case study for VLCC ship during transit Suez Canal The analyses before and after VLCC trim control using ballast to prove that the trim control method can use a quick emergency response action to refloat stranding ship advancing in Suez Canal with its own means in typical stranding case by using digital commercial software HECSALV.

Keywords: STRANDING, EMERGENCY RESPONSE SYSTEM, REFLOATING STRANDING SHIP WITH ITS OWN MEANS.

2. INTRODUCTION:

The Suez Canal considers one of the main navigation ways 12 % from international trading pass through it., the ship transit Suez Canal in a time period from 12 to 16 hours. The Suez Canal daily capacity 76 standard ships and increased to 97 after opening new Suez Canal. Emergency situations strike unexpectedly and prevent the vessel from completing the voyage to transit the Suez Canal. Predict a system for emergency response in Suez Canal become A necessary step to protect the navigation against unexpected action SCERS supports and enables quick actions to mitigate the effect of the incident. The ability to respond immediately to an emergency on the vessels during transit SC and plan for the quickest return to normal operation. Attention to the ISM Code – Emergency Preparedness. Part of SOPEP and Vessel Response Plan. Evidence of an active approach and commitment to safety and the environment. Assistance in "Managing risk". For oil tankers, oil barges and FPSOs transit the Suez Canal. SCERS ensures compliance with mandatory requirement of MARPOL Annex I, Ch.5, Reg.37(4), requiring "oil tankers have to involve in land-based calculation programs for damage stability and structural strength". OPA'90 and 33CFR155.240 conditions are met program provides the necessary technical support required in the critical hours after a vessel is stranded. SCERS consists of data base contain electronic model to all the vessels transit SC before the Convoy sailing SCERS team enter the loading case to the electronic model which prepared using commercial software HECSALV or equivalent and also trim control by define the amount and position for adding water ballast according to stability and strength calculation as advanced step for refloating the grounded ship in Suez canal using her own means in case of vessel stranding .during the Convoy sailing SCERS team observe the position of each vessel and ready to immediately take action according to the emergency situations.
This paper aims to investigate possibility of refloating the stranded ship case during transit Suez Canal by its own means using SCERS in the positive active mood with proactive step by ballasting fore peak tank before transit SC with always trim aft this technic in the typical Suez Canal stranding. considering Suez Canal applying the ship emergency response system to cover Suez Canal. (Authority SC (2019))

3. BACKGROUND:

a stranded ship is subject to very different combined forces buoyancy and ground reaction equal to the total ship weight, she is in a critical position because she is affected by force distribution according to the stranding case not the same in normal service. In all cases, fast action for refloating the ship from dangerous situation, for reducing stress in the hull and high risk of pollution.

Varsami et al. studied refloating a bulk carrier ship using the combined effect of the main engine in different levels and directions of speed and ballasting/de-ballasting the ship to minimums the bow draft in order to reduce the pressure from the ship hull on the sea bottom (Varsami, A., 2012).

A. Suez Canal Characteristics:

The Canal seafloor types change according to the position, through soils of silt and clay sedimentations deposited in the north and this formation extends 40 km to the south of Port Said. The intermediate region of the Canal starting from Kantara to Kabret is combined of fine and coarse sands, while the south part consists of dispersed layers of rocks, containing mixture from soft sand and some calcium rocks. The extreme tidal range in Suez Canal is varying from 65 cm in the north to1.9 m in the south. The bank gradient of the water cross section is 3:1 in the south and 4:1 in the north.

B. OPERATION in SUEZ CANAL:

For free double-lane flow, the channel is too narrow. The ships, thus, travel through convoys, using bypasses. Out of 193 km (120 mil), the double passes are increased in all (50%) after opening new Suez Canal project in 2015. The new Suez Canal increased the standard ships ability from 76 to 97 standard ships can pass the canal in 24 hours and also decrease the ship normally transits the canal form18 to 11 hours.

As free two-way traffic not permitted in the canal, all ships transit regularly in convoy lines. It scheduled for a scheme of 24 hours. A single convoy begins from Suez at 6 a.m. every day. At 6 a.m. This convoy transported unhindered. It uses the eastern path. Two southbound convoys interwoven in the northbound journey of this caravan. The first begins in the north at 0.00 o'clock from PORT SAID, with the big bitter lake anchoring. The second southbound convoy begins at 07.00 hours from Port Said with anchors to make the northbound convoy go via the west bypass of Ballah. This convoy has smaller and often unloaded ships.

C. EFFECT OF ACCIDENT ON CONVOY SAILING:

According to Suez Canal characteristics any kind of accident (Fire-Collision /Grounding with Major leakage or spillage of oil cargo) during the Convoy sailing especially at a single lane of traffic can stop the navigation partially or completely so the time become very important factor for dealing with the accident.

I. SHIPPING ACCIDENTS:

In 2004, The grounding case oil tanker AL SAMIDOON incident occurred in the Suez Canal. As a result, oil spill containing about 9,000 tons of crude oil which is moved with the effect of high current. The Suez Canal emergency plan for control oil spill was been activated, using booms, skimmers and dispersants. The slicks drifted to the north in the direction of Mediterranean Sea as sheens and tar-balls (Dewina & Yamauchi, 2009).

On February 26, 2006, the oil tanker "GRIGOROUSSA" ran aground at Suez Canal, leaked 2,700 tons of oil and polluted 8 miles of coastline.

On March 23, 2021, the Container ship "EVER GIVEN" ran aground at Suez Canal, lodging herself against both banks of the waterway. The period of six days, the salvage team from Suez Canal Authority (SCA) consists of more than 11 tugs and 2 dredgers cooperate with international salvage company to start salvage plan as a combined of dredging to remove the ground under the ship hull and using the tugs bollard pull to return the ship to the deep water.

D. CONTANGANCY PLAN IN SUEZ CANAL:

The Suez Canal Authority (SCA) For Several years has been establishing measures to respond within its jurisdiction to oil pollution incidents. to ensure the procedures and activities of the authority are in accordance with the national contingency plan for the oil spill, the EEAA will collaborate together with the SCA to develop a written emergency plan for the pollution of oils.

Responsibility for oil spill inside the Suez Canal remains with the Suez Canal authority in compliance with its mandate. (ABD El-GeliL. I (1998)).

The pollution control plan aims to define procedures and responsibilities in the event of a fuel spill. The Suez Canal Authority not involved in emergency response system to dial with ship stranding during transit SC specially in the single pass.

4. Calculating of Ground Reaction:

A. Methods of Calculating Ground Reaction:

B. Nomenclature	
R	The ground reaction force
W_i	Total ship weight before grounding
W_a	Total ship weight. After grounding
T fa	forward Draft before grounding
T fs	forward Draft after grounding
D_f	Distance.from. the.forward perpendicular.to. the.center.of.flotation
d_r	Distance. Between. the centers .of ground reaction.and . flotation
L	Length.between perpendicular
$T_{m.bs}$	Draft at midship before grounding.
$T_{m.as}$	Draft at midship after grounding.
TPI	The mass in tons. Required for immersion 1 inch.
t	total trim in inches.
MTI	Moment required to increase trim one inch.
LCF	The center of ship area at waterline.
dr	The Distance between centers. of ground reaction.and LCF
Dn	Distance from the LCF to the NP
Dnr	The Distance between NP and dr
B	Buoyancy
NP	The Neutral Loading Point
SCERS	Suez Canal emergency response system
VLCC	Ship type very large crude oil carrier.

Table 1: Intact Trim and Stability summary

No.	Method	Formula
1-	Change.of Displacement Method	$R = W_i - W_a$
2-	Change.of. Forward Draft Method	$R= \frac{(TPI) \times (MTI) \times (L) \times (Tfa - Tfs)}{(MTI \times L)+(dr \times df \times TPI)}$
3-	Tons.per.Inch.Immersion Method.	$R = (T_{m.bs} - T_{m.as}) \times TPI$
4-	The change of trim method	$R=\frac{MTI \times t}{dr}$

- All methods give results that are approximate.
- Ground reaction had to be calculated by two methods and the results should be close.
- The methods of change in forward draft method and in displacement method can be used in all stranding cases.

C. . EFFECT OF WEIGHT CHANGES ON GROUND REACTION:

Effect of Weight Changes on Ground Reaction in the Stranded ships depend on the position of the weight decreasing the ground reaction and increasing the buoyancy force.

D. THE NEUTRAL LOADING POINT:

The neutral loading point is a point in the stranded ship at which adding or removing weight without any change in the ground reaction; In addition, at that point the parallel sinkage due to weight addition equal the change of trim. Figure 1 shows the location of the points required to determine of the neutral loading point location.

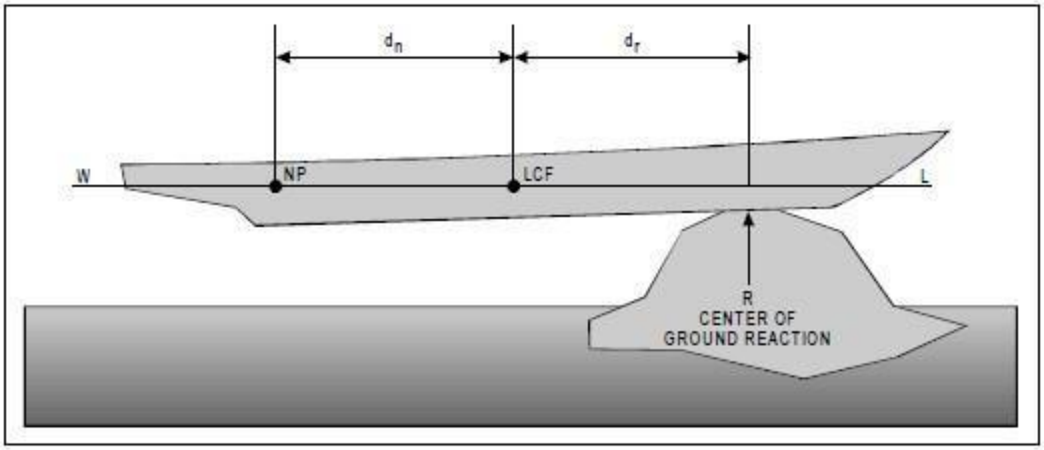


Figure 1: Typical ship stranding case during transit SC and Locate the Neutral Loading Point

E. Effects of Weight Changes on Ground Reaction:

Figure 2 show that in case of removing weight forward of the neutral loading point decreasing the ground reaction while adding weight forward of the neutral loading point decreasing the ground reaction. The NP will be off the ship if the distance between center of the ground reaction and the center of flotation is less than L/8, and the ship stranded along its length.

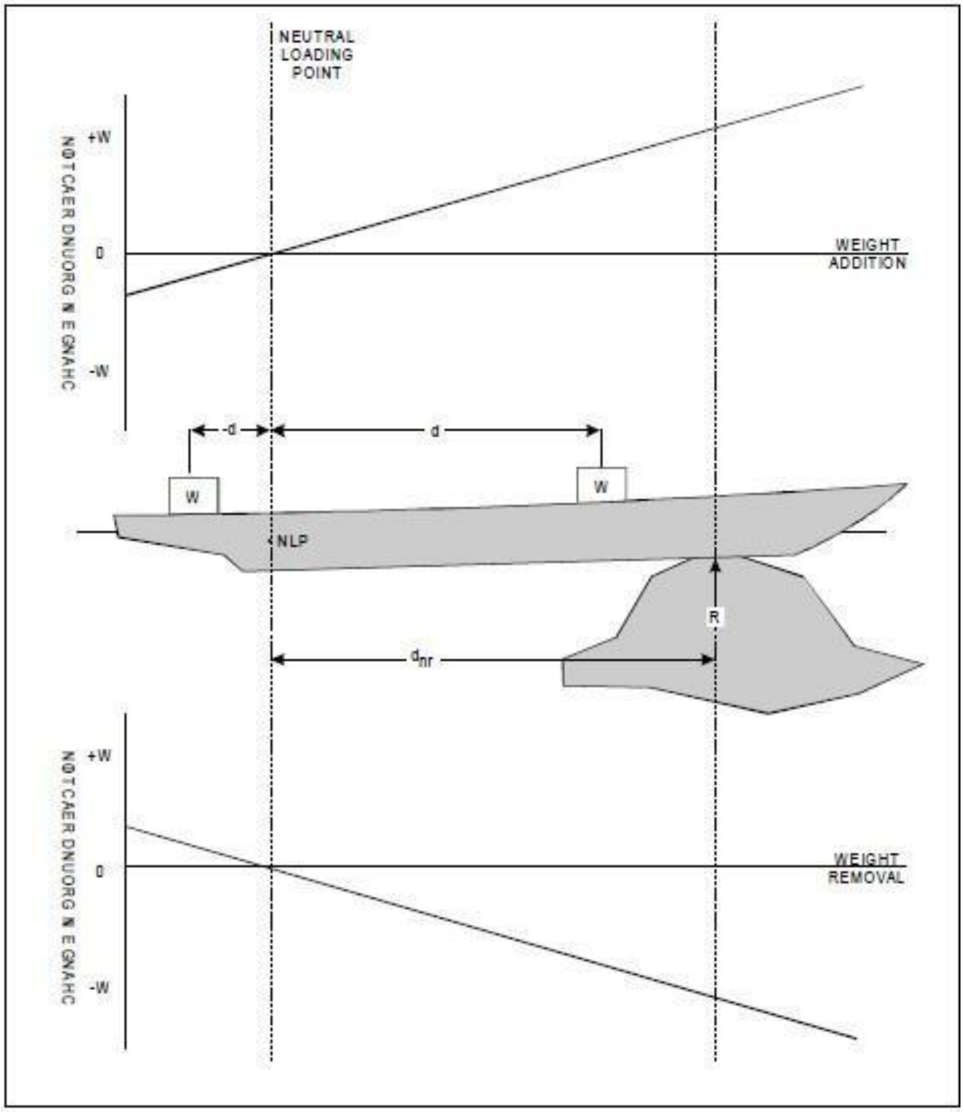


Figure 2: Effects of Weight Changes on Ground Reaction

F. THE TUG BOLLARD BULL:

The tug Bollard bull (F) is the puling force needed to free the ship from shallowwater in short tons can be calculated by multiplying coefficient of friction(µ) by the ground reaction(R).

$$F = 1.12 \times \mu \times R$$

Coefficient of static friction (µ) depend on the type of seafloor for mud Silty soil or Silty soil 0.2 to while Sand from 0.3 to 0.4 and coral from 0.3 to 0.4 but it increased from 0.8 to 1.5 for rockyseafloor. (NAVSEA (S0300-A6-MAN-010), 2006:)

5. DIGITAL SHIP EMERGENCY RESPONSE SYSTEM (ERS) A.

ERS OVERVIEW

ERS enables fast action around the clock by the land base access specialist teams of naval architects, salvage experts and ship master are ready to introduce advice immediately after receiving the data check list from the stranded ship master. The team used software tool containing, pre-prepared ship model for the stranded ship. The first step enters the actual loading case before stranding, the next step enters the loading case after stranding according the information sent from stranded ship master and simulate the stranding case. Finally send the advice with the salvage plan to the ship master. In case of external support is needed the advice is sent to the ship by steps to control the situation until the external support can be mobilized.

ERS REGULATION REQUIREMENTS

ERS complies with the following regulations and industry guidelines:

- MARPOL 73/78 Annex I, Regulation 37 and MARPOL Regulation 1/37(4), as which state that ship must have digital land-based programs for calculation damage stability and residual structural strength.
- Requirements of OPA 90 in 33 CFR 155.240.
- IACS Rec. No. 145 and ISM Code, Section 8, which requires the ship operator to establish procedures to respond to potential emergency shipboard situations, including the use of drills and exercises to ready for emergencies.
- The Guidelines OCIMF on Capabilities of Emergency Response Providers.

B. SOFTWARE TOOLS:

HECSALV commercial software used in this study as example. Is enable a simulation of stranding ship, it enables good analyses for the ship stranding situation. It simulates salvage plan steps for refloating a stranded vessel. Software tools capability including simulation for ground reactions, Tank damage, Tide-level-change and oil out flow calculation :

Many software tools used by ERS the worldwide used:

1-HECSALV 2-GHS

CASE STUDY

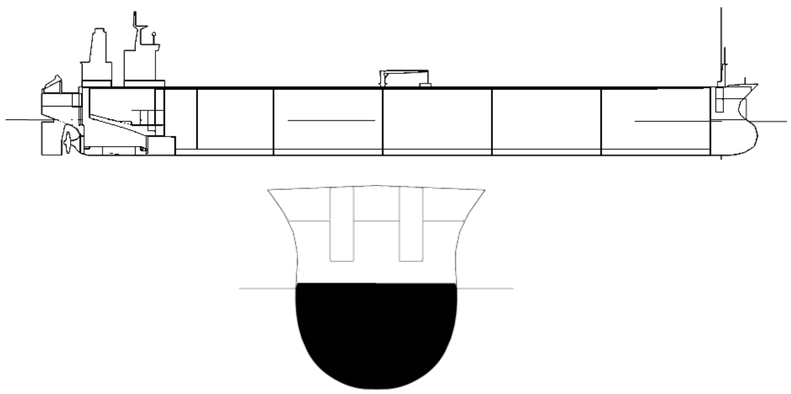
REFLOATING VLCC STRANDING DURING TRANSIT SUZE CANAL WITH ITS OWN MEANS

Assumption that;

1-Suez Canal (SC) using Emergency Response system (ERS) and already have prepared model for all tanker transit SC using HECSALV commercial software.

2- SC using ERS in the active mood by enter the actual loading condition for the tanker before enter SC using HECSALV model. (Tidal and current positive or negative effect are not considered in this case study)

3- SC using ERS in the active Positive Action mood for tanker by ballast fore peak water ballast tank just before transit SC with condition final trim aft.



Ship particular

LOA m	333.227	LBP m	318.000
Depth m	31.250	Beam m	58.000

Initial Loading case before stranding

TFP 16.012m TAP 16.795m Light ship 40,853tons

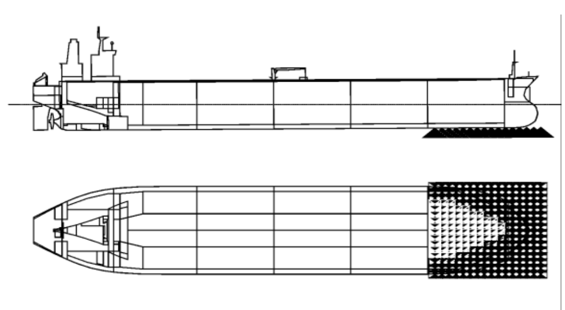
Displacement 245,383 tons Cargo Oil 194,577 tons

fore peak tank (4,855tons, LCG 152.867 f M.S.)

TPC 165.2 Ton MMIC 3500 t .m LCF 6.293 m M.S.

Case 1 Stranding as typical SC Stranding case (stranding fore part at side bank)

Summary	Value
T M.S before Stranding	16.403m
T M.S after Stranding	16.179m
Total reaction (R)	3699 MT
LCR	48.7A m.FP
TCR	0.47S m.CL
Force to free	5,549 MT
Friction Coeff.	1.5



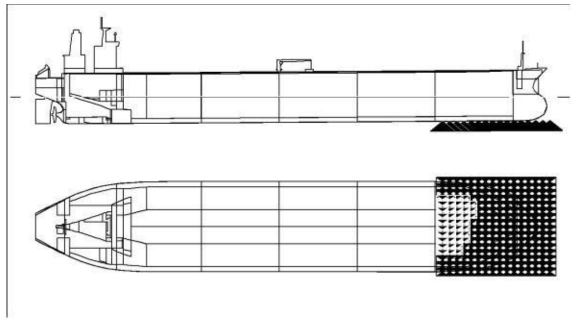
In this case de-ballasting fore peak tank is enough to refloat the ship with condition:

TFP 14.728 m TAP 17.557 m Trim 2.828 m

Shear force (SF) 31% Bending Moment (BM) 38% GMt 10.182 m

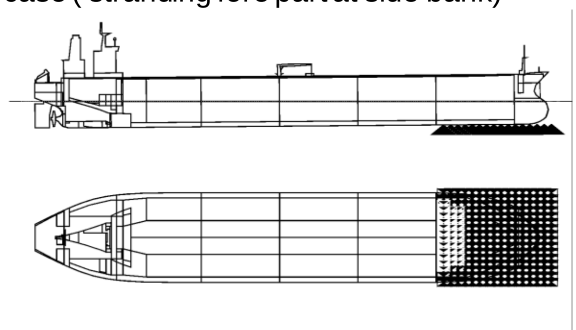
Case 2 Stranding as typical SC Stranding case (stranding fore part at side bank)

Summary	Value
T M.S before Stranding	16.406m
T M.S after Stranding	16.101m
Total reaction (R)	5136 MT
LCR	56.67A m.FP
TCR	2.95P m.CL
Force to free	7,704 MT



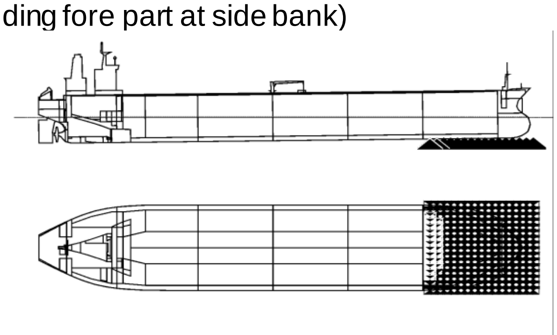
In this case de-ballasting fore peak tank is enough to refloat the ship.
TFP 14.728 m TAP 17.557 m Trim 2.828 m
Shear force (SF) 31% Bending Moment (BM) 38% GMt 10.182 m
Case 3 Stranding as typical SC Stranding case (stranding fore part at side bank)

Summary	Value
T M.S before Stranding	16.406m
T M.S after Stranding	16.044m
Total reaction (R)	6506 MT
LCR	56.950 m.FP
TCR	0.264S m.CL
Force to free	9,759 MT



Step 1: de-ballasting fore peak tank reduce ground reaction from (6506) MT to (343) MT (trial by using main engine power at Astern dead slow speed to free from the ground)
Step 2 : ballasting aft peak tank 50% (1033) MT the ship is free floating wih final drafts:
TFP 14.570 m TAP 17.852 m Trim 3.282 m
SF 32% BM 48% GMt 12.183 m
Case 4 Stranding as typical SC Stranding case (stranding fore part at side bank)

Summary	Value
T M.S before Stranding	16.406m
T M.S after Stranding	15.818m
Total reaction (R)	10,569 MT
LCR	58.026 m.FP
TCR	4.393P m.CL
Force to free	15,854 MT



Step 1: de-ballasting fore peak tank reduces ground reaction from (10,569) MT to (4,423) MT
Step 2: ballasting aft peak tank 100% (2066) MT reduce ground reaction from (4,423) MT to (3,475) MT.
Step 3: Transfer cargo oil from NO 1 COC tank (4880) MT LCG (118.723 F m-M. S) to slope tank P& slope tank SB each (2440) MT LCG (100.288 A m-M. S). Reducing ground reaction from (3,475) MT to (68) MT.
(trial by using main engine power at Astern dead slow speed to free from the ground)
TFP 12.998 m TAP 19.614 m Trim 6.615 m

SF 29% BM 53% GMt 11.9 m
Step 4: Ballast NO.5 WBT P&SB tank (2100) MT each with total amount (2100) MT to free the ship from grounding with final:
TFP 12.998 m TAP 19.614 m Trim 6.615 m
SF 29% BM 53% GMt 11.9 m

Summary:
The analysis of the results in the case study shows that in the typical Suez Canal stranding case with the fore part on the side bank, the ballasting fore peak tank (4855) tons in that case before transit SC as a proactive step in the Suez Canal Emergency Response system is equivalent to tug boat bollard pull 6200 ton. At that typical stranding case the first action has been taken de ballast fore peak tank after survey the stranding condition. In the case NO (1) and NO (2) with ground reaction (R) (3,699&5136) MT empty fore peak tank is enough for refloating the vessel while case NO (3) which more grounding with (R) (6506) MT is remaining (343) MT ground reaction in order to refloat the vessel Ballast aft peak tank 50% (1033) MT the ship free floating. The ground reaction in the case NO (4) reduced from (10,569) MT to (4,423) MT after de ballast fore peak tank. Ballast aft peak tank 100% (2066) MT in order to reduce ground reaction from (4,423) MT to (3,475) MT the next step Transfer cargo oil from NO 1 COC tank (4880) MT LCG (118.723 F m-M. S) to slope tank P& slope tank SB each (2440) MT LCG (100.288 A m-M. S). Reducing ground reaction from (3,475) MT to (68) MT which overcome with ship power. In all the previous cases the strength and stability calculation were in the normal range.

6. Conclusion:

Predict a system for emergency response in Suez Canal become A necessary step to keep the safe navigation all the time against unexpected action. Enable Suez Canal authority from containment of any kind of crisis in a shortest period. SCERS work in operational positive active mode with proactive action through the following steps:

1- Data base consists of digital model for all Ships transit SC approved from classification societies linked with land-based calculation programs for damage stability and residual structural strength with operational team work around the clock (HECSALV program Software Tools was an example in case study).

2- SCERS in the active mood by enter the actual loading condition for all ships before enter SC and define the ship position during transit SC to enable the SCERS team to identify the type of seafloor and values of current, wind, tide according to the ship position.

3- SCERS in the positive active mood with proactive step by ballasting fore peak tank before transit SC with always trim aft this technic in the typical Suez Canal stranding case with the fore part stranded on the side bank when de-ballasting 1000 ton from fore peak tank after stranding for example that equivalent to use tug with bollard pull 1500 ton in case rock seafloor or 330 ton in case of clay seafloor ready to use without losses.

4-In case of bad impact action act to stop the navigation in SC in both side due to terrorist operation or huge impact stranding ship as the case of EVER GIVEN stranding which stop the navigation for 6 days at 23, march,2021 and the situation is needed to share with international salvage companies or others partner SCERS enable to share the information and start accurate salvage plan to return the navigation in SC in shortest period.

REFERENCES:

- Abd El-GeliL. I (1998). National Oil Spill Contingency Plan, Egyptian Environmental Affairs Agency
- Abdel-Hameed E. Abdel Aziz, 2016. Application of Marine Environmental Monitoring in Egyptian Oil Spill Contingency Plan. Maritime Postgraduate Studies Institute. The Arab Academy for Science, Technology and Maritime Transport.
- Authority SC, 2019. Importance of the Suez Canal, https://www.suezcanal.gov.eg.
- Barrow D (2006). Ship Emergency Response Service – Marpol Annex I Reg.37 Oil Tankers. Lloyds Register
- Herbert-ABS**.(2015)** .HECSALV .www.herbertsoftware.com Features:
- Sobeh, H (2018). Alwattan] MAMISH: The success of the maneuver against oil pollution in East Port Said Port]. Future Media.
- Abdel Fattah Swidan, Computer Aided Marine Salvage Operations, Master Thesis ,College of Enginering and Technology,Arab Academy for Sience,Technology and Mritime Transport(AASTMT),June 2011.

  El-Dessouky, U., Hussein, A., El- Kilani, H.S. and Hegazy, E., Hazard Identification during Refloating Of Stranded Intact Double Hull Tanker, Proceeding Black Sea' 2012, Vol. 2, 4-6 October, Varna, Bulgaria
- U. M. El-Dessouky1 , A.W. Hussein2 , H.S. El- Kilani2 , E. H. Hegazy2, Refloating Scenarios of an Intact Stranded Tanker, Port Said Engineering Research Journal, March 2014.
- IACS , RULES 2012, Common Structural Rules For Double Hull Oil Tankers ,
- NAVSEA (S0300-A6-MAN-010), 2006: U.S. Navy Salvage Manual, Volume 1, Stranding and Harbor Clearance, Published By Direction of Commander, Naval Sea Systems Command, 412 pp
- Picolo, S., Vasconcellos, J.M, 2009: Technical Aspects Of Refloating Operations For Grounded Vessels, COPINAVAL
- ProfessionalMariner"http://www.professionalmariner.com/March-2011/Tanker-with-diesel-fuel-stranded-for-2-weeks-after-running-aground-in-Northwest-Passage/
- Resolve Marine group"http://www.resolvemarine.com/job-history. php
- Salvage Engineering Software, HECSALV (2011), Herbert Software solutions, Inc.
- TITAN Salvage "http://www.titansalvage.com/What-We-Do/ Response - and -Results
- Varsami, A., Popescu, C., Hanzu, R., Chircor, M. (2012), Refloating A Ship Using Her Own Means, Proceedings of the 23 and International DAAAM Symposium, 23-26th November, Vienna, Austria, Volume 23, No.1, pp. 0263- 0266,

Emerging Technologies in East Port-Said Megaproject.

M. Shahhat [(1)i],

(1) Marine Lecturer in the Sea Training Institute (STI), the Arab Academy for Science, Technology and Maritime Transport (AASTMT) - Alexandria, Egypt.w1802438@alumni.wmu.se"

ABSTRACT:

East Port-Said Seaport connects between the Suez Canal and the Mediterranean Sea, as well as the connection among three continents: Africa, Asia, and Europe. Within this context, the East Port-Said Development (EPSD) project seeks to achieve the sustainable development goals (SDGs) under the UN 2030 Sustainable Development Agenda due to the project's operational areas being located in industrial, logistic, and residential areas. In other words, The EPSD project is located in a very sensitive area. In addition, it faces many challenges and risks such as water scarcity, noise and air pollution, underwater noise, and coastal erosion.

Patently, the construction or extension of new ports, cities, and industrial areas usually causes negative impacts on the marine environment before, during, and after the construction. Therefore, depending on the state-of-the-art technology such as drones, hydrophones, Conductivity, Temperature and Depth device (CTD), satellite telemetry devices, and air quality monitoring meters, surveying, and monitoring are quite important to mitigate these cumulative impacts. The main objective of this research paper is to help decision-makers, such as governmental agencies, to protect the biodiversity and achieving the SDGs.

This research paper is based on the premise that the competent authorities are obligated to take proactive measures to anticipate and mitigate these potential threats and risks to protect the marine environment and people's health to achieve sustainable development and economic growth. On the other hand, smart ports play an important role in maintaining safety, security, and energy efficiency. Therefore, the environmental impacts on the port region will mitigate. This research paper includes qualitative data analyses where the literature review has been introduced to address the importance of relying on modern technologies to protect the marine environment and people's health, and on the other hand, finding appropriate solutions to mitigate the potential threats on the environment.

Keywords: SDGs, drones, smart ports, coastal erosion, water scarcity, environmental impacts.

Introduction:

The EPSD project considers the Mediterranean Sea gate to the Suez Canal, which is a link in the midst of Africa, Asia, and Europe and situated in the North Sinai Peninsula. In addition, the main reasons for constructing the EPS port in 2000, which opened in 2004, were to attain the national economic growth by attracting new shipping lines, increase export, and to demonstrate the key role of the port city in connecting between national and international trade (Arvis et al., 2019). Furthermore, the port development and establishment of the economic zone started in 2015 whereby the EPSD project is working on the enlargement of the port with a view to making it 12.4 km and attracting the economy of scale ships by increasing the port's depth to 22 meters. In addition, the EPSD megaproject contains a new residential area that will accommodate one and a half million people, and an industrial area including factories and industries such as ceramics, textiles, cement factories, and building materials.

The EPSD project zone suffers from many cumulative impacts of climate change such as coastal erosion and sea-level rise (SLR). In general, the North coast of Egypt (Nile Delta) is vulnerable to SLR, which is expected to reach one meter in 2100. Ergo, the city of Port Said is one of the most vulnerable cities in the globe to SLR. Furthermore, it is susceptible to land subsidence by almost Five centimeters every decade (Saleh & Becker, 2019). On the other hand, coastal erosion in the North East Delta has increased due to mineral mining and quarrying dunes. Moreover, establishing the Aswan high dam in the 1960s has helped protect upper Egypt from flooding enabling Egypt to use it as a clean source of electricity. However, building the Aswan High Dam reduced the quantity of water that was flowing rapidly into the Mediterranean Sea. Thus, the Aswan High Dam has helped in reducing both the quantity of fish and silt. So, the decrease in the quantity of silt caused negative impacts on farming and coast replenishment (Stanley & Clemente, 2017).

In 2011, the Ethiopian government (upstream country) established the grand Ethiopia renaissance dam (GERD). The dam is said to help in reducing the amount of sediment-replenishment. So, the Egyptian North coast has the potential of being vulnerable to coastal erosion (Negm et al., 2019).

Recreation facilities along the Egyptian North coast have increased due to ocean sprawl which caused negative impacts on biodiversity.

In furtherance of the foregoing, the Egyptian government seeks to attract new navigational lines, especially considering the economies of scale, through benefiting from ships crossing the Suez Canal by extending the Suez Canal Container Terminal (SCCT). It is projected that the East Port- Said Port can compete with ports in the region such as Pireaus port in Greece and Jabal Ali in the UAE.

Egypt depends on the EPSD megaproject to achieve the UN 2030 Agenda for Sustainable Development. Therefore, the expected increase in cargo exports and imports as well as the number of vessels passing through the Suez Canal will cause environmental and social impacts in the project

region. So, it is quite essential to depend on modern technology to predict and mitigate these cumulative impacts before, during, and after constructing such megaprojects. Moreover, the in-hand research will address these cumulative impacts by using risk assessment tools.

1- The Importance of Environmental Monitoring:

Environmental monitoring aims to attain economic utility and reduce environmental and social impacts. Moreover, relevant monitoring can demonstrate risks, identify the influence of human activities on biodiversity such as underwater noise, and detect the non-indigenous species, and the change in marine ecosystem services.

Thereafter, proper monitoring is very important during, before, and after establishing the EPSD megaproject. So, suitable monitoring for air and water quality can help decision-makers to attain strategic goals. So, modern environmental devices can help the competent authority in protecting biodiversity and achieving the sustainable development (Bean et al., 2017). In this regard, the proper monitoring can be attained through the following environmental devices:

1.1 Using Conductivity, Temperature and Depth (pressure) (CTD) in measuring hypoxia and water turbidity

The CTD device uses during monitoring operations to measure hypoxia (dissolved oxygen level in different water depths) because oxygen is considered a fundamental source of life for organisms. Moreover, it measures chlorophyll that generates the absorbed energy in flora, fauna, and algae during the photosynthesis process, converting light to chemical energy. Furthermore, it uses in measuring the upper limit of water turbidity, temperature, and conductivity (salinity). So, the competent authority can rely on the device during and after project construction via deployed a group of sensors from a research ship (Bean et al., 2017).

1.2 Using Environmental DNA (eDNA) in detecting invasive species:

The goal of using eDNA is to detect invasive species that can cause negative impacts on biodiversity in the East Mediterranean. Invasive species tend to affect the food chain and change the ecosystem services and affect the human and marine environment health, and cause economic losses (Zakaria, 2015) . Also, they generate from the Suez Canal, especially after the latest enlargement in

2015. Non-indigenous species are coming from the Red Sea and crossing the SC to the East Mediterranean (Adriat et al., 2017).

The second reason of producing the invasive alien species in Mediterranean is emanates from ships that discharge ten billion tons of ballast water annually around the globe. Furthermore, ballast water use during cargo handling operations for ships' stability in the port and at sea for ships balance as well. Thus, the discharged ballast water contains invasive species, which poses a detriment to the the biodiversity resulting in economic and ecological losses (Saglam & Duzgunes, 2018). So, via analyzing a gathered sample from vessels' ballast water tanks in a laboratory a list of discovered and specified alien species can be obtained.

Thirdly, fish farms are considered as a source of invasive species where Egypt in recent years depends on aquaculture as a main source of fish protein instead of depleted fisheries sector and for sustainable development. Moreover, Egypt takes the first place when compared with Africa in aquaculture production by almost one and half million tones (FAO, 2018). Furthermore, climate change as an indirect impact increases the sea temperature therefore, has helped on spread out the non-indigenous species such as jellyfish. In addition, human activities (threats) such as overfishing and ocean sprawl have damaged the sea turtle's proliferation which was feed on jellyfish and sustain biodiversity .

Thus, all of the aforementioned reasons have helped on spreading out the invasive species in the East of the Mediterranean whether they were direct or indirect threats. So, they have caused adverse impacts on marine ecosystem services and biodiversity and affected the food web. Moreover, they have caused economic and habitat losses.

1.3 Environmetal Drones roles in monitoring climate change impacts on coastline:

Port Said city is one of the most vulnerable areas in the Nile Delta for land subsidence and witnessed adverse impacts of climate change such as coastal erosion and SLR that has depleted fishstocks causing harm to the the fisheries sector. Almost thirty percent of the governate is vulnerable to erode and deteriorate if the SLR increased by Fifty centimeters (Shaltout et al., 2015).

Remote sensing of environment through (satallite imagery, LIDAR, digital video imaging, etc) Has proved to be useful. Nevertheless, remote sensing has some issues and weaknesses given that the system is vulnerable due to the environment in which it operates in, e.g., cloud and dust. Although, LIDAR covers a large area, but the operational cost is very high. In addition, the advantages of digital video imaging is limited because it has a fixed position and range and suitable for a small area coverage (Appeaning Addo et al., 2018).

While using small environmental drones (Unmanned Aerial Vehicles UAVs) (See Figure 1) in beach survellience and monitoring can present more elaborated data than in remote sensing applications on shoreline erosion, SLR, and land subsidence in short and long term. Furthermore, the dependence on using UAVs in surveillance has increased significantly in recent years whether fixed wing or multi rotor, because of the environmental drone running process is quite simple, cheap, and high accuracy (Vacca & Onishi, 2017). In addition, drones are a suitable method to examine the state of the coast in terms of coastal erosion, sea level rise , and land subsidence.

Figure 1:Using Environmetal drone in coastline survellience and monitoring.

Source:(https://theconversation.com/how-we-used-drones-to-monitor-coastal-erosion-in-ghana-107442).

Therefore, using high-precision data obtained from drones, the area that needs sand nourishment has been identified to compensate for the shortage in the sediment quantity along the beach to prevent coastal erosion (Provost et al., 2019). Moreover, some countries in Africa use the UAVs such as Ghana, Liberia, and South Africa in beach surveillance because of coastal erosion and flooding. However, using UAVs in air quality monitoring is vary between countries where it depends on the country's regulations and agenda (Villa et al., 2016). Furthermore, using a private drone in Egypt still prohibited because of protection of privacy and security issues. In addition, low battery capacity and strong winds are challenges and weaknesses in using small environmental drones in environmental monitoring.

1.4 Using air quality monitoring meter in GHGs emissions measurement:

GHG emission from seaborne trade represents almost 3 percent of the total yearly emissions. Moreover, GHG emissions from ships are expected to increase to seventeen percent by the mid of 21st century if uncontrolled (Liu et al., 2019). So, IMO has taken proactive measures to cut down GHG emissions from ships. While, the world target requires to cut down emissions to raise the planet temperature by almost 1.5 or 2 degrees by the end of 21st century from different economic sectors (Bouman et al., 2017).

As a result of the expecting increase in air pollution which will generate from factories and heavy shipping traffic in the EPSD project area. So, decision makers should install air quality monitoring meter in residential area and nearby port region, to enable them in measuring GHGs emissions concentration in the air such as volatile organic compounds (VOC), and nitrogen oxides (NO) and CO2. Thus, by using this information the competent authority can address the sources of air pollution and its amount. So, they can take proactive actions to protect marine environment and people living or work in the port region.

1.5 Using the hydrophone in underwater noise measurement:

The hydrophone device uses in measuring underwater noise generated from such as merchant ships, mineral mining operations, and military exercises. Thus, it enables competent authority in addressing underwater noise influences on marine mammals if it exceeded permissible levels. Because, the underwater noise causes trouble and injury marine species such as larvae, small fish, and spawn. In addition, under water noise has negative impacts on marine mammals since marine mammals can leave and migrate or strand on the beach in the high noise region. Therefore, as a result of the expecting increase in shipping traffic in the coastal area nearby the EPSD region it is essential to depend on a hydrophone device to measure and record digital underwater noise pollution. Moreover, it will help in checking underwater sound within the acoustic exposure limit or reached peak sound levels especially during port operation stage (Zhang et al., 2020).

1.6 Using Satellite telemetry device in tracking marine mammals:

Marine mammals tracking in the Egyptian North coast is very difficult task because of many reasons like illegal, unreported, and unregulated (IUU) fishing, noise pollution, heavy traffic, and recreation facilities. Furthermore, whales, dolphin, sea turtles, and sea birds are considered endangered marine species in Egypt (Mahrous et al., 2019). Thus, satellite telemetry instrument can track them and to address their spawning position (Chérubin et al., 2020), individual trend, and annual migrant (Hobson & Wassenaar, 2018). By using a satellite tag device, the researchers can get more information about marine mammals. So, they can take proactive actions to protect endangered marine mammals from extinction.

2-Mitigating Potential impacts during the project operation stage:

The EPSD megaproject during operation stage will experience a gradual increase in ships numbers visit the port due to constructing the industrial area and the last expansion of the port. Therefore, the congestion due to heavy traffic will increase in the port area so the decision makers should take the following threats into consideration:

2.1 Dredging Operations:

Dredging operations have ecological and economic impacts. In addition, dredging operations have increased regarding port operations and coastal development. Ergo, the adverse impacts on biodiversity along the coast will increase because of water turbidity. Moreover, dredging operations and land reclamation will occur before, during, and after establishing the EPSD project to go deeper by increasing the port's depth and length to enable the port to accommodate the largest ships. Thus, dredging operations, disposal of dredging materials, and accumulated sediments accretion should follow LC72 requirements (London convention 1972). Moreover, using a dredging curtain around the dredging area to decrease the spreading of water turbidity. Furthermore, it is quite essential to keep the water turbidity within the permissible limit in the dredging area to protect the fish.

2.2 Water Scarcity:

Egypt is one of ten states vulnerable to water scarcity in 2025, According to the UN report. Egypt relies on the River Nile as the primary source of fresh water (Gad, 2017). Moreover, many reasons are increasing water scarcity in Egypt, for example, the establishment of Ethiopia's Grand Renaissance Dam (GERD) (upstream country) in 2011, and Egypt is worried about decreasing its portion of water coming from the River Nile soon (Wheeler et al., 2016). In addition, climate change impacts and population increase all of which have increased water scarcity in Egypt (Negm et al., 2019)

The project region is considered a remote area and located away from the River Nile. So, it vulnerable to water scarcity. Moreover, disposal of polluted water from factories and industrial areas will affect water quantity and quality. To decrease these accumulative impacts, constructing desalination plants nearby the project area is required (Villacorte et al., 2015).

Nowadays, Egypt depends on groundwater as an alternative source to face water scarcity in the North Sinai and the project region as well. In addition, fresh water comes from the River Nile through The El Salaam Canal and from ground water should be clear from salinity and heavy metals to be healthy and drinkable. Therefore, all of these solutions to water scarcity in the project region will bridge the gap between people need and the amount of fresh water available.

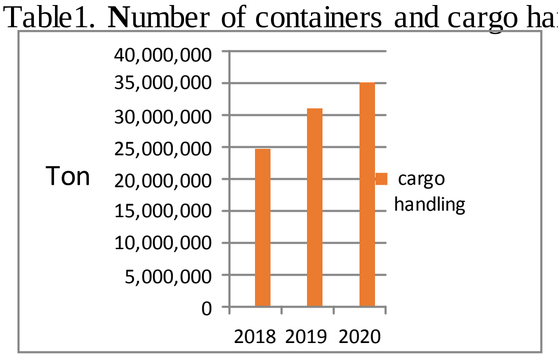
2.3 Coastal Erosion:

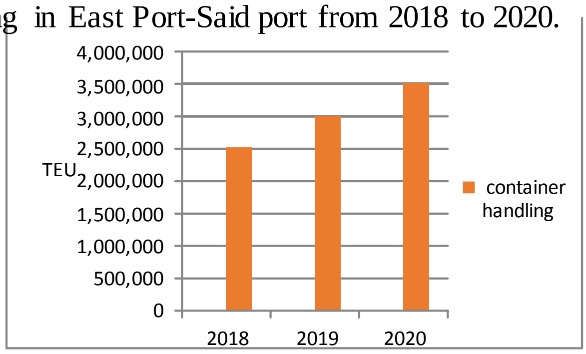
The EPSD megaproject is located in an area vulnerable and suffers from climate change impacts such as coastal erosion due to SLR as a result of constructing the Aswan High Dam in the 1960s which decreased the amount of silt which comes from the River Nile (Elkafrawy et al., 2020). Consequently, building with nature is quite essential such as planting mangroves and willows in the front of the coastline to mitigate coastal erosion and absorb the carbon dioxide as well.

2.4- Noise Pollution:

The source of underwater noise in the project region generate from large ships propellers (Jalkanen et al., 2018). Therefore, marine mammals migrate the region or stranding on the coast because the underwater noise will effect on marine mammal's communication and breeding. Moreover, cargo handling operations increase the noise pollution in the project area so, it disturbs people living nearby the port or work in it (Algueró, 2020). Where the number of the TEU and cargo handling quantity have increased in the East Port-Said port in the last three years (See Table 1).

Table1. **N**umber of containers and cargo handling in East Port-Said port from 2018 to 2020.





Source: (Maritime Transport Sector, 2020)

Overall, these bar charts show a gradual increase in both the number of TEU and cargo handling quantity in East Port-Said port despite of spread out COVID-19 in 2020 and which affected the seaborne trade globally where almost 80 percent of the globe trade is transported by sea in volume and 70 percent in value (UNCTAD, 2020) . Furthermore, this increase is due to corrective measures which have been taken by the Suez Canal Container Terminal SCCT such as decreasing the port dues and presenting new incentives to attract new navigation lines to enable the EPS port to compete with Hub ports in the region. In addition, according to the Suez Canal Authority SCA report in 2020 number of ships that crossed the Suez Canal was about 19000 ships represents 1.21 billion tonnes and approximately 10 percent of the total international seaborne trade. Thus, the number of ships will increase in the coming years, and the adverse impacts on marine species will raise in this region as well.

There are solutions in mitigating these impacts first the vessel traffic system (VTS) has to order ships to navigate with slow steaming to decrease underwater noise especially in approaches area (Leaper, 2019). Second solution to mitigate the noise pollution in the port region is establishing insulation fences and green belts of plants around the port can be good barrier for noise.

2.5 Air Pollution:

There are many sources generate air pollution in the harbor such as old trucks, shore cranes, vessels main and auxiliaries' engines, and dust from bulk ships during loading or discharging (Psaraftis, 2019). So, it worth noting that the port authority should take Rotterdam port as an idol green port. Since, it is considered a pioneer port in using renewable energy as an alternative and clean source of energy instead of depending on fossil fuel. Moreover, the EPSD area has absolute advantages regarding using solar panels because the sun shines about throughout the year as well as generate energy from wind turbines.

Nowadays, there is a global trend in transferring seaports to become green ports in order to attract new shipping lines and foreign and national investors to invest in clean energy such as cold ironing. Therefore, the green port can enable the EPS port to compete with the others ports in the Mediterranean Sea or in the Middle East. Furthermore, the green port will decrease the GHGs emissions in the port region. Consequently, it will decrease climate change impacts and harmful diseases for people and marine environment in the project area.

2.6 Residential Area:

In recent years the Egyptian government seeks to decrease people congestion over a narrow area and try to exploit unoccupied and unexploited regions by establishing new cities to achieve the UN2030 Agenda for sustainable development and save new job opportunities for youth. In this regard, to decrease any conflicts, the decision makers should follow the UN 1992 conditions and use a proper people settlement plan to avoid any cultural, tribal, and ethnic issues as well.

3. Risk Assessment Tools:

Dredging operations cause direct impacts on marine species as a result of human activities such as recreational facilities and ocean sprawl along the coast and land reclamations. The EPS port tries to keep up with the global trend of going deeper by increasing the port depths to accommodate the economy of scale ships and to transfer the port from seaport to green port to attract new shipping lines and decrease environmental and social impacts. Therefore, by doing so the decision makers should put the following management strategies into considerations:

3.1 Seasonal Restrictions during Dredging Operations:

The EPSD should follow and do a seasonal restriction through seasons of the year through reducing or cessation dredging activities. Because, dredging operations increase sediments concentrations, turbidity. Thus, dredging operations represent a high-risk during spawning and recruitment season for larvae, small fish, and juveniles. Seasonal restrictions are quite important to conserve biodiversity and food web especially during the season of spawning and migration. However, seasonal restrictions are not depending on appropriate scientific evidence` and are diversely performed.

3.2 Sediments Concentrations and Threshold Reference Value:

Threshold reference values are determined for every reaction and present in what way low concentrations of unsettled sediments affect marine species. Furthermore, it uses to safeguard marine habitats from harmful human impacts. Moreover, it is required to secure marine species from either fatal consequences or physical injury. Therefore, it uses to suspend dredging operations when marine species vulnerable to harm as a result of specific impacts. In addition, maintaining turbidity under the permissible limit during dredging operations for about one day will protect ninety-five percent of fish (Wenger et al., 2018).

CONCLUSION:

All in all, depending on modern technology are playing an important role in bridging the gap between curing cumulative environmental impacts from poor planning and monitoring in the past and the future need for sustainable development of marine resources.

The EPSD project is situated near urban and industrial areas and close to heavy traffic and congestion area. So, it is a very strategic and sensitive region. In addition, the economic objectives of the project are to improve national GDP, save new job opportunities for youth, and attract new investors and shipping lines. Ergo, it is worth noting that sustain and protecting the ecosystem services will attain these strategic goals.

The national megaproject is located in an area vulnerable for SLR and shoreline regression. Therefore, Establishing projects to attain economic utility would be very beneficial in improving the country's GDP, but not at the expense of the environment and people's health.

Suitable monitoring for water and air quality will reduce and mitigate the ecological impacts. Therefore, The EPSD mega-project is witnessing an enlargement and construction of a logistic and residential area nearby the harbor. So, it is essential to depend on state-of-the-art technology in the monitoring and surveillance to decrease the cumulative environmental impacts during, and after establishing the project.

RECOMMENDATIONS:

- Implementing a ballast water management convention is required to protect biodiversity and decrease invasive species impacts on the marine environment and people's health.
- Implementing a cost-benefit analysis where the government may invest in commercial projects that attain benefits at present or produce a quick return on the short-term. However, investing in capacity building, education, and reducing global warming impacts would achieve the SDGs.
- Using LULC land use/ land cover plays a key role in achieving the UN2030 Agenda for sustainable development. Moreover, Egypt is suffering from poor planning and construction of some haphazard projects in the past. Therefore, it led to terrible overpopulation in narrow areas and caused adverse impacts on the ecosystem and environment.

- Adopting Annex Six of the MARPOL convention is quite important because there is a global trend in transferring seaports to green ports to decrease GHGs emissions. The port authority can apply fines on polluters and give a bonus to vessels that decrease or cut off the GHGs emissions in the port region. Furthermore, establishing Carbon Capture and Sequestration (CCS) and forestation nearby the project region is required to protect the environment and people's health.
- planting mangrove forests along coasts is building with nature. In addition, mangrove forests protect the coast from erosion, decrease the salinity of the earth, and suitable for tourism activities.
- Establishing Smart ports to maintain safety, security, and energy efficiency. Consequently, the environmental impacts in the port region will mitigate.

REFERENCES:

Adriat, A., Zenetos, A., & Por, S. (2017). *Progress in Mediterranean bioinvasions two years after the Suez Canal enlargement It has been well documented that the Suez Canal is the main pathway of Marine Alien The successive enlargements of the Suez Canal have raised concern over increasing prop- a*. *58*(2), 347–358.

Algueró, B. N. (2020). Growth in the docks : ports , metabolic flows and socio – environmental impacts. *Sustainability Science*, *15*(1), 11–30. https://doi.org/10.1007/s11625-019-00764-y

Appeaning Addo, K., Jayson-Quashigah, P. N., Codjoe, S. N. A., & Martey, F. (2018). Drone as a tool for coastal flood monitoring in the Volta Delta, Ghana. *Geoenvironmental Disasters*, *5*(1). https://doi.org/10.1186/s40677-018-0108-2

Arvis, J.-F., Vesin, V., Carruthers, R., Ducruet, C., & de Langen, P. (2019). Maritime Networks, Port Efficiency, and Hinterland Connectivity in the Mediterranean. In *Maritime Networks, Port Efficiency, and Hinterland Connectivity in the Mediterranean*. https://doi.org/10.1596/978-1-4648-1274-3

Bean, T. P., Greenwood, N., Beckett, R., Biermann, L., Bignell, J. P., Brant, J. L., Copp, G. H., Devlin, M. J., Dye, S., Feist, S. W., Fernand, L., Foden, D., Hyder, K., Jenkins, C. M., van der Kooij, J., Kröger, S., Kupschus, S., Leech, C., Leonard, K. S., ... Righton, D. (2017). A Review of the Tools Used for Marine Monitoring in the UK: Combining Historic and Contemporary Methods with Modeling and Socioeconomics to Fulfill Legislative Needs and Scientific Ambitions. *Frontiers in Marine Science*, *4*, 263. https://doi.org/10.3389/fmars.2017.00263

Bouman, E. A., Lindstad, E., Rialland, A. I., & Strømman, A. H. (2017). State-of-the-art technologies, measures, and potential for reducing GHG emissions from shipping – A eview. *Transportation Research Part D: Transport and Environment*, *52*, 408–421. https://doi.org/10.1016/j.trd.2017.03.022

Chérubin, L. M., Dalgleish, F., Ibrahim, A. K., Schärer-Umpierre, M., Nemeth, R. S., Matthews, A., & Appeldoorn, R. (2020). Fish Spawning Aggregations Dynamics as Inferred From a Novel, Persistent Presence Robotic Approach. *Frontiers in Marine Science*. https://doi.org/10.3389/fmars.2019.00779

Elkafrawy, S. B., Basheer, M. A., Mohamed, H. M., & Naguib, D. M. (2020). Applications of remote sensing and GIS techniques to evaluate the effectiveness of coastal structures along Burullus headland-Eastern Nile Delta, Egypt. *Egyptian Journal of Remote Sensing and Space Science*. https://doi.org/10.1016/j.ejrs.2020.01.002

FAO. (2018). *WORLD FISHERIES AND AQUACULTURE*.

Gad, W. A. (2017). WATER SCARCITY IN EGYPT: CAUSES AND CONSEQUENCES. In | *IIOABJ* | (Vol. 8). www.iioab.org

Hobson, K. A., & Wassenaar, L. I. (2018). Tracking Animal Migration with Stable Isotopes. In *Tracking Animal Migration with Stable Isotopes*. https://doi.org/10.1016/C2017-0-01125-4

Jalkanen, J. P., Johansson, L., Liefvendahl, M., Bensow, R., Sigray, P., Östberg, M., Karasalo, I., Andersson, M., Peltonen, H., & Pajala, J. (2018). Modelling of ships as a source of underwater noise. *Ocean Science*, *14*(6), 1373–1383. https://doi.org/10.5194/os-14-1373-2018

Leaper, R. (2019). The role of slower vessel speeds in reducing greenhouse gas emissions, underwater noise and collision risk to whales. *Frontiers in Marine Science*, *6*(AUG). https://doi.org/10.3389/fmars.2019.00505

Liu, H., Meng, Z. H., Lv, Z. F., Wang, X. T., Deng, F. Y., Liu, Y., Zhang, Y. N., Shi, M. S., Zhang, Q., & He, K. Bin. (2019). Emissions and health impacts from global shipping embodied in US–China bilateral trade. *Nature Sustainability*, *2*(11), 1027–1033. https://doi.org/10.1038/s41893-019-0414-z

Mahrous, M., Farrag, S., Ahmed, H. O., Mohamed, M., Toutou, M., & Eissawi, M. M. (2019). Marine Mammals on the Egyptian Mediterranean Coast " Records and Vulnerability ". *International Journal of Ecotoxicology and Ecobiology*, *4*(1), 8–16. https://doi.org/10.11648/j.ijee.20190401.12

Negm, A., Elsahabi, M., & Tayie, M. S. (2019). *An Overview of Aswan High Dam and Grand Ethiopian Renaissance Dam. June 2018*, 3–17. https://doi.org/10.1007/698

Provost, E. J., Butcher, P. A., Colefax, A. P., Coleman, M. A., Curley, B. G., & Kelaher, B. P. (2019). Using drones to quantify beach users across a range of environmental conditions. *Journal of Coastal Conservation*, *23*(3), 633–642. https://doi.org/10.1007/s11852-019-00694-y

Psaraftis, H. N. (2019). Sustainable shipping: A cross-disciplinary view. In *Sustainable Shipping: A Cross-Disciplinary View*. https://doi.org/10.1007/978-3-030-04330-8

Saglam, H., & Duzgunes, E. (2018). Effect of ballast water on marine ecosystem. In *Green Energy and Technology* (pp. 373–382). Springer Verlag. https://doi.org/10.1007/978-3-319-62575-1_26

Saleh, M., & Becker, M. (2019). New estimation of Nile Delta subsidence rates from InSAR and GPS analysis. *Environmental Earth Sciences*, *78*(1), 1–11. https://doi.org/10.1007/s12665-018-8001-6

Sector, M. T. (2020). *Maritime Transport Sector Achievements*.

Shaltout, M., Tonbol, K., & Omstedt, A. (2015). ScienceDirect Sea-level change and projected future fl ooding along the Egyptian Mediterranean coast. *Oceanologia*, *57*(4), 293–307. https://doi.org/10.1016/j.oceano.2015.06.004

Stanley, J. D., & Clemente, P. L. (2017). Increased land subsidence and sea-level rise are submerging Egypt's nile delta coastal margin. *GSA Today*, *27*(5), 4–11. https://doi.org/10.1130/GSATG312A.1

UNCTAD. (2020). COVID-19 and maritime transport: Impact and responses. *Report No. UNCTAD/DTL/TLB/INF/2020/1*.

Vacca, A., & Onishi, H. (2017). ScienceDirect ScienceDirect Drones : military weapons , surveillance or mapping tools for Drones : military weapons , surveillance or mapping tools for environmental monitoring ? The need for legal framework is environmental monitoring ? The need for lega. *Transportation Research Procedia*, *25*, 51–62. https://doi.org/10.1016/j.trpro.2017.05.209

Villa, T. F., Gonzalez, F., Miljievic, B., Ristovski, Z. D., & Morawska, L. (2016). *An Overview of Small Unmanned Aerial Vehicles for Air Quality Measurements : Present Applications and Future Prospectives*. 12–20. https://doi.org/10.3390/s16071072

Villacorte, L. O., Tabatabai, S. A. A., Anderson, D. M., Amy, G. L., Schippers, J. C., & Kennedy, M. D. (2015). Seawater reverse osmosis desalination and (harmful) algal blooms. *Desalination*, *360*, 61–80. https://doi.org/10.1016/J.DESAL.2015.01.007

Wenger, A. S., Travers, M. J., Hobbs, J. A., Harvey, E., Rawson, C. A., Atkinson, S., Erftemeijer, P. L. A., Mcilwain, J. L., Wilson, S., Evans, R. D., Mclean, D. L., Newman, S. J., Browne, N., Clarke, D., & Saunders, B. J. (2018). *Management strategies to minimize the dredging impacts of coastal development on fish and fisheries*. *April*, 1–10. https://doi.org/10.1111/conl.12572

Wheeler, K. G., Basheer, M., Mekonnen, Z. T., Eltoum, S. O., Mersha, A., Abdo, G. M., Zagona, E. A., Hall, J. W., & Dadson, S. J. (2016). Cooperative filling approaches for the Grand Ethiopian Renaissance Dam. *Water International*, *41*(4), 611–634. https://doi.org/10.1080/02508060.2016.1177698

Zakaria, H. Y. (2015). Article Review: Lessepsian migration of zooplankton through Suez Canal and its impact on ecological system. *Egyptian Journal of Aquatic Research*, *41*(2), 129–144. https://doi.org/10.1016/j.ejar.2015.04.001

Zhang, G., Forland, T. N., Johnsen, E., Pedersen, G., & Dong, H. (2020). Measurements of underwater noise radiated by commercial ships at a cabled ocean observatory. *Marine Pollution Bulletin*, *153*(February), 110948. https://doi.org/10.1016/j.marpolbul.2020.110948

[i] Captain: Mamdouh Awad Abdelrahman Shahhat. Marine Lecturer in the Sea Training Institute (STI), the Arab Academy for Science,Technology and Maritime Transport ~~(AASTMT) – Alexandria, Egypt~~.MSc. In Ocean Sustainability, Governance, and Management, the World Maritime University (WMU) – Malmo, Sweden.

A Design for Wirless Commuincation System for Smart Ports

Mahmoud Beshr [(1)], Moustafa H. Aly [(2)] and Ivan Andonovic [(3)]

(1) Assistant Professor, Arab Academy for Science and Technology and Maritime Transport, Alexandria, Egypt, mbeshr@aast.edu
(2) Professor, Arab Academy for Science and Technology and Maritime Transport, Alexandria, Egypt, mosaly@aast.edu

(3) Professor, Strathclyde University, Glasgow, United Kingdom, i.andonovic@strath.ac.uk

ABSTRACT

Communication systems and infrastructures are considered main enabler for smart ports. The Light Fidelity (LIFI) communication system can provide cost effective, easy to install, fast, and secure communication system as it can make use of already installed lighting systems in the ports to provide communication link. Thus, LIFI ensures interference free with other radio frequency communication systems. Given the privileges of LIFI communication systems, this paper aims to test and evaluate the adoption of LIFI communication systems in ports and how LED layout can affect the system. A design tool for system planning is developed to determine optimum LED placement that provides a specified system performance, conforms to illumination standards and minimizes the variation of the Signal-to-Noise Ratio (SNR) across the communication link thereby maintaining a good quality of service (QoS). The evaluation of SNR, BIT Error rate (BER), data rate and illumination level are conducted for representative metrological conditions over the year to ensure smart port system performance and efficiency.

Keywords: Light Fidelity (LIFI) Performance, LED Layout, Smart Ports, Metrological Conditions

I. INTRODUCTION

Although the industry of ports and container shipping is often regarded as being conservative and resistant to change due to its nature and processes, the utilization of recent communication system technologies can lead to major enhancements in port system efficiency [1],[37]. One of the main pillars that are promising in this regard is smart ports. Despite being promising, smart ports face many challenges, one of these key challenges is to have a well-established wireless communication system that provides connections between different units, facilities, containers and moving trucks[1], [2],[36]. To have such a system, a total infrastructure renovation is required and this is considered the main barrier that faces smart ports from both economic and operational perspectives. Economically, infrastructure renovation requires very high cost which may not be feasible given the economic challenges currently facing the whole world. Operationally, maintaining this infrastructure to ensure its sustainability is also challenging given the advanced technologies required. One of the ways to overcome these challenges is the Light Fidelity (LIFI) communication system as it ensures different competitive advantages that make LIFI system preferred among different communication system technologies[31-37].

LIFI system is used to help address the mismatch, presenting an interesting set of characteristics; low power consumption, license free and RF interference free operation whilst offering the option to create and isolate a wireless cell by direct control of the light signal. Of the recent generations of wireless technologies, the Long-Term Evolution (LTE) depends on extensive spectrum reuse and well-designed cells. The range of techniques under the LTE umbrella increases system capacity but at a cost of a complex interference management overhead [1], [2]. The market for wireless networks is extending to be applied to have reliable, secure and economic communication system. Ultimately, it harnesses the unrelenting growth in the deployment of solid-state lighting based on LEDs [1], [3-5], [34].

LED layout is defined as the distribution of transmitters across the ceiling of a room (indoor environment for smart port), a key factor that modulates system performance. The location of the transmitters and, in turn, the relative positions of the transmitters with respect to receivers, limits system availability and network coverage across a room or in outdoor port operation. In addition, it is also important to optimize LED layout in order to mitigate the impact of sunlight on the system performance [1-3],[29].

The impact owing to LED layout has been reported [6-11] but a limited number of configurations have been considered; circular or square shapes for a standard room office only without consideration of the impact of sunlight irradiance. Also, the arrangement of LEDs has also been considered [12] from a statistical perspective, specifically the variance of the SNR over the room. One constellation is proposed and analyzed but a wider optimization of the layout to maximize system performance has yet not been addressed.

Although the path loss of the system has been characterized in [13], only Line of Sight (LOS) path components are considered in the analysis and sunlight is treated as Additive White Gaussian (AWG) noise. The level of sunlight irradiance is measured in the room under consideration; however, that represents a point evaluation as sunlight irradiance varies dramatically according to the time of day, the location, day of year and metrological conditions. Also, different room sizes and shapes are not considered [2], [31-33].

The state-of-the-art in terms of layout optimization is thus limited viz. two LED constellations, restricted to LOS components only with the impact of sunlight irradiance treated as AWG noise. A LED layout design has been considered without consideration of its impact on communication system performance [6] for specific room geometries without meeting lighting standards [14]. The variation of received signal strength to minimize SNR variations over the room has also been investigated but again without consideration of Non-Line of Sight (NLOS) paths and sunlight irradiance. The goal here is to provide an in-depth analysis of LIFI system performance designs under an extended range of environmental conditions. The analysis methodology developed can be applied to treat any room size, any surface reflectivity and any location, over different metrological conditions and with different LED panel specifications. It provides a base for an extensive design tool that aids the estimation of system reliability, availability planning and assessment. System planning must draw on design guidelines that treat different room shapes and sizes which include NLOS effects and sunlight irradiance over the year to enhance the quality of service provided. Finding the optimum LED layout that provides an acceptable system performance with minimum energy consumed is a key challenge for LIFI systems.

The remainder of the paper is organized as follows. Section II presents the detailed system architecture. Section III shows the proposed LED layout, followed by evaluation concerning SNR, BER and data rate performance. Finally, Section IV is devoted to the main conclusions.

II. SYSTEM MODEL

LED panels are placed on the ceiling and photodiodes on horizontal surfaces at distance 0.85 m from the floor as shown in Figure 1. Light rays are subjected to many reflections in their path from transmitter to receivers. LOS and NLOS components are considered in the analysis up to the fifth reflection. A range of surface reflectivity is considered in the analysis (plaster and plastic walls) and all surfaces are considered as pure Lambertian reflectors as most of the surfaces within the indoor environments that are approximated accurately as Lambertian reflectors [15]. The impulse response of multiple sources emitting equal power subjected to multiples reflections is given by [16].

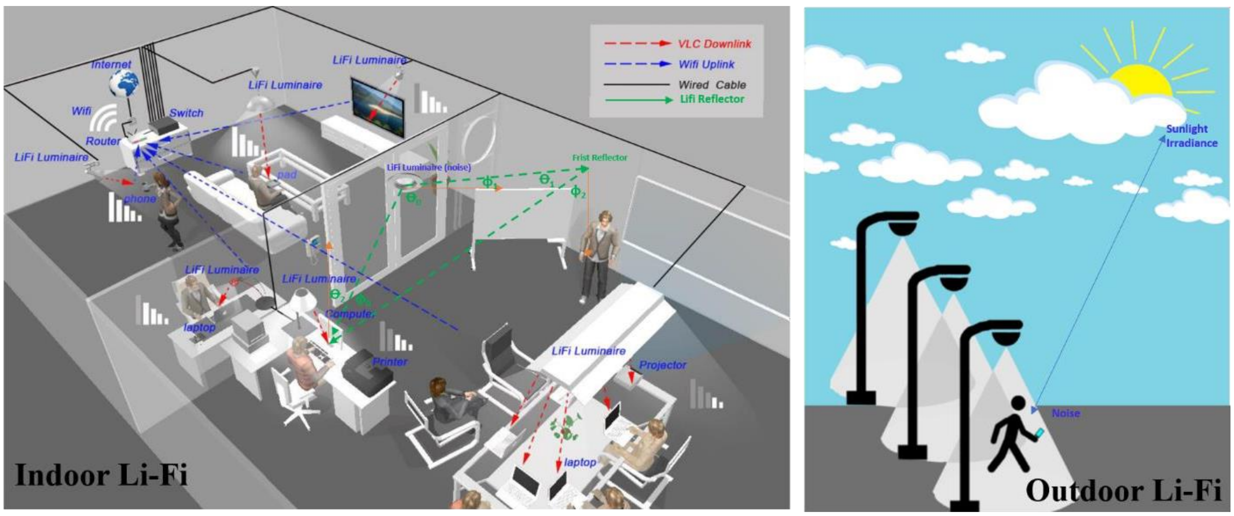


Figure 1. Geometry of system model for indoor and outdoor LIFI system

$$h(t) = \sum_{n=1}^{NLED} \sum_{k=0}^{\infty} h^{(k)}(t;\Phi_n) \quad (1)$$

$$h^{(k)}(t;\Phi_n) = \int_s [L_1 L_2 \ldots\ldots L_{K+1} \Gamma^{(k)} rect(\frac{\theta_{k+1}}{FOV}) \times \delta(t - \frac{d_1+d_2+\cdots d_{k+1}}{c})] \, dA_{ref}, k \geq 1 \quad (2)$$

Where

$$L_1 = \frac{A_{re}(m+1)\cos^m\Phi_1 \cos\theta_1}{2\pi {d_1}^2}$$

$$L_2 = \frac{A_{ref} \cos \Phi_2 \cos\theta_2}{\pi {d_2}^2}$$

$$L_{k+1} = \frac{A_{PD} \cos \Phi_{k+1} \cos \theta_{k+1}}{\pi {d_{k+1}}^2}$$

where k is the number of reflections, N is the total number of LEDs, L_{k+1} is the path loss, ${\Gamma_n}^{(k)}$ is the reflected power, Φ_1, is the viewing angle of the LED. The beam is incident at angle θ_1 after distance d from source to reflection point and the mode number m is a function of transmitter viewing angle given by $m = -1/\log 2\,(\cos\phi_{1/2})$. c is the speed of light, A_{PD} is the photodiode physical area, A_{ref} is the reflecting area of the light ray and rect(x) is given by [16-18]:

$$rect(x) = \left\{ \begin{matrix} 1\ for\ |x| \leq 1 \\ 0\ \ for\ \ |x| > 1 \end{matrix} \right\} \quad (3)$$

As the spectrum of sunlight irradiance falls in the same band of operation of the system, the impact of sunlight is considered in the layout optimization process to emulate more realistic operational scenarios. Sunlight irradiance has been modelled over the year using the model in [19]. The impact of sunlight irradiance is considered hourly over different metrological conditions for two different representative locations Cairo –Egypt and Berlin-Germany over the year (a total of 8760hrs). The cloud coverage over the representative locations is also considered in the analysis. Table 1 summarizes the simulation parameters.

Table 1: System simulation parameters

System Parameter	Value
Photodiode Responsivity	0.54 $^{A}/_{W}$
Data Rate (R_b)	1 Mbit/s
Photodiode area A_{pd}	$0.5*10^{-4}$
ϕk irradiance angle	80
Receiver field of view (FOV)	45
Transmitter full width half maximum (FWHM) angle	9
Plastic wall surface reflectivity	~ 0.2
Plaster wall surface reflectivity	~ 0.8
Number of LED panels	4
Number of LED chips	900
LED Panels dimensions	2m*2m
LED transmitted power	0.452 W
Neighbouring LED chips spacing	4 Cm

III. LED LAYOUT OPTIMIZATION

Performance is analyzed over four seasons in representative environments using Monte Carlo simulations. The methodology is seeking to find the optimum placement of the LED panel in the indoor port operation environment that provides high system availability and efficiency. The optimization is constrained by two main requirements; maximizing the average SNR across the room at an acceptable lighting illumination according to EN12464-1standard [14].

The characterization considers a range of LED panel placements across a room of any size. A MATLAB routine provides the SNR variation across the room within the illumination constraint. However, the global optimum provided by this route is not sufficiently robust and results from these nonlinear equations are tested and confirmed [21] through Monte Carlo simulations which consume significant computational time of up to72 hours/simulation accomplished by using a high performance computer facility.

It is worth noting that a number of optimization approaches exist. For example, genetic algorithms and pattern search [22], [23] may provide a global optimum for the nonlinear optimization problem considering the stated constrains; however those algorithms are sensitive to initial conditions. Further, results from those algorithms yield a global optimum and need extensive verification to ensure that the results are the optimum for the spectrum of conditions and constrains [21], [24], [25]. Although the methodology considered for the present analysis is specifically developed to treat a number of design aspects for systems that emulate real scenarios, results have been tested for different constrains to validate the methodology.

The analysis of VLC technology unitization at smart ports context had not been fully analyzed [31-37], using MATLAB software, system had been simulated to evaluated the technology unitization at smart ports environment. The analysis is carried out for a 1 Mbit/s data rate and 0.54 $A/_W$ photodiode Responsivity. Simulation parameters are largely the same as stated in Table 1 except that LED chip Power 63 mW which is required to enable a meaningful comparison between the results from the adopted methodology and other research work [26]. The optimization methodology considers not only the LED position but also system performance over different metrological conditions over the year and level of illuminations at indoor environment and outdoor environment to ensure that good level of illumination at different locations.

A. SNR Performance

The evaluation is carried out over the year for two representative locations, Berlin and Cairo. Summer and winter seasons are considered only; results for the rest of the year are assumed to lie between these extremes. Indicative performance can be derived from the results for autumn and spring in [29].

B. Summer

Four LED panels provide the specified illumination level in the range 300 lx - 800 lx as stated by the European standards for indoor workplace lighting EN12464-1 [14]. Here, the LED panels provide illumination in the range from 300 lx - 800 lx over the room area. The average SNR (Figure. 2 and Figure. 3) over the room for a Cairo summer - clear sky where the noise owing to sunlight irradiance is at the maximum value - is in the range of ~ 86 dB -53 dB, ~81 dB - 50 dB for plaster and plastic walls respectively.

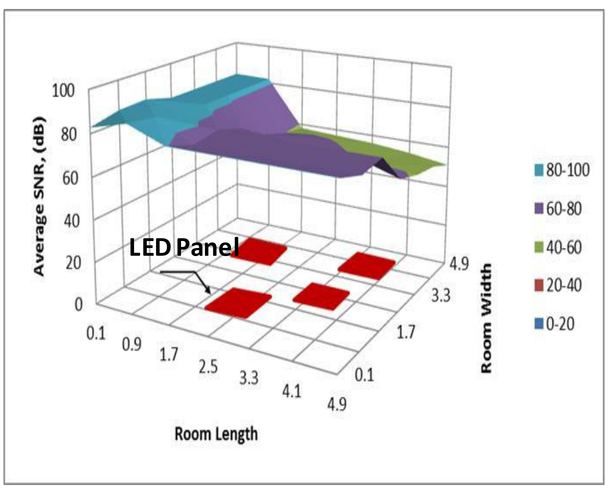


Figure 2. Average SNR for a Cairo Summer, Clear Sky and Plaster Wall

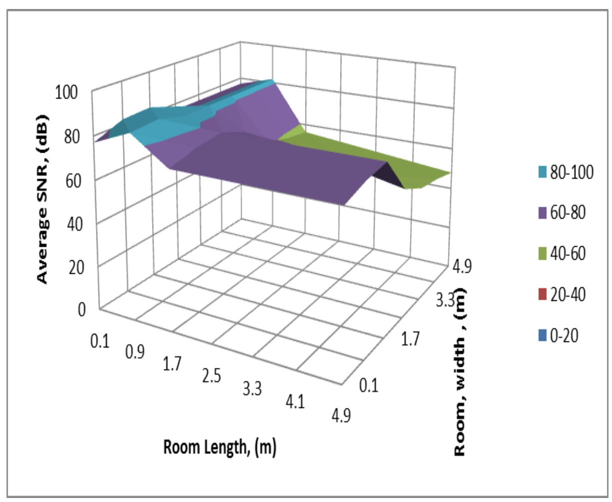


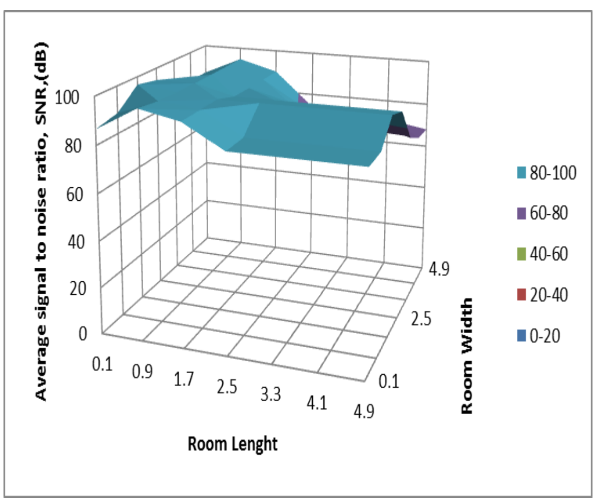
Figure 3. Average SNR for a Cairo Summer, Clear Sky and Plastic Wall

The average SNR increases by 15% when the proposed LED layout is compared to the results of [26] under the same simulation conditions. The maximum average SNR for both LED layouts in [26] is 73 dB and under the same scenario the SNR is enhanced by ~15% and ~10% for plaster and plastic walls respectively. The minimum average SNR is 53 dB in a corner of the room.

Moreover, the luminance level for office environments is stipulated to be 400 lx on average (equal to ~ 60 dB SNR) over 50 % of the room while the rest of the room should not fall below 100 lx on average; the lighting constraint is thus also fulfilled by the proposed LED layout. Hence the LED layout provides optimized system performance in the presence of sunlight and fulfils the relevant lighting illumination standard.

C. Winter

In winter, sunlight irradiance is at a minimum, especially in Berlin owing to a high percentage of cloud cover. The average SNR for a Berlin winter lies in the range of ~ 87 dB - 63 dB and~ 82 dB -54 dB for plaster and plastic walls respectively (Figure 4) and Figure 5). The SNR improves by ~17% compared to the results of [26]. As expected, the SNR decreases to ~ 53 dB for plastic walls due to the poorer surface reflectivity. The SNR within the room varies as a function of sunlight irradiance and cloud cover over the year.



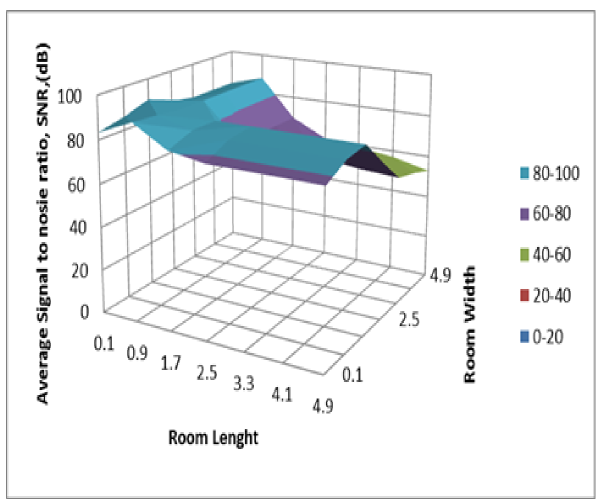


Figure 4. Average SNR for a Berlin Winter, Cloud Sky and Plaster Walls

Figure 5. Average SNR for a Berlin Winter, Cloud Sky and Plastic walls

A comparison of performance as a function of metrological conditions - as represented by Cairo and Berlin - is presented in Figure 6 (plaster walls) and Figure 7 (plastic walls). Figure 6 and Figure 7 summarize the maximum and minimum average SNR for the proposed LED layout. The layout provides an enhancement of system performance compared to the results in [26]; the maximum SNR lies in the range of ~ 96 dB – 68 dB achieved as expected in Germany for a winter day with significant cloud coverage and plaster walls. SNR in Cairo are in the range of ~ 87 dB - 52 dB, 89 dB -54 dB, 95 dB - 61 dB for summer clear sky, summer cloudy sky and winter clear sky respectively. For Berlin, the SNR is in the range of ~ 94 dB - 64 dB and ~92 dB - 62 dB for winter clear sky and summer clear sky respectively. Again, the lighting illumination standard [14] is fulfilled under all metrological conditions.

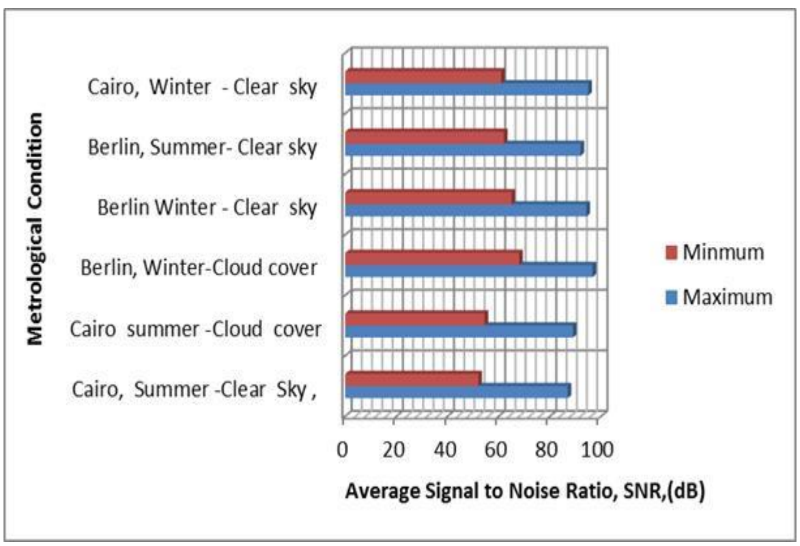


Figure 6. Average SNR for Cairo and Berlin over the Year for Plaster Walls

The proposed LED layout provides better system performance for the same room size with a lower number of LEDs than Komine *et.al* [27] viz. the former used 1400 LED chips as opposed to the 900 chips in the present study.

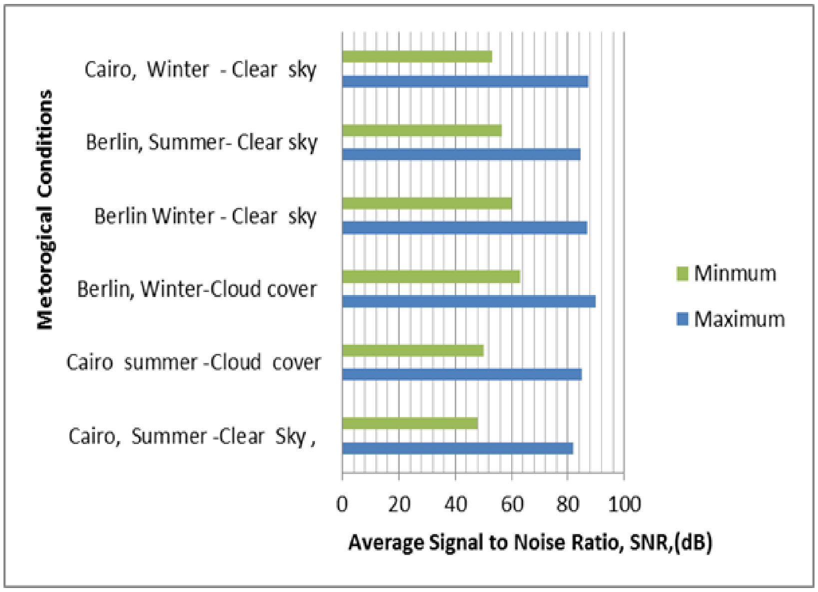


Figure 7. Average SNR for Cairo and Berlin over the Year for Plastic Walls.

The same system performance is achieved with ~ 35% reduction in the number of LED chips illuminating the same size of room attributed to an optimized layout and the higher intensity of chips employed compared to [27]. The central luminous intensity of chip employed in [27] was 0.73 cd (20 mW transmitted power) and the employed chip (63 mW transmitted power) has maximum luminous intensity of 9.5 cd.

IV. CONCLUSIONS

LED layout is investigated in order to optimize LIFI system performance and fulfil the lighting requirement governed by standards. Research to date has reported on LED layout design in indoor environments; however, few analyses consider the optimization from a mathematical perspective and they do not consider fulfilling the lighting standards and commercially available LED panels. Moreover, evaluations are confined to a specific room size, do not consider the impact of sunlight irradiance and cloud cover and are limited to LOS components only.

The framework developed aims to provide design guidelines for system developers applicable to any room size, wall reflectivity, and illumination level, location worldwide with consideration of both LOS and NLOS components and the impact owing to sunlight irradiance over the year. Figures 6 and 7 summarize the performance of the indoor LIFI system at indoor smart port environment. The developed framework for LED layout design in LIFI system shows that LIFI system can provide smart and economic solution in smart ports operation and shows the availability of system as function of SNR in different real operation and metrological indoor environment that can be applied in smart port design.

REFERENCES

[1] Burchardt, H., Serafimovski, N., Tsonev, D., Videv, S. and Haas, H. (2014). VLC: Beyond Point-to-Point Communication. *IEEE Communications Magazine*, *52* (7), 98-105.

[2] Hranilovic, S. (2005). *Wireless Optical Communication Systems*. Springer.

[3] Haruyama, S. (2011). *Visible Light Communications: Recent Activities in Japan. Smart Spaces: A Smart Lighting ERC Industry* [Paper Presentation]. Academia Day at BU Photonics Center, Boston University.

[4] Elgala, H., Mesleh, R. and Haas, H. (2011). Indoor Optical Wireless Communication: Potential and State-of-the-Art. *Communications Magazine, IEEE, 49* (9), 56-62.

[5] Haas, H. (2011). *Wireless Data from Every Light Bulb*. TED Global, Edinburgh.

[6] Ding, D., Ke, X. and Xu, L. (2007). An Optimal Lights Layout Scheme for Visible-Light Communication System. In *Proceedings of the 18th International Conference on Electronic Measurement and Instruments, ICEMI'2007*.

[7] Azizan, L.A., Ab-Rahman, M.S and Jumiran, K. (2012). Analytical Approach on SNR Performance of Visible Light Communication for Modern Lighting Layout. In *Innovation Management and Technology Research (ICIMTR), International Conference. IEEE.*

[8] Nguyen, H. Q., Choi; J.H., Kang, M., Ghassemlooy, Z., Kim, D.H. Lim, S.K. Kang, T.G., Lee, C.G. (2010). A MATLAB-Based Simulation Program for Indoor Visible Light Communication System. In *Communication Systems Networks and Digital Signal Processing (CSNDSP), 7th International Symposium, IEEE*.

[9] Trong-Hop, D. and Myungsik, Y. (2012). Received Power and SNR Optimization for Visible Light Communication System. In *4th International Conference on Ubiquitous and Future Networks (ICUFN), IEEE*.

[10] Jiayuan, W., Kang, Z. and Nianyu, Z. (2011). Research on Indoor Visible Light Communication System Employing White LED Lightings. *IET International Conference on Communication Technology and Application (ICCTA 2011)*.

[11] Tronghop, D., Hwang, J., Jung, S., Shin, Y., Yoo, M. (2012). Modeling and Analysis of the Wireless Channel Formed by LED Angle in Visible Light Communication. *In Information Networking (ICOIN), 2012 International Conference, IEEE.*

[12] Wang, Z., et al.,(2012) Performance of a novel LED lamp arrangement to reduce SNR fluctuation for multi-user visible light communication systems. Optics express, 2012. 20(4): p. 4564-4573.

[13] Cui, Kaiyun & Chen, Gang & Xu, Zhengyuan & Roberts, Richard. (2010). Line-of-sight visible light communication system design and demonstration.in Communication Systems Networks and Digital Signal Processing (CSNDSP), 2010 7th International Symposium on. 2010. IEEE.

[14] Standardization, E.C.f. and *EN 12464-1. Light and lighting – Lighting of work places – Part 1: Indoor work places.*, 2011, European Committee for Standardization Brusel. p. 56 p.

[15] Komine, T. & Lee, J. & Haruyama, S. & Nakagawa, M.. (2005). Adaptive Equalization for Indoor Visible-Light Wireless Communication Systems. 294 - 298. 10., *2005 Asia-Pacific Conference on.* 2005. IEEE.

[16] Kwonhyung, L. and Hyuncheol, P.and Barry, J.R. (2011). Indoor Channel Characteristics for Visible Light Communications. *Communications Letters, IEEE, 15* (2), 217-219.

[17] Barry, J.R., Kahn, J.M., Krause, W.J., Lee, E.A., and Messerschmitt, D.G. (1993). Simulation of Multipath Impulse Response for Indoor Wireless Optical Channels. *In IEEE Journal on Selected Areas in Communications, 11 (*3), 367-379.

[18] Visible Light Communications Consortium.; http://www.vlcc.net.

[19] Beshr, M., Andonovic, I. and Aly,M. (2012). The Impact of Sunlight on the Performance of Visible Light Communication Systems over the Year. In *Proceedings of SPIE - The International Society for Optical Engineering (Vol. 8540 85400F-1).*

[20]LXHL-LW6C-datasheet. *LXHL-LW6C.* ; http://www.datasheetarchive.com/LXHL-LW6C-datasheet.html**.**

[21] Stefan, I. and H. Haas.(2013). *Analysis of Optimal Placement of LED Arrays for Visible Light Communication*. in *Vehicular Technology Conference (VTC Spring), 2013 IEEE 77th*.. IEEE.

[22] Cheng, R. and M. Gen, *Genetic algorithms and engineering design*. New York, 1997.

[23] Gen, M. and R. Cheng, *Genetic algorithms and engineering optimization*. Vol. 7. 2000: John Wiley & Sons.

[24] Koziel, S. and X.-S. Yang, *Computational optimization, methods and algorithms*. Vol. 356. 2011: Springer**.**

[25] Gancarz, J., H. Elgala, and T.D. Little, (2013).*Impact of lighting requirements on VLC systems.* Communications Magazine, IEEE, 2013. 51(12): p. 34-41.

[26] Grubor, J. & Randel, S. & Langer, K. & Joachim, W. (2008). Broadband Information Broadcasting Using LED-Based Interior Lighting. Journal of Lightwave Technology. Journal of Lightwave Technology, 2008. 26(24): p. 3883-3892.

[27] Komine, T. and Nakagawa, M. (2004). Fundamental Analysis for Visible-Light Communication System Using LED Lights. *Consumer Electronics, IEEE Transactions*, *50* (1), 100- 107.

[28] Philips. *CoreView panel -RC160V LED34S/830 PSU W60L60 CLI- Data sheet*. 2020; http://www.ecat.lighting.philips.com/l/indoor-luminaires/recessed/coreview-panel/910503910029_eu/.

[29] Grubor, J. & Randel, S. & Langer, Klaus-Dieter & Joachim, Walewski. (2008). Bandwidth-efficient indoor optical wireless communications with white light-emitting diodes. in *Communication Systems, Networks and Digital Signal Processing, 2008. CNSDSP 2008. 6th International Symposium on*. 2008. IEEE.

*[30]*Matheus, L. & Borges, A. & Vieira, & Vieira, M. & Gnawali, O. (2019). Visible Light Communication: Concepts, Applications and Challenges. *IEEE Communications Surveys & Tutorials.*

[31] Teixeira, L. & Loose, F. & Barriquello, C. & Alonso, J. & Alfonso R., Vitalio & D. Costa, Marco. (2020). An Analysis of Visible Light Communication Energy Cost. *2020 IEEE Industry Applications Society Annual Meeting*

[32] Ismail, S. & Salih, M. (2020). A review of visible light communication (VLC) technology. *AIP Conference Proceedings.*

[33] Popoola, W. & Tang, X. & Zvanovec, S. & Rajbhandari, S. (2017). Visible Light Communications – A Review. *IEEE COMSOC MMTC Communications - Frontiers.*

[34] Zhu, Y. & Chen, X. (2020). Visible Light Communication System Based on White LED. *2020 IEEE International Conference on Artificial Intelligence and Computer Applications (ICAICA)*

[35] Yang, Y. & Zhong, M.& Yao, H. & YU, F. & Fu, X. & Postolache, O. (2018). Internet of things for smart ports: Technologies and challenges. *IEEE Instrumentation & Measurement Magazine*

[36] Dong, X. & Xiong, G. & Yuantao, Li & Xiujiang, G. & Yisheng, Lv. (2013). Intelligent ports based on Internet of Things. *Proceedings of 2013 IEEE International Conference on Service Operations and Logistics, and Informatics, SOLI 2013*.

[37] Bojic, F. & Bošnjak, R. & Gudelj, A. (2021). Review of Smart Ports in the European Union, *19TH International Conference on Martime Transport Science ICTS 2020.*

Enhancing the Productivity of Alexandria Port through Transforming the Agricultural Biomass Wastes

Author:
Sally Sanhory. Email: Sanhorysally@gmail.com. Lecturer Assistant at Arab Academy for Science, Technology and Maritime Transport, Alexandria, Egypt.
Co- Author1:
Dr. Ahmed Ismail. Email: yaseenahmedismail@gmail.com. Deanery of Admission and Registration, AASTMT, Alexandria

ABSTRACT:
There is a continuous growth for sea trade and the emergence need for sea transportation has caused a the considerable improvements in ports. This research aims to testify a proposed method that can increase the throughput of Alexandria port as well as to cope with the current global issue which is the green transformation and space. The purpose of this paper is to assess the current transformation methods used in the disposing of the agricultural biomass wastes, review the effect of carbonization method and the effect of carbonization process that results in the production of coal on Alexandria port throughput (TEUs). Based on the reviewed literature, this paper aims to increase the productivity of Alexandria port to suggest better methods for the disposal of agricultural biomass wastes that is eco-friendly, through conducting SWOT analysis to find out the benefits of the applicability and the expected drawbacks or disadvantages.

Key words: Alexandria port, productivity, transformation agricultural biomass wastes, TEUs.

INTRODUCTION:

The expected volume of agricultural wastes in Egypt ranges from 22 to 26 million tons per year. These huge quantities must be beneficially utilized rather than being incinerated or disposed in a land fill. The excess dependence on fossil-based fuels such as oil and natural gas as a main source of energy in Egypt can cause environmental harms and health problems. Furthermore, the latest increase in fossil fuels prices has pushed the national economy towards a serious issue. Thus, it became a must to find alternative sources of energy that can cope with the extensive use of fossil fuels. In parallel, agricultural wastes results in numerous problems to the rural villages and countryside in Egypt as the traditional disposal practice of such wastes is burning in the field the thing that creates air and soil pollution problems. The main five agricultural products that produces the biggest quantities of wastes are rice, sugarcane, corn, cotton, and wheat (Shaaban et al., 2018). The reduction in the amount and increasing cost of the fossil fuels plus the rising greenhouse effect that produced energy and environmental problems. Thus, a proper alternative for fossil fuels are needed and so, the interest in renewable energy sources increased. Renewable energy is known as the energy obtained from naturally continuous and persistent flows of energy happening in the local environment. By the discovery of substitute fuels that can work on the fossil fuels burners currently in place rather than the usage of non renewable sources the environment will be more protected. These substitutes can be obtained from the biomass wastes as a raw material since they are the only substitute renewable source for coal. Biomass is the organic waste that derives from plants and produced by photosynthesis making them all green energy sources. During their creation, biomasses already used the exact same amount of carbon dioxide they will later emit as exhaust, so they are usually referred to as a carbon neutral fuel when it is burnt (Amer et al., 2020).

Biomass waste is a renewable natural raw material that are being produced from plants and animals. Until the mid 1800s, Biomass wastes were on top of the total annual U.S. energy consumption. It resumes to be an important fuel in many other countries, especially for cooking and heating in developing countries. The usage of biomass fuels in the sectors of transportation and electricity production is expanding in a lot of developed countries as a mean of reducing the carbon dioxide emissions from fossil fuel use. In 2019, biomass provided nearly 5 quadrillion British thermal units (Btu) and about 5% of total primary energy use in the United States. One o fits features ist hat it containes kept chemical energy from the sun. photosynthesis (Eia, 2020)

In this research the effect of the carbonization transformation process of biomass wastes is tested and the resulted impact on the Egyptian economy will be studied, as the transformation process used in this research results in the production of useful products and the coal is on top of them the thing that could create a new market for the Egyptian exports.

LITERATURE REVIEW:

Biomass sources for energy includes wood, wood processing wastes, agricultural plants waste materials such as corn, soybeans, sugar cane, switchgrass, woody plants, algae, crop and food processing residues and biogenic materials in municipal solid waste paper, cotton, animal manure and human sewage. Biomass is being transformed to energy sources through multiple processes, such as: Direct combustion which involves burning the wastes to generate heat, Thermochemical carbonization conversion to generate solid fuel (coal), Chemical conversion and this method is being used to generate liquid fuels and finally Biological conversion that involves the generation of liquid and gaseous fuels (Eia, 2020).

In this research thermochemical conversion of biomass was investigated were biomass were heated to 400–500 ℃ in full isolation of oxygen generating fuels such as charcoal, bio-oil, renewable diesel, methane, and hydrogen.

The reduction in the petroleum-based fuels and the increase in environmental concerns have directed the production of chemicals via biochemical processes through the use of renewable carbon sources. Numerous biomass wastes types and varieties, that are recyclable and massively underutilized are produced all over the world in massive amounts. They comprise different chemical elements, which may assist as initial points for the manufacture of a wide range of important bio-based products, intermidiary products, or end products through multiple conversion ways.

These conversion ways will help the manufacturer to benefit from new products rather than misusing those wastes. (Jin Cho, et al., 2020). Growing concerns around the generation of biomass waste have caused conversation around sustainable utilization of these apparently waste materials as an opportunity towards energy production, manufacturing of chemicals and other value-added products. (Usmani, et al., 2020).

Huge amounts of annual global production of agricultural wastes are reported, particulary from cereal crops. On global bases, 66% of the remaining plant biomass are produced from cereal straw (stem, leaf and sheath material), while more than 60% of these remaining materials are being produced in low-income and developing countries. Sugarcane wastes and leaves are the second largest contributors, with the other remaining biomass including the 'oil crops', roots and tubers, nuts, fruits and vegetables. It must be considered that these biomass wastes have a potential use in the field of energy production as a substitute for non-renewable energy sources (Tripathi et al., 2019).

Mainly agricultural wastes are being collected from the remaining parts of biomass materials after cutting the valuable parts of crops. biomass wastes constist of carbohydrates in the shape of cellulose (35- 45%) and hemicellulose (25-40%) (Shaaban, et al., 2018). Agriculture is one of the largest biological sectors with the highest biomass production which becomes an important raw material used for the bio economy cycle. It helps in the reduction of fossil fuel use and greenhouse gas emissions. It also adds to the prosperity of new potential green markets and job opportunities by encouraging the transformation of vegetable waste into value-added products, such as food, feed, bio products and bioenergy (Francisco et al., 2020).

The hydrothermal carbonization in earlier decades witnessed being effeciently used and transformed all over the world, sbut in the developed regions it is being better utilized. Their optimal usage is mainly obtained for in terms of transformation of biomass into valuable solid (coal), liquid and gaseous fuels. Definitely, Hydrothermal carbonization is effective, effecient and eco-friendly method; it inhabits wide capability regarding the production of high-energy density solid fuels.

Though, the manufacturing and superiority of solid fuels from carbonization differs upon several parameters; temperature, feed type, residence time, pressure and substance (Nizamuddin, et al., 2017) the following figure shows how the carbonization process is being completed.

Figure (1) Carbonization process.
Source: (Amer et al., 2020).

Wood charcoal has many usages in multiple areas and it is the main fuel for the usage in cooking in a lot of countries such as Ethiopia because of its low cost and availablity. But, the usage of wood charcoal has concerns on the overall health and pollution because of the smoking produced. So, biomass coal provides a safer substitute to wood charcoal using agricultural wastes (dry leaves, coffee husk, sugarcane trash, grass, etc.) these materials are being transformed into the shape of charcoal briquettes to offer significantly needed source of cheap fuel source that is cleaner in the burning process and does not negatively affect the environment (Bogale, 2018).

A late study proposed that 34 MMT million metric tons of biomass wasstes per annum are expected to be required to substitute 20% of fuel, chemical and oil-based products with biomass products, with a minimum of 50 million metric tons are to substitute 30% by 2030. And, an extra 48 MMT of biomass will be needed to produce standard biofuels, with up to 80 MMT required to produce bio-based power and heat (Attard et al., 2020).

GAP ANALYSIS:

From the previous studies and researches that were conducted on the hydrothermal carbonization of biomass wastes in Egypt and the world, very limited researches were conducted to study the effect of the transformation of biomass wastes on the Egyptian economy and on the value chain of the manufacturers. Even with all the negative effect and the obstacles that the biomass wastes imposing towards the development. In addition, the previous study had examined the effect of transformation but from a chemical point of view and limited or no researches examined the impact from supply chain, business and economy point of view.

CONTRIBUTION:

The research contribution is to apply the new concept of biomass carbonization to the Egyptian agricultural biomass wastes that are imposing a big problem and obstacle for both the economy and the agricultural products manufacturers. As the previous researches contributed on the way of transformation and the knowhow behind it but lacked to verify the effect on the economy and the manufacturers supply chain. This is why this research contribution will be on the area of the effect and impact of the transformation of these non-valuable goods to a valuable product that has many uses which is the coal. Therefore, this research aims to increase the productivity of Alexandria port through transforming the agricultural biomass wastes.

RESEARCH PROBLEM

The agricultural biomass wastes are one of the big problems that exists in the Egyptian market. As a result of the refining and manufacturing of the agricultural products there exist a huge number of wastes that are being produced. In parallel these wastes cause several problems such as air and soil pollution. The main five crops that produces the biggest amounts of wastes are rice, sugarcane, corn, cotton, and wheat respectively. The estimated number of agricultural wastes in Egypt ranges from 22 to 26 million dry tons per year (Shaaban et al., 2018). These huge quantities must be beneficially utilized rather than being incinerated or disposed in a land fill. Waste biomass includes an extensive range of materials, and their obtainability is adding an advantageous. The biomass wastes typically have insignificant value and is considered as a pollutant to the environment because of their wrongful disposal methods. There are multiple sources of biomass wastes, either produced as a remaining part of agricultural products or industrial sectors as waste from agricultural processes or frozen vegetables/fruits factories, respectively (Amer et al., 2020).

Due to the inconsistency of supply, connecting and transporting biomass is costing a lot of money that in this case being paid by the manufacturer of the agricultural products. These costs that are paid by the manufacturers to transport and to get rid of these wastes are imposing a barrier to the manufacturer, environment and to the country. While in other scenarios if these wastes became of benefit the manufacturer could sell it and benefit from it (Fahmy, 2017). Global environmental concerns such as cutting forests and climate change that arise as a result of non-sustainable removal of wood from forests and fossil fuel burning, has resulted in the identification of the need to find efficient and alternative environmentally substitute energy source. The current environmental problems such as air, water, soil pollution, and land degradation have also subsidized to the need for assessing environmentally sound energy options (Rao, 2020).

RESEARCH METHODOLOGY:

SWOT analysis is a strategic planning tool used to evaluate the strengths, weakness, opportunities and threats of any organization. SWOT analysis aims to Build on organization strengths, minimize organization weaknesses, seize opportunities and counteract threats of an organization. It used to reconnoiter possibilities for new solutions for problems that face any organization. In addition, identifying opportunities for an organization or make a strategic decision (Arslandere and Öcal, 2016). According to SWOT analysis, strengths and weaknesses emanate from analyzing internal environment for the organization and opportunities and threats emanate analyzing external environment of an organization (Vlados, 2019)

SWOT analysis is one of the most important tools for strategic analysis, and it is considered the first stage of preparing and designing plans within enterprises, and it also helps people to make and make decisions that affect their lives, and it is also an easy and very important way. Where it should not be ignored or not used in the work environment, and the importance of SWOT analysis is summarized according to the following points. Moreover, SWOT can be used to deal with obstacles and threats that faces a company. Also, provides appropriate means to take advantage of the available opportunities, and reduces the control resulting from the elements of weakness affecting the efficiency of the facility's work. SWOT analysis provides information on all its elements; threats, strengths, opportunities, and weaknesses (El-Rouby and Ismail, 2021).

RESEARCH AREA:

The agricultural land area in Egypt is close to the Nile Valley and delta, narrowed by some oases in Sinai. The entire civilized area is around 7.2 million feddans. The sum of the area cropped annually is around 11.5 million feddans, this area represents a cropping ratio of about 2:1. The largest number of agricultural products is for the Cereals. One oft he main contributers is rice as it is one of the major field crops, rice is being grown on nearly 500 000 feddans, and is considered the second most important export crop after cotton. Wheat is the main cereal in the winter grained crops and the third largest crop in terms of area cropped (about 600 000 feddans). Maize is the second most important crop (750 000 feddans) (Elsherif, 2018). Because of these large amounts of agricultural products being cropped annually, Egypt is a perfect option for being the research area for this study. As it has all the natural resources needed. All of these crops produce tones of biomass wastes that are misused by the farmers and manufacturers.

Alexandria is ranked among the top ten ports in the Mediterranean Sea and is also ranked 89 among 100 of container throughput (Damietta Port Authority 2017). Alexandria, El-Dekheila and Port Said are included in the top eight busiest terminals in Africa for the year 2015, East Port Said is ranked among the top ten ports in the Middle East (Ismail, 2019).

RESEARCH VARIABLES

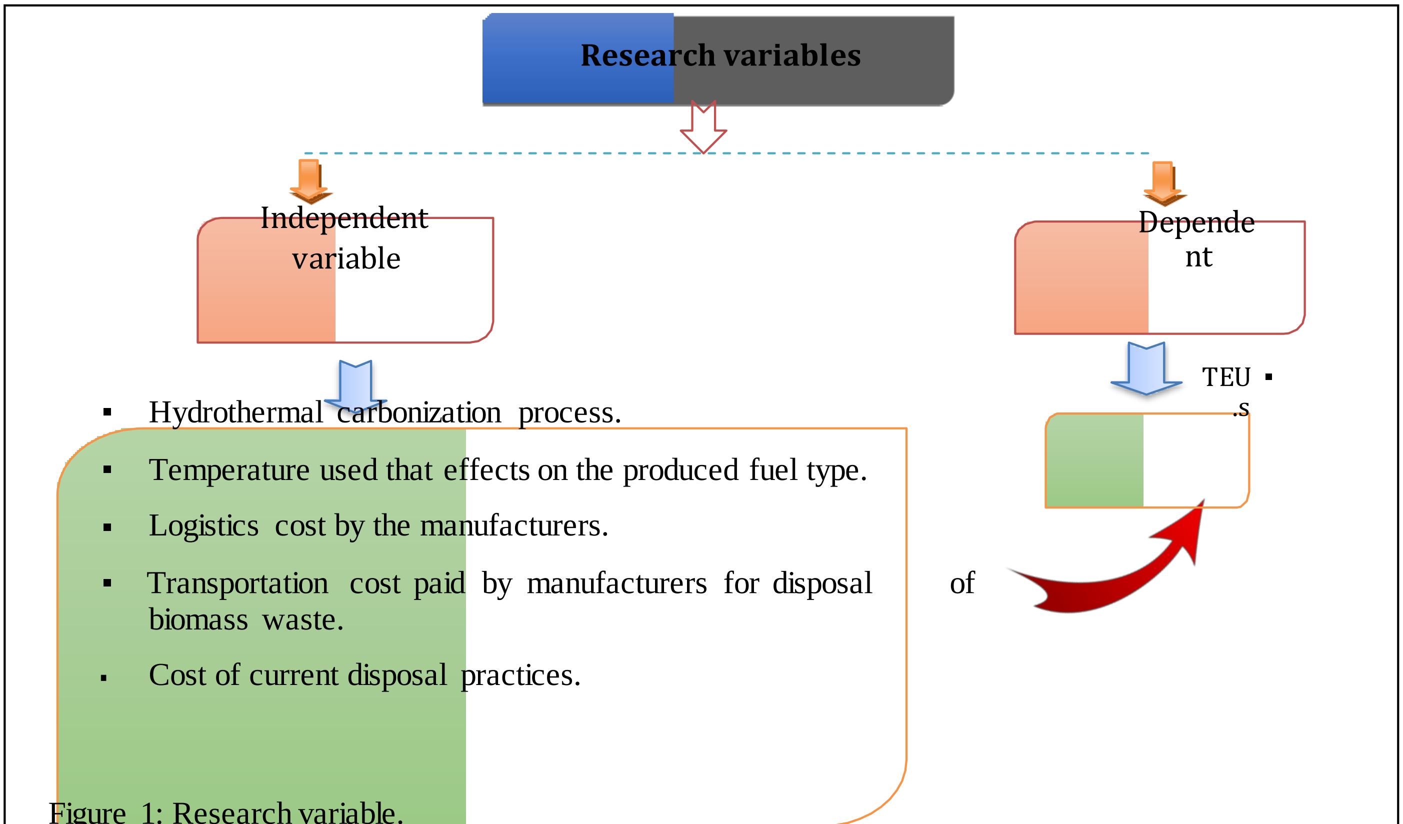


Figure 1: Research variable.
Source: (By the authors).

EMPIRICAL ANALYSIS AND DISCUSSION:

The empirical analysis and results from this research is assessed and found by the conduction of SWOT analysis that helps in providing a precise research report and a framework for the suggested practices by this paper. There are different strength points as illustrated next:

- The efficient use of agricultural biomass wastes: usually farmers and manufacturers are not having safe option for disposing or using the agricultural wastes, so this paper help them benefit from a neglected source of energy.
- Potential Environmental protection: as the followed method of disposal for agricultural wastes in Egypt is the disposal in land causing contamination or to burn causing several problems because of the released CO_2 and the emissions produced that results in several health problems.
- Less inland transportation for the disposal of the wastes: by transforming the agricultural wastes to coal this will lead to compressing the size of it which means that the transportation required for moving the final product is much less, usually the manufacturers that produces huge quantities of wastes are paying large costs in the transportation and disposal as they have no option for reusing so the current status of biomass wastes in Egypt is that it is only a cost or burden for the manufacturer and they don't get any profits out of it.
- Increased benefit for the ecosystem: because of the reduced produced emissions from inland transportation and CO_2 produced from the burning process followed in the disposal.
- Increased exports: there are huge amounts of agricultural biomass wastes produced annually, and as a result the expected amount of coal will be relatively high. The thing that can make Egypt one of the large exporting countries for coal and start competing in this industry with the world coal large producers which are Australia, Indonesia, Colombia and Canada respectively.
- Increasing the productivity of Alexandria port: this paper focuses mainly on Alexandria port as it is the nearest port to the manufacturer producers who are the potential producers for the biomass based coal and has the required capabilities. As a result, to the big quantities produced from the transformation process that helps in the manufacturing of huge quantities of coal, the throughput and productivity of Alexandria port is expected to increase in accordance to the hypothesis. As there is existing relationship between increasing the exports and the port productinvity.
- Increasing the port throughput: as a result of the increased GDP caused from the increased manufactured amounts of coal that is expected to be produced, the throughput of the port will increase as a result oft he increased production and the increased exports.

In addition, there are weaknesses points; as shown next:

- The need for big investments: in order to make the hydrothermal carbonization method of transforming the agricultural biomass wastes into coal advanced machinery and equipment is needed and large investments are needed which could be an obstacle for implementation because of the unwillingness of entities to invest in the new project.

- The need for large areas to make the plants: in order to make the industrial plants large areas of land is needed and preferably to be located nearby to the agricultural manufacturing firms in order to reduce the transportation cost of the raw material to the minimum.

Also, there are opportunities for this proposed framework; as follows:

- Expansion opportunities for manufacturing firms: firms that are specialized in the manufacturing of agricultural products are having an opportunity to expand their business, they are producing the raw material as useless waste that they have the key resource for free so they can easily make an extension for their machinery with the hydrothermal carbonization machinery and become producers and exporters of coal.
- The current direction of the government into eco-friendly solutions: this can make it easier to achieve the project as there will not be restrictions from the government as they are currently trying to push all industries into becoming green.
- Potential revenues for manufacturers: currently the manufacturers are not gaining any benefit from the biomass wastes they produce moreover, they pay for farmers and transportation truckers for the disposal. But, with the carbonization they can sell the biomass wastes to other manufacturers as it will become a valuable raw material.
- The large consumption of agricultural products in Egypt: Egypt is consuming huge quantities of grains and agricultural products annually such as rice and wheat the thing that make the availability of the biomass wastes is continuous.
- The continuous increase in the population: this makes the consumption of agricultural products increases and accordingly the biomass wastes is always available.
- Employment opportunities: for the manufacturing firms and as a result of the increased port throughput.

In contrast, there are some threats:

- Resistance of the manufacturers to change.
- Consumers could be afraid of trying new products which are fossil based.
- The strong competition that could be faced with the world large coal producing companies.

CONCLUSION:

By all counts, and in accordance to the literature review this research helps in increasing the productivity of ports and specially Alexandria port by suggesting and proposing a new idea that can helps in many areas. Firstly, by transforming the agricultural biomass wastes in a green way under pressure and heat to an important source of energy which is coal. Secondly, by making Egypt one of the potential strong exporters in coal which is used in many countries as a source of energy and heat. And there is high international and local demand on coal. Thirdly to have an insight reflect on the performance and productivity of Alexandria port as it is the port that will serve for the exports of coal from all the potential manufacturers of the biomass based coal. Alexandria port was chosen as it is the main port in Egypt and has connections with many ports all over the world. This will increase the probability of the succeed of the project. Moreover Alexandria port current plan and vision is to expand the port throughput to accommodate more cargo handling. Not only the throughput but also the advanced technology that drives mostly all the services provided in the port and the future expansions in the technologies provided. And finally to cope with the current direction of the country which is to go green in all industries, reduce the carbon footprint produced by burning the agricultural biomass wastes and decrease the dependency on non renewable sources of energy by creating new renewable sources that could substitute it.

REFERENCE:

1. Amer, M., & Elwardany, a. (2020). Biomass Carbonization.
2. Attard, J., Mcmahon, H., Doody, P., Belfrage, J., Clark, C., Anda, J., . . . Gaffey, J. (2020, april). Mapping and Analysis of Biomass Supply Chains in Andalusia and the Republic of Ireland . sustainability, 12(11).
3. Bogale, W. (2018). Preparation Of Charcoal Using Agricultural Wastes. research gare.
4. Eia. (2020, august 28). Biomass: renewable energy from plants and animals. Retrieved from EIA
5. independant statistics and analysis: https://www.eia.gov/energyexplained/biomass/
6. Elsherif, M. (2018). Egypt agricultural land . (f. a. organization, Producer) Retrieved from fao:
7. http://www.fao.org/3/v9978e0e.htm
8. Fahmy, K. (2017). Efficiently managed biomass. cairo climate talks.
9. Francisco , Camacho, F., Duque, M., & Belmonte, U. (2020). Agricultural waste: Review of the evolution, approaches and perspectives on alternative uses. science direct.
10. Jin Cho, E., Phi Rinh, l., Song, Y., Gyo, Y., & Jong, H. (2020). Bioconversion of biomass waste into high value chemicals. science direct, 298(0960-8524).
11. Nizamuddin, S., Ahmed, H., & Griffin, G. (2017). An overview of effect of process parameters on hydrothermal carbonization of biomass. science direct, 73, 1289-1299.
12. Pistone, A., & Espro, c. (2020). Current trends on turning biomass wastes into carbon materials for electrochemical sensing and rechargeable battery applications. science direct, 26(100374). Rao, U. (2020). Environmental Effects of Energy from Biomass and Municipal Wastes . In ELOSS, INTERACTIONS: ENERGY/ENVIRONMENT (pp. 10-17).
13. Shaaban, S., & Nasr, M. (2018). Agricultural Wastes-To-Green Energy in Egypt. juniper publisher, 3.
14. Tripathi, N., Hills, C., Singh, R., & Atkinson, C. (2019, october). Biomass waste utilisation in low- carbon products: harnessing a major potential resource. nature.
15. Usmani, Z., Sharma, M., Kumar, A., Sivakumar, N., Lukk, T., & Pecoraro, l. (2020, 322). Bioprocessing of waste biomass for sustainable product development and minimizing environmental impact. science direct(124548).
16. Arslandere, M. & ÖCAL, Y. (2016). SWOT Analysis As A Tool For Strategic Management And
17. An Implementation In A Firm In Machine Industry, 1 st International Academic Research

18. Congress, 3-5 November.
19. Vlados, C. (2019). On a Correlative and Evolutionary SWOT Analysis. Journal of Strategy and20. Management. (12)3. 347-363.
21. El-Rouby, H. & Ismail, A. (2021). Challenges and Opportunities of Applying Block-Chain Technology in Food Supply Chain in Egypt, The 1st Business and Entrepreneurship International Conference, 31 March – 1 April, 2021, Current Business Practices and Future Trends Leading to Organizational Excellence and Sustainable.

The Performance Evaluation of Smart Communication System for Ports across Different Seasons.

Mahmoud Beshr (1), Moustafa H. Aly (2) and Ivan Andonovic (3)

(1) Assistant Professor, Arab Academy for Science and Technology and Maritime Transport Egypt, mbeshr@aast.edu
(2) Professor, Arab Academy for Science and Technology and Maritime Transport, Alexandria, Egypt, mosaly@aast.edu
(3) Professor, Strathclyde University, Glasgow, United Kingdom, i.andonovic@strath.ac.uk

ABSTRACT

Given the great development that industries are currently witnessing and the huge needs for ports to simplify the trading between countries, there is a huge demand on utilizing technologies to satisfy the communication needs for different stakeholders such as port authorities, shipping agencies and operators. One of these ways is Visible Light Communication (VLC) which is characterized by being a very high data rate, secure, and energy efficient network that uses high bandwidth pulsed light. The VLC provides a secure and efficient way to transmitting information in the existence of barriers such as Radio Frequency (RF) interference. Thus, the aim of this paper is to evaluate how sunlight irradiance can affect the VLC system performance. Furthermore, this paper uses modelling and simulation techniques to analyze the effect on the system Signal to Noise Ratio (SNR) for Egypt and Germany. The performance evaluation considers different metrological conditions to simulate port's context and operations over the year.

Keywords: Visible Light Communication, Smart Ports, Sunlight Irradiance

INTRODUCTION

Utilization of communication technologies in ports operation can be considered as enabler for port system automations (smart ports) where the communication links (VLC system link) among container ship, ship-to-shore handling, carriers, yard storage and terminal management[1], [12], [13], [17]. The VLC system can provide fast, secure and cost-effective solutions by unitizing the LED blub light for communication among different stages at indoor and outdoor environments.

Despite the fact that the VLC system performance is affected by sunlight intensity which differs according to the location under consideration, day of the year, time of the day and some meteorological conditions, more than 45% of sunlight spectrum locates in the visible light band, and thus, the VLC is still able to promise high speed connections and cost-effective solutions even in environments and areas that are vulnerable to electrometric wave radiations[17]. The VLC in cooperation with The Internet of Things (IoT) can provide a secure and cost-effective solution for different challenges in smart port context. Sunlight irradiance in addition to cloud cover significantly affect the VLC[2],[14], [16].

Most of research studies that focus on evaluating the performance of VLC systems [1], [2], [4] deal with sunlight as Gaussian noise; here the evaluation considers the sunlight intensity variation over the year. Further, cloud cover also varies significantly over the year, rendering the level of sunlight irradiance captured by the receiver a strong function of weather conditions. Accordingly, this paper uses Egypt and Germany as two representative locations in order to capture the hourly sunlight irradiance as a function of latitude and longitude of locations, day of the year, time of the day and level of cloud cover.

The visible light communication impulse response has been analysed through taking into consideration only one reflection from standard room walls [2], [4],[15] at the indoor environments such as terminal management in ports. Thus, to add to existing literature, this paper evaluates the impulse response for both non line of sight (NLOS) to third reflection and line-of-sight (LOS) components by considering relatively large rooms to analyse how the results might differ when room size changes.

The following illustrates the remainder of the paper. The VLC system architecture with its mathematical representation are described in Sec. 1, at indoor port system environments. Section II illustrates the impact of sunlight. Section III presents the effect of cloud cover on sunlight irradiance. Section IV covers evaluation of the SNR. It displays and discusses the obtained results. Section V is devoted to the main conclusions.

I. SYSTEM MODEL

The main assumption is that there are communication links using VLC system between port system components where VLC System had been utilized for both indoor environment (terminal management) and outdoor environment between ship-to-shore, carriers, yard storage and terminal management. At terminal management offices, it is assumed that LED light illumination is unitized for communication within the office and also outdoor light bulbs had been considered for external communications as shown in Fig. 1.

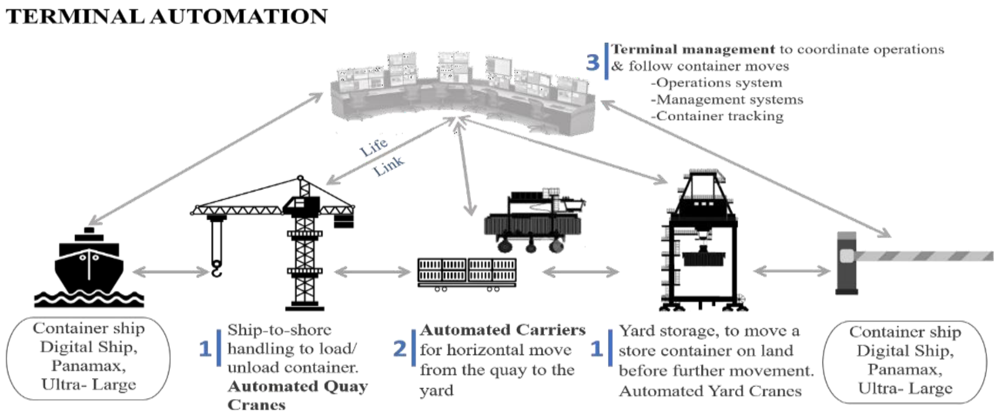


Figure 1. Terminal Automation using VLC System Links

Figure 2 shows how the optical path is subjected to several reflections. Transmitter is placed on room ceiling, while the receiver is placed on its floor. Φ_1 denotes the radiated LED light viewing angle and θ_1 denotes the incidence angle.

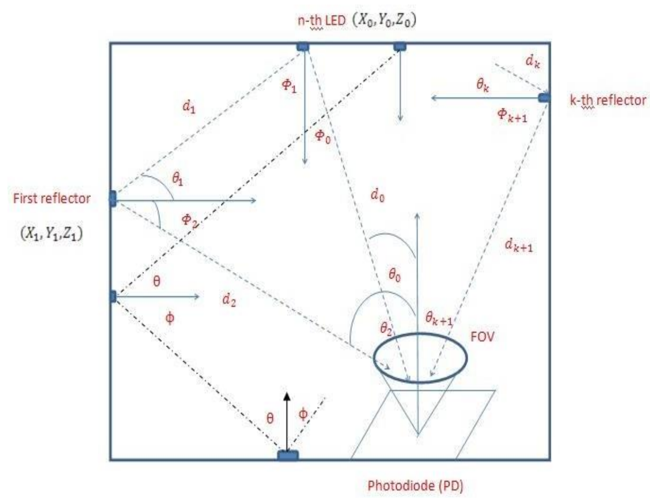


Figure 2. Geometry of the Analysis Environment Comprising N-transmitter LEDs and a receiver photodiode (PD)

For multiple reflections and multiple sources, Fig. 1 is utilized to show the path geometry and to get the impulse response. Equation (1) shows the impulse response, where N_{LED} shows the total number of LEDs [2]. Equal emitted powers are assumed for each LED. When the light beam incident on wall or any surface at indoor environment (terminal management), the sunlight is considered as noise which may affect system performance as well as number of signal reflection till it arrives receiver ; the After k-reflections of the n[th] LED, the response is given by [2, 3, 7]

$$h(t) = \sum_{n=1}^{NLED} \sum_{k=0}^{\infty} h^{(k)}(t; \Phi_n) \quad (1)$$

$$h^{(k)}(t; \Phi_n) = \int_s [L_1 L_2 \dots\dots L_{K+1} \Gamma^{(k)} rect(\frac{\theta_{k+1}}{FOV}) \times \delta(t - \frac{d_1 + d_2 + \dots d_{k+1}}{c})] \, dA_{ref}, \ k \geq 1 \quad (2)$$

where

$$L_1 = \frac{A_{re}(m+1)cos^m \Phi_1 cos\theta_1}{2\pi {d_1}^2}$$

$$L_2 = \frac{A_{ref} \cos \Phi_2 cos\theta_2}{\pi {d_2}^2}$$

$$L_{k+1} = \frac{A_{PD} \cos \Phi_{k+1} \cos \theta_{k+1}}{\pi {d_{k+1}}^2}$$

L_{k+1} is the loss in each path. Here, we integrate with respect to S, surface of reflectors, and Pref, reflecting element area. $m = -1/\log_2(\cos \phi_{1/2})$ is the mode number of a radiation lobe, which indicates the beam directivity related to ($2\phi1/2$), the LED the viewing angle. ϕ_k and θ_k are, respectively, irradiance and incidence angles. The received power is inversely proportional to the square of d_k, the distance between transmitter and receiver. The photodiode (PD) detects with an incidence angle less than its acceptance angle, or its FOV, the field of view. The rect (x) special function can be obtained by [2, 5]

$$rect(x) = \begin{cases} 1 & or \ |x| \leq 1 \\ 0 & for \ |x| > 1 \end{cases} \quad (3)$$

where c represents the free space light speed.

$\Gamma^{(k)}$ is the power of the reflected ray, after k- bounces from the n^{th} LED, and is given by

$$\Gamma_n^{(k)} = \int_{l\lambda}^{u\lambda} \Phi_n(\lambda) \rho_1(\lambda)_2(\lambda) \dots\dots \rho_k(\lambda) d\lambda \quad (4)$$

The reduced form of Eq. (4) is

$$\bar{\Gamma}_n^{(k)} = P_n \rho_{n,1} \, {}_{n,2} \dots\dots\dots.. \rho_{n,k} \quad (5)$$

where $\rho_{n,k} = \frac{1}{P_n} \int_{l\lambda}^{u\lambda} \Phi_n(\lambda)_k(\lambda) d\lambda$ is the average reflectance, and $P_n = \int_\lambda \Phi_n(\lambda)\lambda$ is the power radiated from the n[th] LED for k=1. Equating Eqs. (4) and (5), one can get [2]

$$\Gamma_n^{(1)} = \bar{\Gamma}_n^{(1)} = \int_{l\lambda}^{u\lambda} \Phi_n(\lambda)\rho_1(\lambda)d\lambda \quad (6)$$

However, the differences are more prevalent when higher order reflections are considered. For LOS, the PD position is given by [2, 7]

$$h^{(0)}(t; \Phi_n) = L_O P_n\, rec(\frac{\theta_o}{FOV})\delta(t - \frac{d_o}{c}) \quad (7)$$

where

$$L_O = \frac{A_P(m+1)cos^m\Phi_o cos\theta_o}{2\pi d_0{}^2}$$

II. SIGNAL TO NOISE RATIO (SNR)

In determining SNR and its corresponding Bit Error Rate (BER), we assume the transmitter operating at R_b data rate, and an ON-OFF keying (OOK) modulation scheme is utilized with pulses of NRZ scheme. The average received power, p, is $p = H(0)P_t$, where P_t is the average transmitted power and H is the channel DC gain, which is explained in details in Sec. III. Also, we assume the channel has no distortion with a gain H(f) = H(0), at any frequency. An equalizer follows the pre-amplifier. Each equalized output sample contains noise whose total variance is given by [2, 3, 7, 8]

$$\sigma_{total}{}^2 = \sigma_{shot}{}^2 + \sigma_{thermal}{}^2 \quad (8)$$

The shot noise is represented as

$$\sigma_{shot}{}^2 = 2qRp_nI_2R_b \quad (9)$$

and the thermal noise is

$$\sigma_{thermal}{}^2 = \frac{4KT}{R_F}I_2R_b + \frac{16\pi^2KT}{g_m}(\Gamma + \frac{1}{g_mR_D})C_T{}^2I_3R_B{}^3 + \frac{4\pi^2KI_D{}^aC_T{}^2}{g_m{}^2}I_fR_b{}^2 \quad (10)$$

The SNR is expressed with the aid of Eqs. (8) - (10) as

$$SNR = \frac{(RP)^2}{\sigma_{total}{}^2} \quad (11)$$

and the BER is given by

$$BER = (\sqrt{SNR}) \quad (12)$$

where

$$(x) = \frac{1}{\sqrt{2\pi}} \int_x^\infty e^{-y^2/2} dy \qquad (13)$$

III. SUNLIGHT RADIANCE

As mentioned before, day of year, time of day, geographic location and meteorological conditions are all affecting the radiation of incident direct solar, q_{sun}, that can be estimated at the mentioned locations. Though, because no accurate measurements exist, irradiance (in W/m^2) can be obtained by the approximated clear sky solar radiation as [1, 9]

$$q_{sum} = 1350.3 \times [1.0 + 0.033 \cos(\frac{360n}{365})] \times [\sin\varphi \sin\delta + \cos\varphi \cos\delta \cos\omega] \qquad (14)$$

Here, solar declination is δ, angular displacement is ω and location longitude is φ. For time conversion from local clock to an apparent solar one, two corrections are to be used. The first one considers the variation of earth rotation rate, and the second is to adjust the differences in local longitude and standard meridian of zone of local time [1, 9].

The solar declination angle is

$$\delta = 23.45 \sin\left[360\left(\frac{284 + n}{365}\right)\right] \qquad (15)$$

Then, ω , the sun angular displacement, west or east of local meridian according to earth rotation is the angle hour, represented by

$$\omega = 15 \times (12 - AST) \qquad (16)$$

where AST is the apparent solar time, that relates to the local standard time, LST, given in minutes from midnight as

$$AST = LST + E \pm 4 \times (\eta - \psi) \qquad (17)$$

The positive and negative signs, respectively, represent the west and the east of Greenwich meridian (zero longitude), η denotes the standard meridian for zone of local time west of Greenwich meridian, and ψ denotes local longitude east or west of Greenwich meridian (zero longitude). Equations (18) to (21) provide an estimation for E, the equation of time, for four main periods [1, 9]

- 1st January and 15th April, $(1 \leq n \leq 105)$

$$E = -14.2 \times \sin[0.028303 \times (n + 7)] \quad (18)$$

- 16th April and 15th June, $(106 \leq n \leq 165)$

$$E = 4 \times \sin[0.053247 \times (n - 106)] \quad (19)$$

- 16th June and 31st August, $(166 \leq n \leq 245)$

$$E = -6.5 \times \sin[0.03927 \times (n - 166)] \quad (20)$$

- 1st September and 31st December, $(246 \leq n \leq 365)$:

$$E = 16.4 \times \sin[0.027802 \times (n - 246] \quad (21)$$

The evaluation of system performance that considers different surfaces reflectivity's is shown in Table I.

Table I. Surface's Reflection Characteristics.

Surface	Reflectivity
Floor surface	~ 0.62
Plastic wall surface	~ 0.2
Plaster wall surface	~ 0.8
Ceiling surface	~ 0.4

IV. AVERAGE SNR

A. Winter Season

During winter for Cairo, the sunlight irradiance is 1185 and 876 W/m^2 for clear and cloudy sky, respectively. SNR (Figs. 3 and 4) was evaluated to be at a minimum of 17 dB for plastic walls with clear skies and 39 dB for plaster walls in the presence of cloud cover; for the ceiling and floor the SNRs are 27.5 dB/ 31dB and 28.5 dB/37 dB, respectively. At Berlin the sunlight irradiance was 823.107 and 347.58 W/m^2 for clear sky and cloudy sky on winter and SNR was evaluated to be at a minimum of 20 dB for plastic walls with clear skies and 40 dB for plaster walls in the presence of cloud cover; for the ceiling and floor the SNRs are 31 dB/34 dB and 36 dB/37.5 dB, respectively

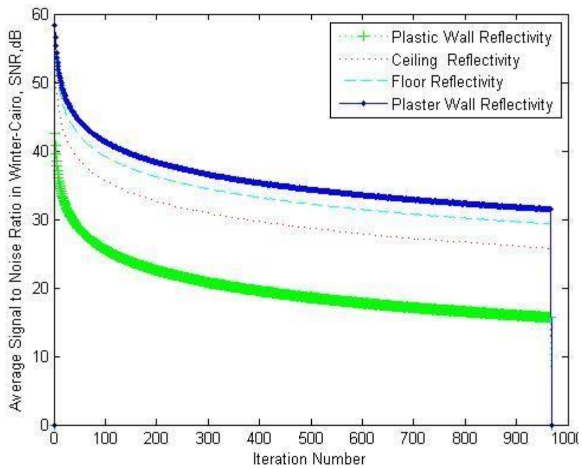


Figure 3. Average SNR for Cairo; Winter

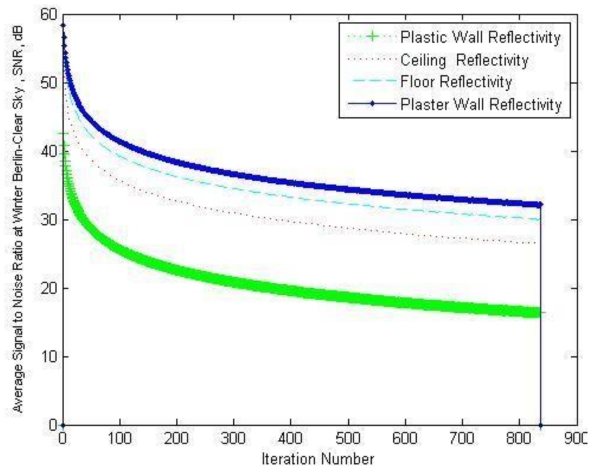


Figure 4. Average SNR for Berlin; Winter

B. Summer Season

During summer, as expected sunlight irradiance is at maximum especially in Cairo, respectively, 1312.911 and 1036 W/m^2, in clear and cloudy sky. The average SNR is, respectively, 13 dB and 17 dB in clear and cloudy sky, for plastic wall surfaces (Figs. 5 and 6). The corresponding SNR for plaster wall surfaces is 35 dB and 38 dB, respectively.

In Berlin the irradiance reaches 1150 and 586 W/m^2, respectively, for clear and cloudy sky, with a corresponding average SNR of 16 dB/27.5 dB, 31 dB/33.5 dB, 18 dB/30 dB and 33 dB/35 dB in plastic walls, floor, ceiling, and plaster wall surfaces (Figs. 8 and 9).

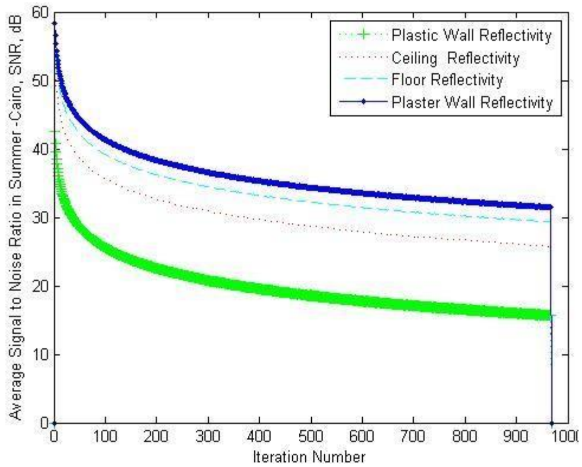


Figure 5. Average SNR for Cairo; Summer

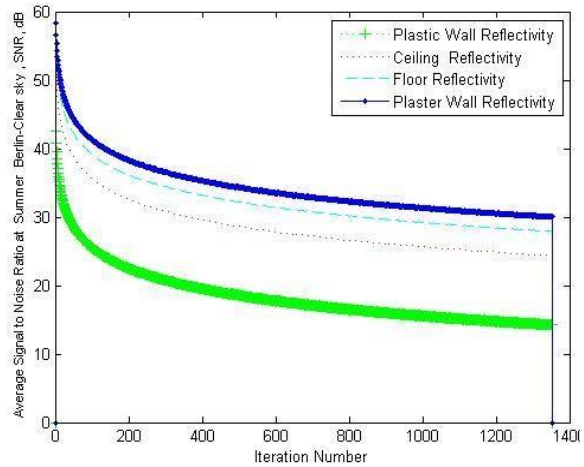


Figure 4. Average SNR for Berlin; Summer

C. Spring Season

During spring, the average SNR was 14 dB and 17 dB for plastic wall surfaces (Figs. 10 and 11), and 30 dB and 37 dB for plaster wall surfaces, in case of clear and cloudy sky, respectively. In the Berlin spring, the average SNR is 18.5 dB/16 dB, 37 dB/32.5 dB for plastic and plaster surfaces for clear and cloudy skies.

D. Autumn Season

Similar to Figure 10 and 11, autumn curves follow the same patterns but with different values. Specifically, during autumn in Cairo, sunlight irradiance reaches 1175.087 W/m^2 and the corresponding average SNR for clear sky and cloudy skies are 16 dB/30 dB, 32.5 dB/35 dB; 18 dB/32 dB and 35 dB/37.5 dB in plastic wall surfaces, floor, ceiling, and plaster wall surfaces, respectively. In Berlin cloud cover is more pronounced and thus the sunlight irradiance is 822.627 and 368 W/m^2 for clear and cloudy sky, respectively. The average SNR is 14.5 dB and 18 dB for plastic wall and was 38 dB and 34.5 dB for plaster wall surfaces for clear and cloudy skies, respectively.

V. CONCLUSION

The impact of irradiance of sunlight on a VLC system performance is evaluated for Cairo and Berlin, as representatives of significant differences in metrological conditions. A comparative performance of attainable BER and average SNR is performed on an hourly basis over the year for clear skies. The minimum SNR is obtained in Cairo, summer clear skies (~13.5 dB) and maximum SNR is achieved in Berlin, winter/cloudy sky (~39.5 dB). Plaster wall surfaces are recommended for locations with high sunlight irradiance due to high reflectivity but plastic walls should be avoided in such environments. The BER range from 10^{-13} to 10^{-10}, for plaster and plastic wall surfaces, respectively.

Thus, the VLC system had proven a good performance for ports in such indoor environment such as terminal management and outdoor environment at the communication link between carriers and storage yard for example. Table II provide summary of the system performance and availability in different metrological conditions that reflect he related system reliability in smart port systems

Table II. Average system performance over different metrological conditions at smart port operations

Season	Plastic wall (dB)		Ceiling surface (dB)		Floor surface (dB)		Plaster wall (dB)	
	Cairo	*Berlin*	Cairo	*Berlin*	Cairo	*Berlin*	Cairo	*Berlin*
Winter	~ 17	~ 20	~ 29.5	~ 31	~ 34	~36	~ 36	~ *37.5*
Autumn	~17.5	~ 19	~ 29	~*30*	~32.5	~33.5	~33	~*34.5*
Spring	~17.5	~ 18.5	~ 27.5	~ 29	~31.5	~33	~33.5	~ 35
Summer	~13.5	~ 17	~ 25.5	~ 27	~ 30	~32.5	~33	~35.5

REFERENCES

[1] Duffie, J. and Becckman, W. (1991). *Solar Engineering of Thermal Process.* 2nd Edition, N. Y. John Wiley & Sons.

[2] Kwonhyung, L. and Hyuncheol, P.and Barry, J.R. (2011). Indoor Channel Characteristics for Visible Light Communications. *Communications Letters, IEEE, 15* (2), 217-219.

[3] Gfeller, F.R and Bapst, U. (1979). Wireless In-House Data Communication via Diffuse Infrared Radiation. *Proceedings of the IEEE*, *67* (11), 1474- 1486.

[4] Lubin Z., Minh H.L., O'Brien, D., Faulkner, G.; Kyungwoo L., Daekwang J. and YunJe O. (2008). Equalisation for High-Speed Visible Light Communications Using White-LEDs. In *Proceedings of 6th International Symposium on Communication Systems, Networks and Digital Signal Processing* (pp. 170-173).

[5] Barry, J.R., Kahn, J.M., Krause, W.J., Lee, E.A., and Messerschmitt, D.G. (1993). Simulation of Multipath Impulse Response for Indoor Wireless Optical Channels. *In IEEE Journal on Selected Areas in Communications*, *11 (*3), 367-379.

[6] Komine, T. and Nakagawa, M. (2004). Fundamental Analysis for Visible-Light Communication System Using LED Lights. *Consumer Electronics, IEEE Transactions*, *50* (1), 100- 107.

[7] Kahn, J.M. and Barry, J.R. (1997). Wireless Infrared Communications. *Proceedings of the IEEE*, *85* (2), 265-298.

[8] Ramirez, R., Idrus, S. and Johor, S. (2008). *Optical Wireless Communications: Ir for Wireless Connectivity*. CRC press, Taylor & Francis.

[9] Quaschning, V. (2005). Understanding Renewable Energy Systems, Earth Scan. Earthscan Publications.

[10] Beshr, M., Andonovic ,I. and Aly ,M. (2012). The Impact of Sunlight on the Performance of Visible Light Communication Systems over the Year. In *Proceedings of SPIE - The International Society for Optical Engineering* (Vol. 8540 85400F-1).

[11] Douaioui, K., Fri, M., Mabrouki, C., and Semma, E. A. (2018). Smart Port: Design and Perspectives. In *Proceedings of 4th International Conference on Logistics Operations Management (GOL)* (pp. 1-6).

[12] Bojic, F., Rino, B., and & Gudelj, A. (2021). Review of Smart Ports in the European Union. *ICTS 2020 Conference.*

[13] Ismail, S. & Salih, M. (2020). A review of visible light communication (VLC) technology. *AIP Conference Proceedings.*

[14] Popoola, W. & Tang, X. & Zvanovec, S. & Rajbhandari, S. (2017). Visible Light Communications – A Review. *IEEE COMSOC MMTC Communications - Frontiers.*

[15] Matheus, L. & Borges, A. & Vieira, & Vieira, M. & Gnawali, O. (2019). Visible Light Communication: Concepts, Applications and Challenges. *IEEE Communications Surveys & Tutorials.*

[16] Zhu, Y. & Chen, X. (2020). Visible Light Communication System Based on White LED. *2020 IEEE International Conference on Artificial Intelligence and Computer Applications (ICAICA)*

[17] Teixeira, L. & Loose, F. & Barriquello, C. & Alonso, J. & Alfonso R., Vitalio & D. Costa, Marco. (2020). An Analysis of Visible Light Communication Energy Cost. *2020 IEEE Industry Applications Society Annual Meeting.*

Smart Contracts, Opportunities And Challenges To The Egyptian Legal System

Mona Elmessery LLM
International Transport and Logistics Institute ITLI, Alexandria, Egypt,
mona.elmessery@gmail.com
Judge. Dr. Amr Abd Elmalek PhD.,
International Transport and Logistics Institute ITLI Alexandria, Egypt,
amr3abdelmalek@hotmail.com

ABSTRACT

With the rise of cryptocurrencies started with bitcoin in 2008, many financial institutions and business entities decided to invest in cryptocurrencies model.

Although the cryptocurrencies concept is under severe debate since appearance from extremely different points of views, the concept of blockchain is totally different, that is almost all technology, finance and even governmental entities welcome the technology, and went through utilizing blockchain in different applications aside from the idea of cryptocurrency.

Smart contract is a revolutionary concept, and it is a future player in maritime transport or smart shipping in some contexts, but studying is a must to test the legality of the mechanism and the process.

This study aims to discover this issue with the Egyptian legal framework on the level of laws, governmental regulations, how and when the local market and business community react with smart contracts; considering how to transform most of the existing commercial contracts into lines of codes.

Keywords: Smart, Contracts, Blockchain, Ledger, Cryptocurrency, Egypt, Legal, System.

Introduction

In March 2021 the bitcoin exceeded 60000 USD value (Coindesk.com, 2021), that couldn't happen without many financial institutions and business entities decided to invest in cryptocurrencies model.

Although the concept of cryptocurrencies is under severe debate since appearance in 2008 by the anonymous individual or group "Satoshi Nakamoto" (Grønbæk, Martin von Haller, 2016) from extremely different points of views, the concept of blockchain is totally different, that is almost all technology, finance and even governmental entities are welcoming the technology concept.
Moreover, they tend to utilize the technology in different useful applications aside from the idea of cryptocurrency.

These applications may go in different areas such as Smart contracts which are being currently legalized in several countries and states (David Rutter, Sean Murphy, 2016), Notarization which is currently in implementation phase by different countries such as EU (EUROPA, 2021), and different database applications including very large scale scientific and business databases (Blockchain for Science, 2021), which is stored by miners and not in specific servers or computers. Maritime transport is one of the fields that smart contracts and blockchain will play a critical role in its development. Smart contract or blockchain in general can be utilized the maritime industry one example is the bill of lading, the other is the regulatory compliance, and many others., which should bring save cost and gives more transparency to the maritime industry (Marija Jovi´c, Edvard Tijan, Dražen Žgalji´c, Saša Aksentijevi´c, 2020)

The issue of smart contracts is a revolutionary concept, and it is a further stage above digitalization, but it is needed to study the concept carefully to test the legality of the mechanism and the process. Many studies have been done to verify the feasibility of smart contracts from legal point of view. (David Rutter, Sean Murphy, 2016)

This study is another attempt to discover this issue of smart contracts and its relations with distributed ledger, block chain and cryptocurrencies under the Egyptian legal framework on the level of laws, governmental regulation, and even how and when the local market and business community react positively or negatively with the smart contracts approach; considering how to transform most of the existing commercial contracts into lines of codes which is the Smart contracts.
Definitions of Contracts, Natural Language Contracts, and smart contracts shall be covered as well as concepts related to the contracting process such as letter of guarantee and expose to some terms like consensus in both smart contracts Science of hadith arenas.

The Study of smart contracts in Egypt will examine its compliance under the law number 131 for year 1948-Egyptian civil law, law number 17 for year 1999-Egyptian commercial law, law number 15 for year 2004-Electronic signature law, law number 175 for year 2018-Combating information technology crimes, law number 194 for year 2020-Law of central bank of Egypt, proposed electronic transactions law which is under discussion in Egyptian house of representatives, decrees, and press releases of the central bank of Egypt. It will examine the acceptance of the smart contracts by the community and the business environment

BACKGROUND

It is needed to define some legal terms for the purpose of comparison and analogy, such as contract, smart contracts, and letter of guarantee as very popular and essential components in the civil and commercial contracts.

1. **Contract definition in Egyptian Legal System:** The Egyptian civil law No. 131 for Year 1948 did not include a specific definition for the contract, the law detailed the contract and its related elements and conditions as commitment sources (Law No. 131 Egyptian Parliament, 1948). The contract is defined in Jurisprudence by Abdelfattah Elsanhoury which is the agreement of two or more wills to create, transfer, amend or terminate an obligation, moreover he stated that he decided to not define the contract while drafting the law to comply with litigation policy which is avoiding lots of jurisprudence definitions in the law to (Elsanhoury, Abdelrazak, 2007), and in the opinion of the author the law came in the existing form to give the legal community the freedom to provide more definitions for the contracts in the legal literature.

2. **Smart Contracts:** The first one who put a definition for smart contract was Nick Szabo, in his famous article Smart Contracts: Building Blocks for Digital Markets, 1996 the definition was simply "a set of promises, specified in digital form, including protocols within which the parties perform on these promises", he illustrated the idea as the contract between the customer [Buyer] and the vending machine owner [Seller], which is a complete sales contract without intermediates and interventions, while the terms of the contract is a series of logic code stored in the vending machine control unit.

   The smart contract should include some key characteristics:

   Digital form: Numeric form usually contained in a computer or any smart device it can be lines of code, data, and software in a form of programs or applications.

   Embedded: Clauses of the contract "or equivalent functional outcomes" are embedded as

   computer code in software

   Performance mediated by technological means: The process of wallet transfer and payment as well as other actions are done by technological means and blockchain operations

   Irrevocable: Once initiated, the process and its outputs, actions, etc. cannot be stopped "unless the code has some special condition to stop" (David Rutter, Sean Murphy, 2016)

3. **Letter of Guarantee in Egyptian Legal System:** As the process of smart contracts depends widely on insurance from both parties in the form of cryptocurrency hold in an intermediate wallet in the blockchain, it is important to define the letter of guarantee in the Egyptian system, which was clearly defined as a written undertaking issued by the bank at the request of a person (called the commander), to pay a specific or assignable amount to another person (called the beneficiary), if he is requested to do so during the period specified in the letter without regard for any opposition. (Law No. 17 Egyptian Parliament, 1999)

   Where consideration must be given to the elements (Consent, determinable object of the obligation, and existing and lawful cause of the obligation) and conditions (Will and legal capacity) of the contract, and if they are available and considered, then we are facing a right contract. As it becomes clear that the smart contract does not differ in essence from natural language contracts. Rather, the difference occurs in the stages of concluding, documentation, implementation and litigation in the event of a dispute.

   There are three approaches in the smart contract applications:

   First approach: "Code is Law" (Hassan, Samer; De Filippi, Primavera, 2016) any natural language contract can be converted into smart contract without limitation

   Second approach: Smart contract is digitizing some components of the business to ease and facilitate specific process such as payment

   Third approach: It is different permutation between first and second such as selecting one or more parts of natural language contract and converting it into lines of code which is smart contract. (David Rutter, Sean Murphy, 2016)

Main Focus of the Article

Consensus can simply be defined as "The process by which nodes on a distributed ledger system reach consensus that a new data entry should be recorded on the ledger. The consensus mechanism is set by the software underlying the distributed ledger system. With approval of more than 50% of the network nodes" (Law Commission, 2020) (Hassan, Samer; De Filippi, Primavera, 2016)

1. Ethereum vs. Bitcoin consensus mechanism and smart contracts

As the consensus is the process of validating transactions on the distributed ledger without the need of third party, historically Bitcoin was the first cryptocurrency which was drafted and designed by the anonymous individual or group called Satoshi Nakamoto, he created the Proof of Work system "PoW", it is manly presented to solve the double spending problem in any decentralized cryptocurrency. The proof of work is a mathematical sort of action which is cryptography the term that cryptocurrency derived from. There is a unique mathematical equation that only powerful computers can solve, upon the solution of the equation the system knows the transaction is authentic, as many things in life PoW is not perfect because of its need to significant amount of power in form of electricity, and its limitation to solve multiple equations simultaneously. High power consumption is one of the most criticizing factors in the distributed ledger technology which is the main ambarella for smart contracts. The drafting of Proof of Stake "PoS" was a natural result due to the limitations and obstacles found in "PoW" mechanism. This took place in 2012 by Scott Nadal and Sunny King and they assumed a figure of power consumption for "PoW" very far from the current consumption level. Currently Ethereum is utilizing "PoW" and it is willing to utilize "PoS" instead in the near future. Ethereum also consists of a distributed ledger which records data. In case of Bitcoin this data is only transaction, but Ethereum enables not merely transactions but also computer programs to be recorded on the ledger. These computer programs are to act as smart contract in the definition of Ethereum. (Law Commission, 2020)

2. Consensus from social and political prospective

Since consensus is an essential component of the distributed ledger and blockchain technologies, the concept of self-execution for the smart contract depending on the consensus is relatively chocking to the business and legal community, although the idea of Nick Szabo of modeling the automatic vending machine as a smart contract is very clear (David Rutter, Sean Murphy, 2016), but the community may not be able to imagine that the conditions of the contract is to be determined by more than 50% of the miners community to validate the condition in the contract. In western community the idea is relatively nearer since the process is similar to voting in democratic systems, but in the Arab world that Egypt is part of, people are not very convinced by consensus as a validation process although a similar concept appeared more than 1000 years ago in the Science of hadith or Hadith studies which is "Tawater" or "Hadith Mutawatir" which can be defined as a successive narration is one conveyed by narrators so numerous that it is not conceivable that they have agreed upon an untruth thus being accepted as unquestionable in its veracity. Or narrated by a group that it is usually impossible for them to be complicit in lying. (Al-Asqalani, Ibn Hajar)

That is in the Arabic Islamic culture narration or consensus is a source of true action via witness that can be considered for any transfer either this transfer for a speech, action or any other transaction.

3. Are electronic edits in the Egyptian system legally binding?

Although it is not very popular in the Egyptian business and legal community that electronic material such as email, social medial messages and content, it is very popular among community, these forms of communication is gaining momentum day after day inside the Egyptian business arena. The Egyptian legal system started to notice the importance of electronic transaction and drafted the law No. 15 for year 2004-Electronic signature law and its implementing regulation in April 2020 as well as several cassation appeals that regulates how electronic material to be legally binding, the implementing regulation stated in article No. 9 the conditions for electronic source for considering it legally binding which are:

That it be technically available to determine the time and date of creation of the electronic writing or the official or customary electronic documents, and that this availability is made through an independent electronic filing system and is not subject to the control of the creator of this writing or those documents, or the control of the person concerned with them.

To be technically available to determine the source of creation of electronic writing or official or customary electronic documents and the degree of control of their creator over this source and the media used in their creation.

In the event that the electronic writing or official or customary electronic documents are created and issued without human intervention, partial or total, then their validity will be fulfilled whenever it is possible to verify the time and date of their creation and that this writing or those documents have not been tampered with.

In the real life and practice level there are two different authorities in Egypt who are responsible to present official extraction of any electronic material

Information Technology Industry Development Agency (ITIDA), Ministry of Communication and Information Technology, it is concerned with any electronic material related to electronic signature mechanism.

General Department of Information Technology, Communication Systems and Information Technology sector, Ministry of Interior, who is responsible for any other type of electronic material validation either for civil or criminal purposes. (Law No. 15 Egyptian Parliament, 2004) (Cassation Appeal No. 17051 for Year 87, 2019)

4. Cryptocurrencies and smart contracts in the Egyptian laws

The central bank of Egypt modified its law by a new one holding No. 194 for year 2020-Law of central bank of Egypt, that included several articles governing and describing several electronic transactions that are utilized in the Egyptian business environment specially banking industry.

The law mentioned cryptocurrencies literally in article No. 206 that states "It is prohibited to issue cryptocurrencies or electronic money, trade in or promote them, create or operate platforms for their trading or implement activities related to them without obtaining a license from the Board of Directors in accordance with the rules and procedures it specifies". The central bank did not totally prohibit the cryptocurrencies and its related platform which is blockchain that is a vital component in the smart contracts. The bank may allow the legal existence of smart contracts and cryptocurrency which is the mean of payment in the smart contract, if and only if it is governed by the bank or to be under its umbrella. (Law No. 194 Egyptian Parliament, 2020)

The central bank assured the prohibit of dealing with cryptocurrencies and consequently smart contracts in several warnings and press releases published in the media and in the official newspaper

5. Opportunities and Benefits of utilizing smart contracts in the Egyptian system

There are several befits of including smart contracts and distributed ledger technologies for the Egyptian business environment over the current centralized ledger that can be summarized in:

Security: In a conventional system, there is what is called the central administrator which is considered a "single point of attack" from security point of view: upon this administrator is hacked, then the hacker can gain control of the ledger and tamper with its data. While, in a smart contract model with decentralized ledger maintained by consensus, there is no single point of attack. The ledger is the collective responsibility of the nodes or miners, which makes it more difficult for a hacker to infiltrate and tamper with the ledger. With the increase of numbers of nodes or miners CPUs the attack of the ledger tends to be impossible practically.

Immutability: The data in the ledger can't be changed that is said to be "immutable". The immutability of the ledger gives trust and confidence.

Efficiency: in a centralized ledger, Inconsistencies may arise between the central ledger and the participants' copies, which require reconciliation. While in smart contract model of decentralized ledger, each participant's copy of the ledger is automatically updated as data is added and no need for data reconciliation. which increases speed and reduces the cost of transactions. (Law Commission, 2020)

Enhanced workflow efficiencies: There is no single point of failure such as the centralized ledger or database.

Greater transparency: Any member can check the ledger and review it at any time without administrator permission.

Automated lifecycle management: The whole lifecycle is automated on the level of payment and the whole contract execution.

New forms of custody and diversity: Business community always prefer to have diversity in the forms of payment and the forms of contracts, smart contract is an addition to the existing forms of contracts currently exist in the Egyptian Business community

Speed: Not only having a whole decentralized electronic process provide faster process but also minimizing intermediates and human intervention in any business agreement gives it very speedy nature. (Jason G. Allen, Michel Rauchs, Apolline Blandin, Keith Bear, 2020)

6. **Valid cases,**

The following are examples that can be done via smart contracts or the existing system can be replaced or being analogous in the current Egyptian business arena and international trade

Ecommerce for retail goods:
As the most famous example of accepting bitcoin as a mean of payment which is Tesla automobile, many other online commerce sites provide cryptocurrency means of payment for any goods that can be sold online. These mechanisms can be transferred in a very simple and direct way to a form of smart contract. In Egypt the ecommerce is acquiring momentum day after day and people can order many online products including retail products and even food delivery can go in the same form (Tuwiner, Jordan, 2021)

Maritime Industry, Shipping, International trade and documentary credit:
Maersk and IBM developed a blockchain TradeLens which is a supply chain system in 2017, it is a very wide digital shipping network one of its members is port of Rotterdam, and many other key players who joined this smart shipping network. Many banks joined TradeLens started with Standard Chartered. Reduction of cost and complexity of trading are examples of the benefits as stated by IBM, this is to track and manage the paper trail of huge number of containers which can be accessed by all key players and stakeholders. (TradeLens, 2021)

Smart contracts can be used in various stages starting from opening the credit on the bank and send it to the beneficiary until payment, which will provide speed and security to the transaction. This even currently simpler with increasing list of banks who are utilizing blockchain, cryptocurrencies, and smart contracts (Emad Mohammad Al Amaren, Che Thalbi Md Ismail, Mohd Zakhiri Md Nor, 2020)
In shipping industry tracking shipments in real time is available and affordable via blockchain, all paper documents literally can be replaced by smart contracts, and less centralized logistics is achievable. (Marija Jovi´c, Edvard Tijan, Dražen Žgalji´c, Saša Aksentijevi´c, 2020)

Other Examples:
Trade Finance: An exchange between two parties can be managed by smart contract via tracking the location of goods, then payment will take place upon one party receive shipment.

Insurance: A template of code can be used to include all conditions of insurance between the insurance company and insured entity.

Digital rights: Documents, images, music, videos, and other software can be included and notarized on the blockchain, then payment will take place upon the distribution of the digital material to the end users (Everestgrp, 2021)

Issues, Controversies, Problems

There are many issues concerned with the cryptocurrencies and blockchain technologies that need to be summarized and to check its relation to smart contracts.

1. **Intrinsic value for common crypto currencies:**

The cryptocurrency is the mean of payment in almost all cases, and finding a smart contract without cryptocurrency might goes to unlogic and misleading concept. Along history Lots of things have been used as medium of exchange in markets including, for example, livestock and sacks of cereal grain and even mobile phone minutes in some cases – which have intrinsic value or usefulness in utilization, but also sometimes merely attractive items such as cowry shells or beads were exchanged for more useful commodities. Expensive, rare, and noble metals, from which early currency were made, fall into both categories.

Gold and silver were the most common metals used to form money throughout history. In natural languages, especially the Indo-European family, the word for silver is still a direct translation to the word for money.

Along history of commerce and never before something is traded without knowing its intrinsic value. The extreme example of things that was used are flowers which has its remarkable beauty to express the intrinsic value. "To be successful, money must be both a medium of exchange and a reasonably stable store of value. And it remains completely unclear why Bitcoin should be a stable store of value" (Krugman, Paul, 2013) . Crypto currencies always fail to answer this question. In fact the intrinsic value of the Bitcoin is the amount of security the Bitcoin has which can be expressed in the amount of validation for the hyper ledger done by the miners.

In fact, Bitcoin price to the United States Dollar for example can be considered as the intrinsic value of Bitcoin itself as believed or concluded by many people. Simply Bitcoin's only intrinsic value is its price.

This radical Libertarian context for Bitcoin, has led many of the cryptocurrency's fans down a rathole of confusion. This is because this group "The Libertarian" believes that money has to be backed by some physical asset, and so many of this group "The Libertarian" want to dissolve the Federal Reserve ore even all central banks and return to the gold.

In addition, people are risk averse and they do not like gambling in general. They are attracted to bit coin because of what is behind it like hyper ledger and block chain technologies which facilitate very low cost, very fast transactions, decentralization, and its illusion of transparency and out of governmental control. They hate to deal with a medium that has no intrinsic value, which will certainly lead to a collapse at any time.

2. Volatility and Instability

No doubt that bitcoin is extremely volatile and instable from the first glance of looking at any cryptocurrency price trend. For example, Bitcoin is the very first cryptocurrency, which is not very stable. "That is why, at this stage, it is difficult to imagine Bitcoin as a payment alternative to existing currencies, but this asset can be used as an investment object". (Mikhaylov, Alexey, 2020)

There are some offerings in the cryptocurrency market which can be considered as a solution for this problem such as stable coins which is cryptocurrencies with values tied to fiat currencies or other assets. But while most stable coins offer limited financial and monetary stability risk, the advent of global stable coins raises much larger issues and concerns, such as governmental approval, and being not common cryptocurrency in the digital assets market. (Douglas Arner, Raphael Auer, Jon Frost, 2020)

3. Legal Capacity and Will

Although the elements of the natural language contract can be satisfied by smart contract, these elements can be summarized in the Egyptian system as consent "offer and acceptance", determinable object of the obligation, and existing and lawful cause of the obligation . There still be the validity conditions of the contract which are capacity and will. The validity of the contract depends on first of which is that both parties have the capacity to conclude the contract that has been compromised. As for performance eligibility, it means the person's ability to dispose of his money, that is, his power to perform legal acts. The eligibility of performance is linked to the human ability to distinguish, this ability differs from one person to another, and this is due either to young age or to being affected by the symptoms of eligibility, such as insanity, dementia, foolishness and negligence.

The Egyptian law also considered the defect of will which may lead to relative voidness of the contract. The defect of will can be summarized in Mistake, fraud, coercion, and exploitation which can be defined as a defect in the will of the contractor arising from some factors accompanying the conclusion of the contract that violate the validity of his choice, had it not been for their influence on himself, he would not have proceeded with the contract. (Elsanhoury, Abdelrazak, 2007)

The process of claiming the defect of will in a contract depends mainly on litigation process, which is not present in the smart contract mechanism that is replacing any intermediate by the consensus mechanism.

4. Anonymous identification

In smart contract, the parties in some cases may not know each other's real identities, the identity of each party is determined by a public key. It might be an entire natural language contract or a hybrid contract comprising natural language and coded terms, the identity of the parties is likely to be apparent from the natural language contract or as a result of emails or face to face conversations when negotiating the natural language terms. When the parties have entered into a smart contract solely by deploying or interacting with code on a distributed ledger, without any natural language negotiations, the identity of the contracting parties may not be known.

In a permissionless Distributed Ledger system, users need not disclose their identities in order to engage in transactions. As an example, in Bitcoin and Ethereum blockchains, each

user account has a public address from which the user can initiate transactions using their private key. While the public address linked to a particular transaction is known, the identity of the user linked to that public address is unknown. In fact, the user is not wholly anonymous, because the transactions they initiate are recorded on a public ledger and analysis of those transactions may enable the user to be identified. Accordingly, users of permissionless DLT systems are said to be 'pseudonymous': transacting under a pseudonym makes the user difficult, but not impossible, to identify. (Law Commission, 2020)

In Egyptian system the contracting parties to know each other's real identities which makes this feature in smart contract is a real barrier.

5. Role of jurisdiction and intermediates

While the Egyptian system did not approve smart contracts yet but it is pending upon approval from the central bank of Egypt. If that ever happen the two previous points will still be barriers to implement and deal with smart contracts for being legally binding business instrument. The jurisdiction process can be included as a part or clause in the code of smart contract upon the legal system requirements and the acceptance of the parties.

In principle, an agreement reached between pseudonymous parties on a permissionless Distributed Ledger system could amount to a legally binding contract. However, as a practical matter, it may be difficult for a party to that contract to obtain a remedy against the other party if the identity of the other party is unknown. It may be necessary to prove the identity of the other party by extrinsic evidence. The pseudonymity of the parties may also make it more difficult to establish that a court has jurisdiction to hear a dispute arising under the contract. It could also pose challenges in transactions where the identity of the parties is important, for example, transactions to which "know your customer" requirements apply. This pseudonymity will also play a barrier in determining capacity and will of the contracting party. (Law Commission, 2020) (SHERBORNE, ANDREAS, 2017)

6. Invalid cases

In general, most of natural language contracts could be transformed into smart contracts. Cases that require exercise of discretion will not be suitable to be translated into lines of code which is a smart contract. (Law Commission, 2020)

We have to reassure that the smart contracts can replace civil commercial contracts or to provide hybrid form from both natural language contract and smart contract.

In some cases we refer to agreements by contract such as marriage contract which is an example of impossible smart contract, another example is the adoption contract which might be impossible to be converted into lines of code, or Distributed Ledger transaction on the blockchain, this is literally stated in the definition of contract that is not every convention that has a legal impact, but this convention has to be in the framework of private law and in the area of financial transaction. (Elsanhoury, Abdelrazak, 2007)

CONCLUSION

The hypothesis of this research is the validity of utilizing the smart contracts and its associated technologies such as distributed ledger, block chain and cryptocurrencies.
Regularly the hypothesis testing takes place quantitatively, qualitatively or both, according to the legal nature of the research the qualitative aspect is considered without the quantitative.
As discussed in this paper, it is clear that including smart contracts in the Egyptian business environment provides lots of benefits such as Security, Immutability, Enhanced workflow efficiencies, Greater transparency, Automated lifecycle management, new forms of custody and diversity, and Speed. Taking into consideration that the Egyptian law does not completely prohibit the cryptocurrency and its related products and derivatives such as smart contracts, but it permits it under certain conditions which is the approval of the central bank of Egypt in summary. The smart contract should be limited in the beginning around the financial transactions or some fields such as maritime transport operations only which mandates that the central bank should create its own cryptocurrency and even a blockchain. The proposed framework should be permissioned distributed ledger, and identity of the both miners and users must be declared and well known by the system, the system should include a stable coin tied with the Egyptian currency. That will allow the fulfillment of the elements and conditions for the natural language contracts in the Egyptian legal system and availability of the jurisdiction process and dispute resolution.

Acknowledgement
The author would like to express the appreciation for the Arab Academy for Science and Technology AAST, *International Transport and Logistics Institute ITLI, and The MARLOG conference for the opportunity to present this work.*

References

Al-Asqalani, Ibn Hajar. (n.d.). *Nuzhah al-Nathar*. Damam: Dar Ibn al-Jawzi.
Blockchain for Science. (2021, 03 31). *List of all blockchain for science projects - Blockchain for Science*. Retrieved from Home - Blockchain for Science: https://www.blockchainforscience.com/2018/04/11/list-blockchain-science-projects/
Cassation Appeal No. 17051 for Year 87, 17051 for Year 87 (Cassation Court of Egypt 03 28, 2019).
Coindesk.com. (2021, 03 31). *Bitcoin Price | BTC Price Index and Live Chart — CoinDesk 20*. Retrieved from CoinDesk: Bitcoin, Ethereum, Crypto News and Price Data: https://www.coindesk.com/price/bitcoin
David Rutter, Sean Murphy. (2016, 11). Can smart contracts be legally binding contracts? *An R3 and Norton Rose Fulbright White Paper*. London, United Kingdom: Norton Rose Fulbright LLP.
Douglas Arner, Raphael Auer, Jon Frost. (2020, 12). Stablecoins: risks, potential and regulation. *BIS Working Papers - Bank of International Settlement*. Basel, Switzerland: Bank for

International Settlements.

Elsanhoury, Abdelrazak. (2007). *The Mediator in explaining Civil Law.* Cairo: Lawyers Syndicate.

Emad Mohammad Al Amaren, Che Thalbi Md Ismail, Mohd Zakhiri Md Nor. (2020). The Blockchain Revolution: A Game-Changing in Letter of Credit (L/C)? *International Journal of Advanced Science and Technology*, 6052 - 6058.

EUROPA. (2021, 03 31). *About Blockchain Based Notary Proof Of Concept | Joinup*. Retrieved from EUROPA - European Union website, the official EU website: https://joinup.ec.europa.eu/collection/blockchain-egov-services/solution/blockchain-based-notary-proof-concept/about

Everestgrp. (2021, 6 3). *Smart Contracts Use Cases | Market Insights™ - Everest Group*. Retrieved from Everest Group | A Leading Global Research Firm: https://www.everestgrp.com/2016-10-smart-contracts-use-cases-market-insights-36265.html/

Grønbæk, Martin von Haller. (2016, 06 08). Blockchain 2.0, smart contracts and challenges. *Bird&Bird*. Copenhagen, Denmark: Bird&Bird.

Hassan, Samer; De Filippi, Primavera. (2016). Blockchain Technology as a Regulatory Technology From Code is Law to Law is Code. University of Illinois.

Jason G. Allen, Michel Rauchs, Apolline Blandin, Keith Bear. (2020). LEGAL AND REGULATORY CONSIDERATIONS FOR DIGITAL ASSETS. London, United Kingdom: Cambridge Centre for Alternative Finance, University of Cambridge Judge Business School.

Krugman, Paul. (2013, 12 28). *Economics and Politics by Paul Krugman - The Conscience of a Liberal - The New York Times*. Retrieved from The New York Times - Breaking News, US News, World News and Videos: https://krugman.blogs.nytimes.com/2013/12/28/bitcoin-is-evil/

Law Commission. (2020, 12). Smart contracts Call for evidence. *Smart Contracts*. London, United Kingdom: Crown.

Law No. 131 Egyptian Parliament. (1948). Civil Law. Cairo, Egypt: Egyptian Government.

Law No. 15 Egyptian Parliament. (2004). Electronic Signature Law. Cairo, Egypt: Egyptian Govenment.

Law No. 17 Egyptian Parliament. (1999). Commercial Law. Cairo, Egypt: Egyptian Govenment.

Law No. 194 Egyptian Parliament. (2020). Law of Central Bank. Cairo, Egypt: Government of Egypt.

Marija Jovi´c, Edvard Tijan, Dražen Žgalji´c, Saša Aksentijevi´c. (2020, 10 26). Improving Maritime Transport Sustainability Using Blockchain-Based Information Exchange. *Sustainability Journal*. Basel, Switzerland: MDPI.

Mikhaylov, Alexey. (2020). Cryptocurrency Market Analysis from the Open Innovation Perspective. *Journal of Open Innovation: Technology, Market, and Complexity*.

SHERBORNE, ANDREAS. (2017, 12). BLOCKCHAIN, SMART CONTRACTS AND LAWYERS. London, United Kingdom: International Bar Association.

TradeLens. (2021, 6 3). *About TradeLens | TradeLens*. Retrieved from TradeLens | Digitizing

Global Supply Chains: https://www.tradelens.com/about
Tuwiner, Jordan. (2021, 03 09). *9 Major Companies Who Accept Bitcoin (Spend Bitcoin 2021)*. Retrieved from Buy Bitcoin Online: 9+ Best Trusted Sites (2021): https://www.buybitcoinworldwide.com/who-accepts-bitcoin/

Exploring The Impact Of Utilizing Iso 21001:2018 To Optimize The Quality Management Of Maritime Education And Training (Met)

Hossam Eldin Hassan Gadalla
Head of Quality Management and Int. Accreditation Unit
Maritime Safety Institute
Arab Academy for Science, Technology & Maritime Transport
Abuqir, Alexandria, P.O. Box 1029, Egypt
hossam.gadalla@aast.edu

ABSTRACT:

Quality of Maritime Education and Training (MET) is growing in importance due to the rapid integration of new educational aids, advanced communication methods, and innovative teaching methodologies. As required by the STCW Convention, MET process should be monitored through a quality management system standard. For this purpose, ISO 9001 is one among a set of management tools that educational institutions have commonly utilized. However, there is a major argument against the standard based on the assumption that academic processes cannot be equated to industrial processes. In 2018, ISO 21001 was established to assist educational organizations in their quality improvement mission. In this manner, this study aims to explore the potential impact of incorporating ISO 21001 into the MET system. The Qualitative analysis is used to compare the two standards in terms of their foundational concepts including structures, main principles, clauses, and terminologies in order to assess whether ISO 21001 is more appropriate for ensuring the optimum management of MET rather than the commonly used standard ISO 9001. Giving the findings of this study, it's concluded that although both standards are formulated in similar structures, ISO 21001 provides a more extensive and broader scope that can benefit MET institutions in building a more impactful and innovative management system.

Keywords: MET, Institutions, STCW, Quality, Management, ISO.

1 INTRODUCTION:

The quality management of Maritime Education and Training (MET) is growing in importance due to the rapid integration of new educational aids, advanced communication methods, and innovative teaching methodologies that can contribute to the development of future professions capable of coping with the maritime industry digitization era. Educational institutions are expected to maintain a constant degree of adaptability to continuously develop new approaches to address society's problems and collaborate with the private sector and research institutes to search out the solutions (Zapata-Garcia, Llaurado, & Rauret, 2007). Distance education, for instance, has become progressively important particularly since the outbreak of the Covid-19 pandemic which has reformed the methods by which learners around the world obtain their education (Clare, N., 2020). MET institutions are thereby facing various additional challenges in maintaining the sustainable improvement of their quality system to keep abreast with the global transformation of education involving innovation-engaged education modalities which, as indicated by Aminudin, Z. et al, (2020), may require much more elevated levels of quality management compared to the traditional classroom education methods.

The International Maritime Organization (IMO), through its revised Convention on Standards of Training, Certification, and Watchkeeping for Seafarers 1978 (STCW), has tackled the value of quality control of MET by adopting requirements to mandate the administration, supervision, and monitoring of the training, assessment, certification of seafarers' competencies through a quality standard system. Furthermore, the IMO demands that this process be subjected to an independent evaluation conducted periodically by independent reviewers (IMO, 2010). Hence, to comply with the IMO instruments, MET institutions ought to be certified by an authorized professional or governmental authority to confirm a continued high level of MET quality is maintained.

For this purpose, ISO 9001 is one among a set of management tools that educational institutions have commonly utilized since the release of its initial version in 1987 and through its subsequent modified versions published in 1994, 2000, 2008, and 2015 respectively (Bao, J. et al, 2021). Each revised version entailed an increase in the scope and coverage of the standard (ASQ, 2020). Such continuous improvement made it one of the premier utilized standards that contributed to improving the quality of products while decreasing the cost of production (Mangula, 2010). The fact that ISO 9001 provides a set of generic requirements regardless of the nature of the organization's activities made it also an exceptional standard for implementing a quality management system (Rebelo, M., Santos, G., & Silva, R., 2014).

In terms of educational institutions, its application has gotten a lot of significant traction over the years, and there's an increasing body of literature on its utilization within this sector (Chiarini, 2015). As indicated by Sari, Y. et al, (2017) the model of quality assurance system within a significant number of maritime institutions is viable with the international standard for quality management system ISO 9001:2015. In general, the standard has been utilized by enormous educational organizations to demonstrate their capacity for consistently providing products and services that meet their customers' needs and comply with regulatory requirements (Jingura, R. et al, 2020).

However, from an alternate perspective, there has been a major argument against its application within the education sector based on the assumption that academic processes cannot be equated to industrial processes. For example, Becket and Brooks, (2008) early uncovered that the quality management models used for manufacturing and service industries such as ISO 9001 may not recognize the centrality of student learning in higher education. Furthermore, distinguishing the customers of educational institutions is a critical issue that may lead to terminology confusion; around there, various scholars attempted to propose common definitions such as students, companies, government, and community to recognize customers in the educational field (Zabadi A. M., 2013). Nassif, S. et al, (2017), reveal that education has its own unique set of quality requirements, hence when applying ISO 9001 to MET; certain inadequacies may arise as a result of the contrast between the production sector and the nature of the educational

sector. As demonstrated by Neidermeier, (2017), although ISO 9001 has been considered acceptable within the service function of education, yet the relation between teaching and learning cannot be regarded as a relationship between a business provider and a consumer. This was agreed by Naveed et al, (2021), who clarified that ISO 9001:2015 is designed to manage tangible items and products, while education deals with service that focuses on communication and interaction rather than tangible items, in

which case, the "production realization" is no longer applicable due to the complicated nature of the human relationships involved in the academic settings.

Since the establishment of the International Organization for Standardization (ISO) in 1947 as an independent organization tasked with developing standards for products and services to ensure their safety, reliability, and quality; ISO has published a massive body of international standards covering almost all aspects of business and technology (ISO, 2021a). As per ISO, the goal of quality management is to empower the organization for producing products or providing services at a certain level of quality. In May 2018, ISO released its new standard ISO 21001(EOMS) which specifies requirements for a standardized management system, specifically made for educational organizations to assist in their quality improvement mission. The standard has been developed by a group of 86 cross-sectoral experts from 39 national standardization bodies with the assistance of various stakeholders (ISO, 2021b). On the other hand, as pointed out by Anttila & Jussila, (2018), the new ISO 21001(EOMS) can support educational institutions to improve the effectiveness of their quality management system since it requires the adoption of more than just general basic quality concepts, structures, and practices.

When considering the quality-related concerns posed by researchers, an inquiry comes to mind regarding the extent and suitability of ISO 9001when applied to educational institutions. In view of these concerns, the author of this study proposes that ISO 21001 might preferably contribute to achieving a solid management system that would animate development and ultimately drives the production of a quality-assured MET rather than the currently utilized ISO 9001.

To support the theme of this proposal, qualitative analysis is utilized in comparing the two standards for understanding which standard has more depth and suitability to higher education. In this manner, the main contribution of this research study is to support the MET institutions currently utilizing ISO 9001 in determining whether to continue its implementation or to covert to ISO 21001 for ensuring effective and innovative management of their MET system.

For a systematic research plan for the study, the author seeks to firstly compare the foundational concepts of both standards including their structures and main principles, then comparing the contents of both standard's main clauses and their corresponding sub-clauses to subjectively assess the extent of each standard's requirements, and finally demonstrating new aspects presented in ISO 21001 including its innovative requirements and terminology to highlight the standard's potential advantages and appropriateness for implementation in MET institutions.

2 THE FOUNDATIONAL CONCEPTS:

As per Gilbert Douglas, (2020), the foundational concepts of both ISO 9001:2015 and ISO 2100:2018 can be seen, for the most part, interacting with several similarities.

The General Structure:

Both standards, in terms of general structure, conform to ISO requirements for management system standards, which use a harmonized High-Level Structure. following ISO directives, identical core definitions, and a similar core text for allowing organizations to apply multiple ISO management systems standards without creating any conflict. The concept of High-Level Structure, according to ISO, (2021c) is that all ISO management system standards consist of (10) key clauses that have to be organized in the same manner, regardless of the application domain. Table (1) demonstrates the ISO harmonized High-

Level Structure, where each key clause is represented by its number, description, and purpose, as identically described in both standards.

Table 1. The harmonized High-Level Structure of ISO standards

No	Clause	Purpose
1.	Scope	Administrative Clauses
2.	Normative References	
3.	Terms and Definitions	
4.	Organization Context	Helps the Institution to determine internal and external issues
5.	Leadership	Provides the quality policy which sets the quality objectives
6.	Planning	Leads to the constructive alignment of quality objectives with actions
7.	Support	Facilitates allocation of resources and development of staff competencies
8.	Operation	Sets parameters for processes and products, enabling staff to be guided
9.	Performance Evaluation	Ensures there are mechanisms for performance evaluation
10.	Improvement	Helps to identify cases for improvement and Leads to continuous improvement

Source: (ISO, 2021c)

The Key Principles:

ISO 21001 introduces EOMS as an operating system model for educational organizations based on a foundational concept of using processes to characterize the key aspects of an organization without requiring a particular process approach. This concept allows ISO 21001 to keep the benefits of ISO 9001 while significantly improving the standard extent to meet the specificities of the educational sector (Sickinger Nagorni, R., and Schwanke, J., 2016). Table (2) demonstrates a comparison of both standards' principles, where each standard is based on a group of principles that specify its overall general management approach.

Table 2. Key Principles of ISO 9001 and ISO 21001

No	Principles of ISO 9001:2015 (QMS)	Principles of ISO 21001:2018 (EOMS)
1	Customer Focus	Focus on Learners and other Beneficiaries
2	Leadership	Visionary Leadership
3	Engagement Of People	Engagement of People
4	Process Approach	Process Approach
5	Improvement	Improvement
6	Evidence-Based Decision Making	Evidence-Based Decision Making
7	Relationship Management	Relationship Management
8	N.A	Social Responsibility
9	N.A	Accessibility and Equity
10	N.A	Ethical Conduct in Education
11	N.A	Data Security and Protection

Source: ISO, 2015 / ISO, 2018

While ISO 9001 (QMS) is based on (7) principles (ISO, 2015), that according to Jingura, R. & Kamusoko, R. & Tapera, J., (2020), can provide a sound basis for general approaches to deal with quality assurance within any organization, ISO 21001 (EOMS), on the other hand, declares (11) management principles (ISO, 2018). A critical contrast can be distinguished in the first principle where "customer focus" in ISO 9001 was substituted by "Focus on learners and other beneficiaries" as the term "customer" is no longer applicable to any principle of ISO 21001. In the second principle, the EOMS declares the visionary leadership that embraces a holistic view of education by defining the services offered by an educational organization to support the development of learners' competence, instead of the transmission of knowledge.

According to the United Nations, Educational, Scientific and Cultural Organization (UNESCO) (2018), education has several stakeholders who should be satisfied with educational outcomes, thus focusing on customer satisfaction including learner and industry are essential quality metrics for improving both the education quality and the graduates' employability.

For this reason, while ISO 9001:2015 focuses on customer satisfaction, ISO 21001:2018 represents a fundamental shift, reflecting the goal of meeting the needs of every learner, as well as every other stakeholder such as governments, labor markets, parents, and guardians, while recognizing that learners' active engagement in their learning process. Furthermore, ISO 21001 introduces four new principles; the obligation for educational institutions to consider the impact of their activities on the economy, society, and the environment referred to as "Social Responsibility", the equitable access to services for a wide range of individuals while fostering lifelong learning opportunities for everyone "Accessibility and Equity", and to perform all activities with integrity and professionalism described as "Ethical Responsibility", while eventually ensuring the security and adequate protection of the learners' data, referred to as "Data security and protection".

The EOMS Perspective Based on "PDCA" Cycle

As indicated by ISO, (2018), ISO 21001 has two key areas; an overarching model named EOMS, and a center design based on the PDCA improvement cycle as described per the following:

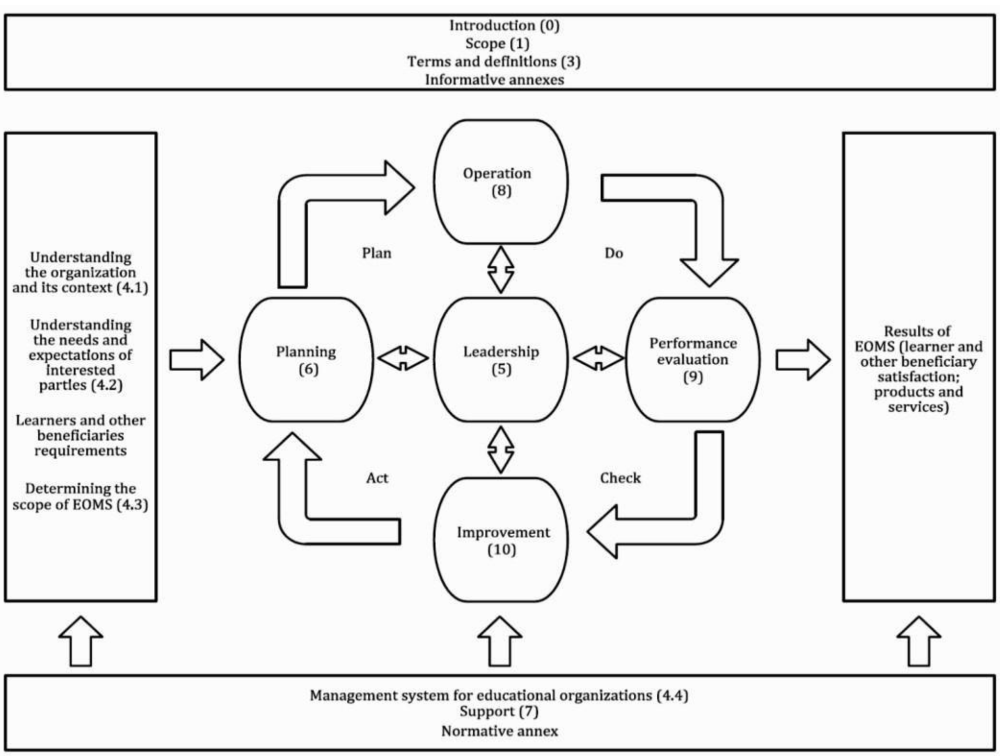
- Letter "P" refers to **Plan** the objectives, processes, needed resources based on the organization's policies and learners'/beneficiaries' requirements while addressing the risks and opportunities.

- Letter "D" refers to **Do** what was planned.

- Letter "C" refers to **Check** the results against the policies, objectives, and planned activities.
- Letter "A" refers to **Act** necessary actions to improve the performance.

Figure (1) depicts the relationship of the PDCA cycle and EOMS with various standard clauses. It can be observed that the PDCA is a four-step model to improve a process or carrying out a change that ought to be repeated again and again for persistent improvement similar to a cycle going on forever. By assembling clauses 4 to 10 with the PDCA cycle, ISO 21001, thusly, provides a valuable interactive quality improvement tool, that guarantees improvement is not at this point managed as a separate activity but is incorporated into the overall work process as a consistent cycle. Based on the comparison, it can be stated that the foundation concepts of ISO 21001 are providing a wider and more extensive scope of management, which can greatly contribute to a far elevated level of consistency and efficiency of the process being explicitly tailed for educational institutions.

Figure 1. The "PDCA" cycle in ISO 21001 EOMS framework



Source: (ISO, 2018)

It can be observed that the PDCA is a four-step model to improve a process or carrying out a change that ought to be repeated again and again for persistent improvement similar to a cycle going on forever. By assembling clauses 4 to 10 with the PDCA cycle, ISO 21001, thusly, provides a valuable interactive quality improvement tool, that guarantees improvement is not at this point managed as a separate activity but is incorporated into the overall work process as a consistent cycle. Based on the comparison, it can be stated that the foundation concepts of ISO 21001 are providing a wider and more extensive scope of management, which can greatly contribute to a far elevated level of consistency and efficiency of the process being explicitly tailed for educational institutions.

3 THE CLAUSE-COMPARISON OF ISO 21001:2018 & ISO 9001:2015

While clauses from (1) to (3) are considered administrative and regulatory statements that are identically introduced in both standards, the distinction can be seen when analyzing clauses from (4) to (10) which define the basic criteria and framework for ensuring and improving quality.

Clause (4): Context of the Organization:

This fundamental clause is divided into three sub-clauses which refer to the context of the organization and ensure there is full comprehension of the stakeholders' expectations and needs. Whereas the scopes of both clauses are similar, ISO 21001 provides an additional concise illustration of the learners and the interested parties as well as a more comprehensive definition for the other stakeholders as the following;

- Students, Pupils, and Apprentices are referred to as examples of "Learners".
- The governments, Labor markets, Parents, and Guardians are considered "Interested parties".
- Employees and Volunteers are presented as examples of "Staff".
- Educational Organizations, Media, Society, External Providers, Shareholders, Commercial Partners, and Alumni are pointed at as "Other stakeholders".

Clause (5): Leadership:

Both ISO 9001 and ISO 21001 place an equal emphasis on leadership, employees' engagement, process approach, continuous improvement, and relationship management. However, a distinguished contrast within the "Leadership" clause is observed where ISO 21001 introduces the expressions "learners" and "other beneficiaries" instead of the term "customer" which was heavily used in ISO 9001.

Since understanding who the customers are in educational institutions is vital for strategic planning, the sub-clause of leadership in ISO 21001 is extended to incorporate provisions for the special needs of learners, which can be viewed as a significant contribution accredited to ISO 21001. Moreover, the sub-clause for policy development is likewise more broad with the inclusion of the organization's social responsibility, and the intellectual property being considered, which are raised with a more extensive scope on addressing the organizational functions, obligations, and authorities.

Clause (6): Planning:

No difference could be observed between both standards in respect to the planning clause. Both the QMS and the EOMS as defined by ISO 9001 and ISO 21001 respectively, provide similar extensions to the issues of planning for changes, risks, and opportunities. Since risk management and planning for achieving the organization's quality objectives are vital key issues that typically act as an entrance to the entire management system, the two standards are declaring the same expanded scope.

Clause (7): Support:

When comparing the support clauses, it can be perceived how ISO 21001 has gone furthermore explicit by including nine sub-clauses for both the involvement and satisfaction of learners and staff. Specific provisions concerning the appropriate facilities for teaching and learning activities are also stated with a more comprehensive sub-clause, that defines types of infrastructure for educational institutions Moreover, additional notes are provided to indicate requirements for the online educational activities which haven't been controlled in ISO 9001. The organization's knowledge sub-clause is also expanded in ISO 21001 for identifying learning resources such as planned review, cataloging, referencing, and intellectual property requirements. Moreover, two sub-clauses for competence general requirements and special needs education are introduced, with a strong emphasis on staff performance improvement.

In contrast to the general requirements for customers presented in ISO 9001, the communication sub-clause in ISO 21001 provides additional value as customers are more actively involved in the process of service with more intensive communication between the learners and the institution. Eventually, although the sub-clause for documented information has the same framework in both standards, ISO 21001 provides additional examples which don't exist in any non-educational organizations such as "curriculum", "academic calendar", "course-catalog", "grades", "scoring", "evaluation", and "code of ethics". The sub-clause is also extended to incorporate requirements for data protection and security, confidentiality, and prevention of unintended use of obsolete documents.

Clause (8): Operation:

In comparison to ISO 9001, It tends to be seen that operation clause is furtherly expanded in ISO 21001 to accommodate educational institutions by addressing the specifications for teaching methodologies, learning environments, assessment criteria, improvement methods, and support services. Additionally, two lower level sub-clauses have been added to the sub-clause of operational planning and control; the first is to determine the criteria for special-needs education, while the second frameworks the precise operational planning and control in the design, development, and expected outcomes. For improved consistency, the clause in ISO 21001 also describes, in more detail, how requirements for the educational products and services are communicated, with a strong emphasis on the establishment of clear methods for collecting, accessing, storing, protecting, and exchanging the learners' data.

Clause (9): Performance Evaluation:

When comparing the two clauses, it can be seen that while ISO 9001 demonstrates a general performance evaluation to meet customer requirements, ISO 21001 points at the satisfaction of learners, other beneficiaries, and staff with additional sub-clauses that place a strong emphasis on how the complaints and appeals are handled, recorded, and appropriately informed to interested parties. Similarly, the sub-clause of management review in ISO 21001 is expanded to incorporate inputs such as formative and summative assessment results and staff reviews.

Clause (10): Improvemen:.

While the conditions of this clause are the same in both standards, the serial of attached sub-clauses has been re-arranged with sub-clauses 10.1, 10.2, and 10.3 in ISO 9001 being replaced with 10.3, 10.1, and 10.2 in ISO 21001, respectively. The goal is to emphasize the logical impotence of improvement initiatives, whereby corrective actions should be implemented promptly when a non-conformity arises, followed by continual improvement and further recognition of improvement opportunities.

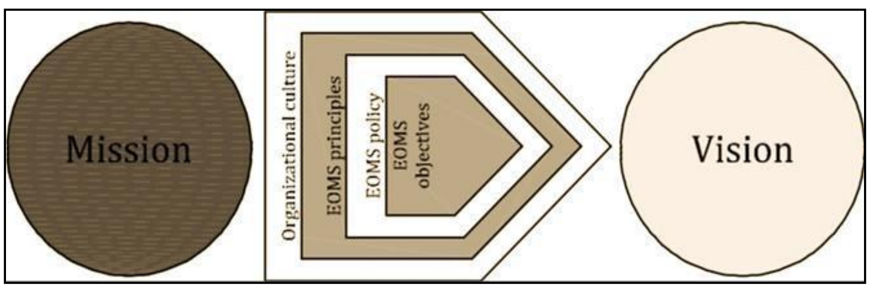
4 KEY ADVANTAGES AND INNOVATIONS OF ISO 21001:

Various key advantages and innovations could be accredited to ISO 21001 in ensuring greater alignment to the educational institutions' goals and action plans, for providing a better-customized experience to learners, with consistent processes and evaluation tools to improve performance.

Quality Assurance Aligned with Organization Mission, Vision, And Strategy:

According to the International Network of Quality Assurance Agencies in Higher Education (INQAAHE), (2018), the Internal Quality Assurance (IQA) process is described as "The process used by an institution, supported by policies and systems, to sustain and improve the quality of education experienced by students, and research conducted by staff". According to Cardoso et al., (2018), IQA should be carried out with a strong sense of engagement and commitment by all staff, which relies on the staff's feeling of ownership inspired by their participation in implementation. Figure (2) illustrates how EOMS policy is outlined by both the organization's culture which represents the entire set of beliefs and values that form the organization's behavior, and the EOMS core principles, to enable, on account of the organization's staff, the sharing, and accomplishment of the EMOS objectives.

Figure 2. EOMS framework related to Mission and Vision



Source: (ISO, 2018)

Thusly, the EOMS policy statements provide the framework for defining the EOMS objectives, which should be regularly revised to ensure that the organization's mission is effectively accomplished while on the continuous path to the organization's vision (ISO, 2018).

: Newly Introduced Terminology (Educational Terms and Phrases):

An in-depth examination of the terminologies used in both standards reveals that the scope of each is vastly different. The language used in ISO 9001 is more applicable to business ventures, manufacturing sectors, and service companies since it is intended to be practical for the application of any form of company (Khachfe, H. et al, 2017). This may prompt some level of misunderstanding and confusion, for example, the expressions "customer" and "stakeholders" utilized in ISO 9001 can be interchangeable when used within the context of the education process. Although students can be recognized, from one perspective, as the customers of educational institutions, another perspective can point at industries such as owners, managers, and manning agencies as the actual customers of education since they employ the "product" of the educational institutions, and invest in the training of their employees, which gives them the right to assess the adequacy of the educational outcomes to ensure that their needs and expectations for the safe operation of their vessels are fulfilled. In this manner, ISO 21001 contains a set of phrases and clear expressions that are appropriate for use in educational institutions to prevent confusion with other stakeholders, for instance, the term "learner" is introduced instead of "customer", while other phrases such as "product" and "product design" are replaced with more appropriate educational terms like "courses" and "curriculum design".

Auditor's Improved Qualifications:

One significant advantage of ISO 2001 is that it represents a marked change in quality evaluating, in terms of necessitating more elevated prerequisites for auditor's qualification and experience. While ISO 9001 certification, only requires knowledge and experience related to auditing skills, ISO 21001, additionally requires expertly affirmed and professionally certified auditors, who come from a high education foundation and maintain knowledge and certification in the field (Coletto & De Monte, 2019).

Given the rapid changes occurring in higher education, this approach towards increased capabilities of reviewers with relevant education-based qualifications supports the argument that ISO 21001 seeks to resolve effective requirements for maritime educational institutions rather than ISO 9001. Moreover, with the combination of extensive monitoring audits, a further advantage of ISO 21001 in the professionalism and consistency of the quality management evaluation is provided.

Improved Management of Distance Learning:

Distance education, also known as 'Distance learning" or 'E-learning', has been existed for a long time, thanks to the introduction and development of distance education programs by several educational institutions as solutions for their growing educational needs. According to Gunduz M., Baykan O. K., & Yildiz F., (2007), it is a form of education in which students, educators, and teaching materials, from different geographies, are brought together through communication technology. Furthermore, as stated by Keles, Mumine K. & Ozel, S. A., (2016), the primary goal of distance education is to overcome the place and time barriers with video, audio, active learning, simulations, and electronic innovations being able to accommodate to a wide range of students with a variety of learning styles.

Lately, since the beginning of the Coronavirus (COVID 19) pandemic outbreak, distance learning has become a fundamental methodology for education and training (Huang et al., 2020). In the maritime industry, the European Maritime Safety Agency (EMSA), (2021) reports that seafarers had significant difficulty revalidating their certificates due to the restrictive crew-change policies suddenly enforced within countries that closed their borders and prohibited ships' crew from embarking and disembarking. In this case, distance learning was demonstrated to be a practical approach that meets the needs of learners by allowing seafarers to complete their training courses online while aboard their vessels, or in any remote geographical location. In a broader sense, the pandemic has constrained all higher education institutions to modernize and accelerate their progress toward becoming more technologically enhanced online institutions to reach a diverse range of learners (Huang et al., 2020).

Notwithstanding, monitoring the quality of distance learning outcomes can be a challenging task for educational institutions (Aminudin, Z. et al, 2020) since there are many faces of distance education including e-learning that is primarily delivered in an interactive environment like Computer-Based Training (CBT). Another type is Work-based learning that is based on the advancement of vocational learning and skills, through which students have the opportunity to apply their academic knowledge gained at university/college to the workplace. Self-directed learning is another type of learning in which students take charge of identifying their learning needs, formulating their learning objectives, and evaluating learning outcomes. Blended learning, also known as mixed learning, is another approach for delivering flexible future education that combines distance learning, e-learning, and work-based learning with traditional face-to-face university teaching and learning methods (Zhang, T. et al, 2020).

For this reason, the ISO technical committee (ISO.TC 232) released three additional guidelines in its work program, one of which outlines the specific criteria for distance learning activities outside of formal learning (ISO, 2021d). These additional requirements are intended to complement the current standard as the foundation for quality assurance and accreditation, which in this manner may create a more compelling case for the utilization of ISO 21001 in dealing with the conveyance of distance learning and ensuring an adequate quality of its outcomes.

Management Representatives and Ease of Implementation:

According to Mehfooz & Saeed L. (2015), top management support, along with the participation and dedication of all personnel, resources, education, and communication, are the primary factors that determine the ease of implementation of any management system. However, the management representatives in MET institutions responsible for quality assurance are often university staff like deans, professors, lecturers, instructors, and other academic faculty who are constantly over-burdened with educational and administrative duties. Even though performing multiple tasks is part of their daily work, it represents a difficult task for them to adapt their management system based on ISO 9001 to suit the mission and vision of their educational setting. An earlier study by Quinn, Lemay, Larsen, & Jahnson, (2009), on the implementation of ISO standards, concluded that academic and educational settings have proved to be the most difficult and challenging areas for ISO 9001 implementation, whereas better results were achieved in administrative and auxiliary service settings.

As a result, implementing a quality management standard that is tailored and developed specifically for teaching and learning activities is the most successful way to solve this issue. In this case, management representatives will not be required to take on additional duties to adjust their quality system to their educational perspective. In this sense, ISO 21001 differs from previous ISO management system standards in that it is not only for education but additionally includes annexes A to G which provide extensive guidance and information on ISO 21001 specifications and education-related principles. This would facilitate the implementation and make it easier for management representatives to put the plan into action. Furthermore, since ISO 21001 has a framework similar to ISO 9001 QMS, current MET management systems have an opportunity to incorporate ISO 21001 standards without having to rebuild their existing quality management systems, as specific modifications with no major changes can be made to the existing management system to achieve its full compliance with the standard criteria.

CONCLUSION:

In view of the comparison outcomes regarding the fundamental approaches to quality articulated in ISO 9001 and ISO 21001, in terms of basic structure, principles, and clauses; it can be recognized that ISO 21001: 2018 is furtherly appropriate for utilization in maritime educational institutes, as it offers a systematic and adequate approach towards managing the quality of MET. This can be attributed to several factors beginning with the PDCA cycle along with the framework for educational organizations (EOMS), which enables institutions to set up a management structure that leads to achieving the organization's mission and vision while maintaining adherence to the needs and desires of learners, industries, employees, and all other stakeholders. Furthermore, ISO 21001 provides a sufficiently applicable educational-based terminology that is more suitable for use in educational organizations, while the inclusion of innovative requirements like distance education demonstrates a noteworthy advantage that contributes to better consistent educational outcomes with regards to advanced communication and innovative teaching methodologies. Finally, the ISO 21001 auditing process, which must be carried out by a high level of reviewers with the appropriate specific educational qualifications ensures that the quality of MET is consistently monitored in a clearer and more reliable manner. Given these findings, this research study concludes that implementing ISO 21001: 2018 (EOMS) in maritime educational institutions would have a significant impact on improving the effectiveness of innovative MET management resulting in the promotion of customized educational services for learners and stakeholders.

RECOMMENDATIONS:

1- The study recommends the implementation of ISO 21001: 2018 (EOMS) in both administrative and academic processes within MET institutions for ensuring consistent and innovative MET management.

2- Further research into the implementation results of ISO 21001: 2018 (EOMS) is advised after a considerable period of its application within MET institutions to evaluate its outcomes in real practice.

REFERENCES:

American Society for Quality (ASQ), (2020). What is ISO 9001:2015 – Quality Management Systems? ASQ website: Quality Resources, ISO 9001. Accessed on 24th December 2020, from https://asq.org/quality-resources/iso-9001

Aminudin, Zuhairi. Maria Rowena, Del Rosario Raymundo. & Kamran, Mir. (2020). Asian Association of Open Universities Journal. Vol. 15 No. 3, 2020. PP. 297-320. Emerald Publishing Limited. e-ISSN: 2414-6994. p-ISSN: 1858-3431. DOI 10.1108/AAOUJ-05-2020-0034. Retrieved on 4th Jan 2021, from https://www.emerald.com/insight/content/doi/10.1108/AAOUJ-05-2020-0034/full/pdf

Anttila, J., & Jussila, K. (2018). Universities and Smart Cities: The Challenges to High Quality. Total Quality Management & Business Excellence, 29(9/10), 1058-1073. Accessed on 22nd Feb 2021, from https://doi.org/10.1080/14783363.2018.1486552

Bao, J., Li, Y., Duan, Z., Li, T., & Zhang, P. (2021). Key Factors Affecting the Quality of Maritime Education and Training: Empirical Evidence from China. Journal of Navigation, 1-13. DOI:10.1017/S0373463320000740

Becket, N., and Brookes, M. (2008). Quality management practice in higher education - What quality are we actually enhancing? Journal of Hospitality, Leisure, Sport, and Tourism Education 7(1), 40-54.

Cardoso, S., Rosa, M.J., & Videira, P., (2018). Academics' Participation in Quality Assurance: Does it reflect ownership? Quality in Higher Education 24(1), 66-81.

Chiarini, A. (2015). Effects of ISO 9001 Certification on Academic Processes. Paper presented at the18th Toulon-Verona International Conference on Excellence in Services, August 31-September 2015. University of Palermo, Italy. Accessed on 28th February 2021, from http://www.toulonveronaconf.eu/papers/index.php/tvc/article/download/183/181

Clare, Naden. (2020). Putting the Real World Back into Online Education. ISO website: News, 12 November 2020: New guidelines for virtual reality in learning just published. Accessed on 11th March 2021, from https://www.iso.org/news/ref2589.html

Coletto, M., & De Monte, T. (2019). ISO 9000 Quality Standards. In T. De Monte, S. Marco, & O. Guido (Eds.), Quality management: tools, methods, and standards (pp. 187-198). Emerald Publishing Limited. Available at: https://doi.org/10.1108/978-1-78769-801-720191012

European Maritime Safety Agency (EMSA), (2021). Official Website: COVID-19 – Impact on Shipping Report. 12 March 2021. Accessed from: http://emsa.europa.eu/newsroom/covid19-impact/item/4351-march-2021-covid-19-impact-on-shipping-report.html

Gilbert, Douglas. (2020). ISO Alongside, Instead, or Inside? The potential of ISO 21001:2018 to change and challenge higher education accreditation. International Journal of Business and Applied Social Science. 6. 48. 10.33642/ijbass.v6n10p5. Accessed on 18th December 2020, from https://www.researchgate.net/publication/345008246_ISO_Alongside_Instead_or_Inside_The_potential_of_ISO_210012018_to_change_and_challenge_higher_education_accreditation

Gunduz, M., Baykan, O. K. & Yildiz F., (2007). Virtual Laboratory Application in Distance Education. Journal of Technical? Online. 2007; 6(2):61-74.

Huang R.H., Liu, D.J., Guo, J., Yang, J.F., Zhao, J.H., Wei, X.F., Knyazeva, S., Li, M., Zhuang, R.X., Looi, C.K. and Chang, T.W. (2020), Guidance on Flexible Learning during Campus Closures: Ensuring Course Quality of Higher Education in COVID-19 Outbreak, Smart Learning Institute of Beijing Normal University, Beijing, available at https://iite.unesco.org/publications/guidance-onflexible-learning-during-campus-closures-ensuring-course-quality-of-higher-education-in-covid19-outbreak/

International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers with Code as amended. International Maritime Organization (IMO). (2010). IMO Website: Our work, Human Element, Pages, Maritime Transport Institutes. Accessed on 17th January 2021, from https://www.imo.org/en/OurWork/HumanElement/Pages/MaritimeTrainingInstitutes.aspx

International Network of Quality Assurance Agencies in Higher Education (INQAAHE), (2018). Quality glossary. Accessed on 5th Jan. 2021 fromhttp://www.qualityresearchinternational.com/glossary

International Organization for Standardization (ISO), (2015). ISO 9001: 2015 Quality management systems (GMS) - Requirements. Fifth edition 2015-09-15. Reference number ISO 9001:2015(E).

International Organization for Standardization (ISO), (2018). ISO 21001: 2018 Management systems for educational organizations (EOMS)- Requirements with guidance for use. First edition 2018-05. Reference number ISO 21001:2018(E).

International Organization for Standardization (ISO), (2021a). ISO Official website: About us, The ISO Story. Accessed on 03rd March 2021. From: https://www.iso.org/about-us.html

International Organization for Standardization (ISO), (2021b). ISO Official website: Standards, sustainable goals, goal 4: quality education. Accessed on 26 Feb. 2021. From: https://www.iso.org/sdg/SDG04.html

International Organization for Standardization (ISO), (2021c). ISO Official website: Standards, ISO Management Standards and The Concept of a High-Level Structure. Accessed on 27th Jan 2021. From: https://www.iso.org/management-system-standards.html

International Organization for Standardization (ISO), (2021d). ISO Official website: Standards by ISO/TC 232. Education and learning services. Accessed on 8th March 2021. From https://www.iso.org/committee/537864/x/catalogue/p/1/u/1/w/0/d/0

Jingura, Raphael & Kamusoko, Reckson & Tapera, Julius. (2020). Critical Analysis of the Applicability of ISO 9001 Standard in Higher Education Institutions. Accessed on 03rd March 2021. From: https://www.researchgate.net/publication/338991998_Critical_analysis_of_applicability_of_ISO_9001_standard_in_higher_education_institutions#fullTextFileContent

Keles, Mumine Kaya & Ozel, Selma Ayse., (2016). A Review of Distance Learning and Learning Management Systems. 10.5772/65222. Accessed on 13th March 2021. From: https://www.researchgate.net/publication/311753469_A_Review_of_Distance_Learning_and_Learning_Management_Systems

Khachfe, Hassan & Nassif, Samir & Hussein, Bassam & Aridi, Mona & Chamas, Mohamad. (2017).

Challenges of Implementation of ISO 9001:2015 in the Lebanese Higher Education Institutions. The Seventh International Arab Conference on Quality Assurance in Higher Education (IACQA 2017).

Mangula, M. S. (2010). Effect of Quality Management Systems (ISO 9001) Certification on Organizational Performance in Tanzania: A Case of Manufacturing Industries in Morogoro. International Journal of Technology Enhancement and Emerging Engineering Research, q (1), 14-19.

Mehfooz, M., & Saeed Lodhi, M. (2015). Implementation Barrier of ISO 9001 within Service and Manufacturing Organizations in Pakistan. IOSR Journal of Business and Management (IOSRJBM), 17(9), 66-77.

Nassif, S. & Chamas, M. & Aridi, M. & Hussein, B. & Khachfe, H., (2017). Challenges of Implementation of ISO 9001:2015 in the Lebanese Higher Education Institutions. Journal of Resources Development and Management, ISSN 2422-8397. Vol.33, 2017. Accessed from: https://www.researchgate.net/publication/317304811_Challenges_of_Implementation_of_ISO_90012015_in_the_Lebanese_Higher_Education_Institutions#fullTextFileContent

Naveed Bin Rais R, Rashid M, Zakria M, Hussain S, Qadir J, Imran MA. Employing Industrial Quality Management Systems for Quality Assurance in Outcome-Based Engineering Education: A Review. *Education Sciences.* 2021; 11(2):45. Accessed from: https://doi.org/10.3390/educsci11020045

Niedermeier, F. (2017). Designing Effective Quality Management Systems in Higher Education Institutions. Module 1. In S. Randhahn, and Niedermeier, F. (eds) Training on Internal Quality Assurance Series. Duisburg/Essen: DuEPublico.

Quinn, A., Lemay, G., Larsen, P., & Johnson, D. M. (2009). Service quality in higher education. Total Quality Management, 20(2), 139-152.

Rebelo, M., Santos, G., & Silva, R. (2014). A Methodology to Develop the Integration of the Environment System with Other Standardized Management Systems. Computational Water, Energy, and Environmental Engineering, 3, 170-181.

Sari Y & Wibisono E & Wahyudi R D & Lio Y., (2017). From ISO 9001:2008 to ISO 9001:2015: Significant Changes and Their Impacts to Aspiring Organizations. IOP Conf. Ser.: Mater. Sci. Eng. 273 012021. Accessed from: https://doi.org/10.1088/1757-899X/273/1/012021

Sickinger Nagorni, R., and Schwanke, J. (2016). The New ISO 9001:2015 - Its opportunities and challenges. Tampere: Tampere University of Applied Sciences. Accessed from: http://www.theseus.fi/bitstream/handle/10024/113266/Schwanke_Jana_Sickinger-Nagorni_Rajka.pdf;jsessionid=00A5DC7C5738664AD2091BE9EE32B8F8?sequence=2.

United Nations Educational, Scientific and Cultural Organisation (UNESCO), (2018). Internal quality assurance: Enhancing higher education quality and graduate employability. Available at: http://unesdoc.unesco.org/images/0026/002613/261356e.pdf

Zabadi, A. M. (2013). Implementing Total Quality Management (TQM) on the Higher Education Institutions - A Conceptual Model. Journal of Finance & Economics, 1(1), 42-60.

Zapata-Garcia, D., Llaurado, M., & Rauret, G. (2007). Experience of implementing ISO 17025 for the accreditation of a university testing laboratory. Accreditation and quality assurance, 12(6), 317-322.

Zhang, T., Shaikh, ZA., Yumashev, AV. & Chłąd M., (2020). Applied Model of E-Learning in the Framework of Education for Sustainable Development. Sustainability. 2020; 12(16):6420. Accessed on 16th March 2021. From: https://www.mdpi.com/2071-1050/12/16/6420/htm

Arab Academy
for Science Technology & Maritime Transport

marlog.aast.edu

see you

11 Marlog 2022