Arab Institute of Navigation
Cross Road of Sebaei Street & 45 St., Miami, Alexandria, Egypt
Tel: (+203) 5509824
Cell: (+2) 01001610185
Fax: (+203) 5509686
E-mail: ain@aast.edu
Website: www.ainegypt.org

Journal of The Arab Institute of Navigation

Semi Annual Scientific Journal
Volume 39 – January 2020
ISSN (2090-8202)

Contents

POTENTIALS OF AUTONOMOUS SHIPS

Recent years have witnessed rapid progress in the development and use of Autonomous and semiautonomous vehicle technology known as Unmanned Arial Vehicle (UAV). The initial development of technology was largely driven by military applications, but it is now progressively used in the civilian world. Not surprisingly, one of the first civil applications of this technology occurred in the maritime industry with the advent of unmanned vehicles. In the same vein, the Maritime Safety Committee (MSC) of IMO agreed in June 2017 to undertake a process to determine the regulatory scope for its identification and the need to modify the regulatory framework to enable the safe and environmental operation of Maritime Autonomous Surface Ships (MASS) within existing IMO instruments.

IMO intends to play a proactive role in ensuring a coherent international approach in this area. This approach actively supported by International Union of Marine Insurance during the MSC meeting. The scope determination process is not scheduled to be completed until June 2020, and only after this date will work begin on a possible modification of the current rules or a separate code related to the MASS. This means that there will be years before IMO will decide on any adjustments, the result is uncertain. During the discussion, several Member States expressed their support for the views expressed by the International Transport Workers' Federation, which urged a more holistic approach in determining the scope of the entire human element and the technical and operational aspects of MASS.

Editorial Board

Challenges of the Global Supply Chain Security and the way to enhancement

Prepared by

1. Mohamed Mahmoud Abdel-Fattah

Head of Training Department, Regional Maritime Security Institute, AASTMT

2. Maged Mohamed Aly Hassabou

Head of Consultancy Department, Regional Maritime Security Institute, AASTMT

Abstract:

The Supply Chain Security (SCS) is defined as the application of policies, procedures, and technology to protect supply chain assets such as product, facilities, equipment, information, and personnel, from potential threats such as cargo theft, terrorism or any other damages into the supply chain (Harrington, 2017). the appropriate physical and operational security procedures and measures shall be identified and implemented to secure the chain supply against the potential threats otherwise, the flow of the global trade could be in a great danger.

This study applied the analytical descriptive approach by presenting the role of supply chains in the international transport network and analyzing the security threats. Then, it displayed various international and regional security initiatives and programs issued to confront such threats. The study proposed 6 different approaches to improve the global supply chain security. Finally, it recommended the establishment of an international entity to coordinate the implementation of such approaches for the purpose of unifying the international efforts and measures aiming to enhance the supply chain security.

Keywords: Supply Chain Security, Maritime Trade, Maritime Security Threats & Measures.

1.Introduction

All countries around the world depend upon the efficient and secure flow and transit of cargoes through the global supply chain system. Supply chains of today's companies have globalized because of the increasing efficiency of maritime transport, supply chains and their logistics services. 90 percent of the entire global trade flows only through maritime transport and related supply chains (UNCATAD, 2015). All estimates indicate that global trade will increase in the future depending mainly on the supply chain security.

Unfortunately, the world is still a dangerous place since our global economy depends mainly on supply chains that are vulnerable to continuous threats. It is unthinkable what would happen if there were several potential threats disrupting the global flow of supply chains. Consequently, supply chains shall be effectively secured against any form of man-made threats or even natural disasters that may disrupt such secure global flow. The man-made threats affecting supply chain security are cargo theft, terrorism, smuggling of goods, as well as piracy and armed robbery (T & L 2030, 2011).

The objective of Supply chain security is to eliminate or even limit the antagonistic potential threats that could disrupt the flow supply chain. Those Antagonistic threats and other potential threats are demarcated by three key words: deliberate (caused), illegal (defined by law), and hostile (negative impact for transport network activities) (Ekwall, 2012).

2. Supply chain and the transport network

The supply chain is defined as, "a chain starting with raw materials and finishing with the sale of the finished goods". Also it is defined as "a connected set of resources and processes that starts with the raw materials sourcing and expands through the delivery of the finished goods to the end consumer". However, those logistics processes could be provided by one company or by different companies. A logistics processes consists of links and nodes. The nodes are geographically fixed points such as refineries and terminals while the links are the modes of conveyance connecting the nodes such as container ships, general cargo ships, oil tankers, Liquefied natural gas (LNG) ships and pipelines (Ekwall, 2012).

The complexity in logistics of the supply chains could be described by mentioning the four different flows involved in the logistics activities. The first two flows are the flow of material and the flow of resources representing the physical part of logistics. The other two flows are the flow of monetary and flow of information representing the necessary flows to make the system completely work The four mentioned flows of logistics require geographical stationary constructions and infrastructure to accomplish the scope of logistics. A few of those infrastructures are owned and used exclusively by one company such as container ships and tankers while some are owned by governments such as port facilities and terminals. The four flows of logistics and the necessary infrastructures are the five requirements for logistics fulfilment (Ekwall, 2010).

The supply chain provides the necessary logistics services by transporting the materials through links towards the nodes ending to expected customers. The different links in a supply chain could be located throughout many countries and connected through the use of a transport network. The transport network is designed to use economy of scale when moving products from consignor to consignee in a supply chain, through nodes and links. These links in the supply chain are subjected to different threats. For instance, oil tankers are subjected to piracy & armed robbery and terrorists' attacks while pipelines are subjected to cargo theft, smuggling goods as well as terrorists' attacks.

3. Threats to supply chain

The supply chain risks comprise terrorist attacks such as destruction and obstruction by sabotage and bombing. They also include the potential misuse, unlawful acts and undesired events. The following paragraphs discus the effect of potential threats on supply chain.

3.1. Cargo theft

The most common threat affecting the supply chain security is cargo theft. While the term "theft" could include cargoes, pieces of equipment, supplies, stores & provisions from work stations or any other types of thievery;

The Majority of theft incidents usually occur in the weakest points in the links through the entire supply chains. It is obviously well known that cargo theft is the oldest, costliest and most commonly committed crime that could destructively affect the whole flow of global trade. There was an old estimate showed that cargo theft was responsible for losses from $10 to $30 billion every year. Besides, there is indirect costs associated with theft such as lost sales, production downtime and missed deliveries (Anderson, 2007).

Consequently, cargo theft is one of the most crucial threats dramatically affecting the supply chain security. Several academic researchers believe that the insiders, whether the company men or the outsourcing men, are implicated in nearly 60 percent of all losses resulting in theft incidents. In addition, according to Ekwall (2012), 65 percent of "whole load losses" happens by the use of insiders' information. In the same context, there are considerable deficiencies because most of both the protective actions and the proactive measures are mainly against the outsiders' threats only not the insiders' threats. The illegal acts of the insiders, whether company men or outsourcing personnel, are not usually done in haphazardly manners but such illegal acts are committed according to social, traditional and environmental conditions presented in the work environment and the surrounding circumstances (Ekwall, 2012).

The complicity of the trusted insiders in cargo theft issues is a real dilemma. some academic researchers indicate that there is a high level of the insiders' involvement although they are supposed to be the first defense line of the supply chain security. Unfortunately, the insiders, in some cases, turn to be the weakest link instead of being considered as the first defense line. Consequently, it is necessary to provide all insiders, both company men and outsourcing men, with an adequate and appropriate awareness concerning cargo theft issues as well as the related training courses. Finally, the potential perpetrators could be outsiders as well as insiders in the supply chain (Europol, 2009).

3.2.Terrorism

The word "terror" is a Latin word means "to frighten". So, a terrorist is a person who try to frighten others. The term terrorist or terrorism is itself controversial because its key concept is usually political. This word has been used by many countries to describe their political opponents. Also, the terrorism has other definition which is "Terrorism is not an ideology or movement, but a tactic or a method for attaining political goals" (Europol, 2010). So, terrorism could be defined as a political action to achieve some objectives whether political, religious or ideological objectives (Park, 2013). Finally, terrorism could be described as a violence tool principally for political purposes and usually causes huge loss of lives and damages of properties as well as a great fear in the minds of people .

After the catastrophic terrorists' attack of 9/11 in the U.S.A., the war against terrorism started. The international community took some steps and accomplished a remarkable success in defeating many terrorists' activities around the world. However, the threat of terrorism is still far from decreasing especially after the 2000s (Park, 2013). According to the official statistics concerning terrorists' attacks, in order to understand terrorists, it is preferable to focus on the potential attacks instead of the probability of such attacks. However, direct and indirect effects of the terrorists' attacks and threats are negatively affecting the global flow of trade, the global economy and the supply chains as well (Ekwall, 2012).

The Middle East and Arab Gulf areas are the most vulnerable places subjected to terrorism with the ratio of 42.5% out of the total places attacked in the entire world. In addition, those places have the greatest number of casualties with the ratios of 53.3% dead and 46.7% wounded people in the world. East and Central Asia are indicated to be a comparatively safer places than the others concerning terrorists' attacks when compared with other areas in the world (Park, 2013). Terrorists usually need particular distinguished targets to achieve their objectives. The growing increase in terrorists' attacks also affects various links in the supply

Chains. The terrorists normally target the weakest links of the supply chains causing a huge loss economically as well as casualties besides achieving their objectives.

The first category targeted and the most subjected targets to terrorists' attacks are the infrastructure of supply chains such as ports, port facilities, ships, oil pipelines or any other vulnerable targets. Those vulnerable targets, usually are not secured enough, could have a catastrophic effect not only on peoples' lives but also on economic losses domain. For example, the investment in the United States fell with the ratio of 2% in 2002 because of the continued terrorism threats after the 9/11 attack in The World Trade Center 2001 (Park, 2013). Finally, terrorism is a special shape of antagonistic threat and a multi-dimensional risk that could never be eliminated with limited usual resources. It requires to be tackled in a unified effective - experienced way to secure the supply chains and the global trade as well.

3.3. Smuggling of goods

The principal target of smuggled goods is the black market. The black market consists of areas where cargoes with no legality are traded for money. The black markets or in other word " illegal markets" are subject to the law of supply and demand the same as the legal markets. Buyers and sellers of such smuggled goods are everywhere. Striving to achieve better business deals led to merging illegal actions into legal markets. The Illegal supply chains use the international trade flow to transport their products all over the world, regardless if the product is counterfeited, stolen or even an illegal drug (Ekwall, 2012).

Smugglers attempt to deceive customs' vigilance by avoiding the common direct paths that are controlled by the authorities. Also, smugglers always target the weakest link of the supply chain to smuggle goods. Companies continuously try to solve the problem of smuggled goods to eliminate their losses. Consequently, such companies keep increasing the efficiency of tracking their own cargoes using sophisticated technology and optimum security procedures and measures. Also, the security experts recommend to control the Potential black markets to eliminate or even limit the availability of Smuggling of goods as much as they could (Ekwall, 2012).

3.4.Piracy and armed robbery

Piracy is an act that is generally ill defined and little understood. This is despite the fact that piracy is the oldest crime over which there is universal jurisdiction. It is a common global classification as hostis humani generis meaning enemy of all mankind (Goshal, 2013). Almost all oceans and seas of the world have had a long history of maritime piracy. Piracy activities continued to exist on a low, sporadic, and opportunistic level in some backwaters of the world's oceans. However, there are three geographical areas in the world considered as hot spots for pirates' activities. first, South East Asia, notably the Strait of Malacca and the South China Sea, has been seen as problematic from the 1990s onwards. Second, the coast of Somalia and the Horn of Africa which have drawn attention since 2007. Third, West Africa where the Gulf of Guinea has been recognized as a critical trouble spot since 2011. In all cases all major international shipping routes are concerned and fairly extensive regional and international actions have addressed piracy (Hassabou, 2016).

Piracy is the most dangerous threat to the maritime industry and to the supply chain security as well since the Second World War. For instance, the Somalia piracy has critical economic effects on the global maritime trade. In response to such threat, over thirty countries have deployed warships to the waters off the Horn of Africa and spent millions of dollars annually trying to secure the world trade. Moreover, the ships wishing to pass through the Suez Canal to reach Europe or North America have suffered from the costs of ransoms, insurance policies and other security measures including using Privately Contracted Armed Security Personnel. Some ships' operators have considered detouring around the Cape of Good Hope off the coast of South Africa. Unfortunately, even such option has caused extra costs because of the much more time and fuel consumed to those trips (Hassabou, 2016).

Consequently, piracy threat demands a firm

Response that matches its seriousness. All prognoses indicate that global trade will increase in the future and along these so-called gateway regions. Unfortunately, the world is still a dangerous place since our global economy is strongly dependent on certain unsecured hubs. it is unthinkable what would happen if there were a piracy attack on just one of them.

4.Supply chain security programs

There are various kinds of security certification programs worldwide in addition to a number of voluntary and compulsory security programs which are driving the world to be more secure against various threats in the supply chains. These programs involve a series of organizations in supply chains and have now become a 'must' for maritime transport industry. The need for increasing security measures in the maritime sector is founded on its high degree of vulnerability and in its crucial role for international trade where any disruption of the maritime supply chain could have drastic effects for the global economy .

Since September 2001 governments, international organizations, customs and private firms have undertaken multiple types of responses and actions to enhance supply chain security (World Bank, 2009). Several studies provide a summary of existing initiatives, divided into international and regional regulations (Hintsa et al., 2009). The international regulations are International Ship and Port Facility Security code (ISPS code) issued by International Maritime Organization (IMO), Code of Practice on Security in Ports issued by (IMO) and international labor organization (ILO) and World Customs Organization framework issued by World Customs Organization. The national regulations are Container Security Initiative (CSI), 24-hour Rule, Customs-Trade Partnership against Terrorism C-TPAT issued by U.S. In addition, there are some other Industry programs (Marlow, 2010; Metaparti, 2010; Yang 2010, 2011). Table.1 shows Overview of global security initiatives and Figure.1 Scope of IMO and US maritime security initiatives across a supply chain.

Table. 1 Overview of global security initiatives

Category	Organization	Regulations	Other
Shipping/port security	U.S.A. Safe port act	US-based evaluation of foreign ports' security and ships' tracking system	Compulsory
	IMO ISPS code	UN-based compulsory application of security regulations to all ships under 500 tons	Compulsory
Container security	United States CSI	US-based 100% container scanning	Compulsory
	WCO	UN-based container scanning regulations if necessary	Voluntary
Supply chain security certification	C-TPAT	US-based export related certification	Voluntary
	WCO Framework	UN-based mutual recognition of security between countries	Voluntary
	ISO 28000	UN-based field-based security management standard certification	Voluntary
Cargo information notification	24-hour rule, 10+2 rule	US-based Cargo information notification rule	Compulsory
	WCO cargo information notification	UN-based Cargo information notification	Voluntary

Source: (Park, 2013)

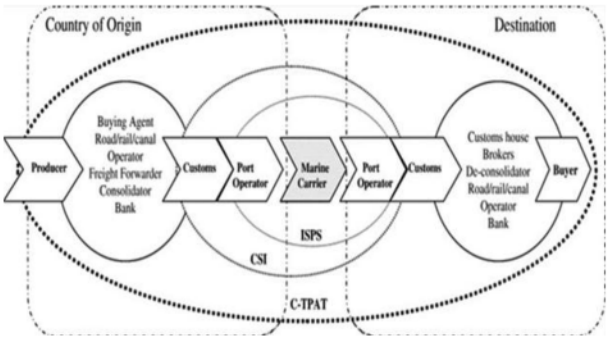


Figure.1 Scope of IMO and US maritime security initiatives across a supply chain Source: (Barnes and Oloruntoba, 2005).

International Organization for Standardization (ISO) adopted in 2005 an industry-based specification called ISO 28000 to secure the supply chain. It is a business system that can confront security threats in the supply chain. ISO 28000 is applicable to all kinds of organizations such as logistics, service, and manufacturing companies. This specification aims to prevent the threats and risks of smuggling and terrorist attacks as well as establish a security oriented business management system. The specification also includes various aspects of business management principles that can plan, implement, sustain, and develop the security requirements. The benefits for being certified are: 1) to upgrade the level of trust and reliability 2) to improve security management 3) to enhance relationship among all trading partners. ISO28000 has a unique feature compared to other security

Initiatives which is the “security risk assessment procedure”. ISO28000 focuses on preventing and minimizing the risks of security breaches and incidents in any kind of emergency situation. In addition, it has a huge impact on the supply chain security because the specification standard is widely adopted by many countries in the world. (Park, 2013).

5. The role of technology

Security technology is constantly improving not only in regard to capability but also regarding to standardization, compatibility and integration with information systems. It is very obvious that there is no only one single technology solution to improve supply chain security. Therefore, security plans shall be periodically developed and amended to confront various current potential threats. In addition, the appropriate efficient and effective security solutions shall be implemented to ensure the flow of global trade and secure supply chain (DHS, 2007).

Considering the costs and complexity associated with enhancing maritime security, it is expected that such costs have been minimized through some exerted efforts by means of modern technologies. These modern technologies could be classified according to the purposes that they can be used for monitoring, controlling, prevention, deterring and forecasting (Acciaro and Serra, 2013).

Monitoring technologies are those aiming at enhancing the security of the supply chain through all different stages. Also, monitoring technologies are at minimizing the risk of malicious interference with the cargoes or at certain areas at port facilities. The common examples of monitoring technologies are cameras and Radio Frequency Identification (RFID) tags. A large amount of literature has posed the light on the effectiveness and the efficiency of RFID tagging or have focused on the benefits of those technologies. On the other hand, prevention technologies could be used to prevent interference with the supply chain and tamper with cargoes as well as ensure full visibility of the all related parties involved. RFID can perform such distinguished task, but we can include fencing and data management Technologies. Container scanning by means of x-rays, pulsed neutron scanners and gamma ray have been available. In addition, seals are considered as an effective tool in preventing tampering with the container. Also, whether the seal of the container is intact or not (Acciaro and Serra, 2013).

In spite of the evident benefits of checking the container contents physically; the combination of different systems could be the most appropriate solution. Actually, container security technologies are positively biased towards a combination of different systems implemented at the same time. The security studies recommend using the intelligent container seals or pre-scanning that permit to identify suspicious containers which shall be then scanned, non-intrusively with x-rays / gamma-rays or even opened if necessary. One of the most crucial issues related to containers' inspections is the inefficiency of scanners and inspectors. The acceptance of security procedures and measures is also very important but only a few of researches contributions addressed such issue (Acciaro and Serra, 2013).

Actually, the layered security approach has multiple opportunities to mitigate consequences and minimize potential threats is much better than the single security approach. The ability to earlier identify threats in the supply chain is desirable target as such identification minimizes any potential loss. Technology acts a vital role in screening cargoes at the critical nodes, port facilities and terminals, of the supply chain through data acquisition, analysis and delivery for instant the secure transmission of cargo manifests. Furthermore, technology ensure and enhance security through scanning and imaging of cargo at those nodes where cargo flows continue. The data flow in the shipping process is considered as preventative measures by providing required information for supply chain security as well as the safety of cargo (DHS, 2007).

6. The proposed approaches to enhance supply chain security

Studying and analyzing both researches Emergence of security in supply chain management literature (Julie et al., 2010) which

introduced five strategies to promote security in supply chains and “Port Security” A Perspective on Trade Facilitation in a Secure Supply Chain (the Association of German Seaport Operators, 2011) which introduced eight key points for an enhanced and integrated port security, this study proposed six approaches for dealing in both strategic and operational levels with the security threats that could negatively affect the supply chain.

The first approach, the most critical one, is to achieve a closer communication among all supply chain partners to plan and control security measures. This approach, closer communication of security processes along the supply chain, is considered as the basic requirement for all other approaches. In this approach, it has to achieve a stronger level of cooperation and communication with supply chain partners concerning information sharing creating more visibility among supply chain partners for making shipping processes more efficient and secure.

The second approach is to develop an assessment for all potential risks for the entire supply chain. The multi layered risk assessment approach to security across all potential transport sectors including railway, land and sea is much more efficient and effective as well as less expensive than alternative approaches that focus on a single layer only of the supply chain. Complying with a single security initiative within a single transport sector does not address the vulnerabilities associated with other potential sectors of transport. The whole end-to-end supply chain starting from the point of loading of the goods through their multi-modal transportation ending to the arrival of goods at their final destination needs to be analyzed and secured instead of focusing security measures only on a single part of the supply chain. Moreover, the multi- layered risk assessment approach is needed to identify those cargo shipments that require more review than other shipments that are low risk and could be allowed to be transported without delay. To further enhance the underlying risk-based analysis, the all related parties of international trade shall have a clear concept of what has to be integrated into a risk analysis to identify and classify risks In the supply chain. The process of determining risk needs to be clearly understood and internationally harmonized.

The third approach focus on synergy effects of the existing security measures and procedures. In other words, this approach needs to focus on strengthening and enhancing the existing security tools before conducting any other additional new security procedures and measures. Such focus will lead to create an efficient and effective security system that provides an optimum available protection and ensure the continuity of the global trade flow according to the international basis. All existing security measures and applied initiatives shall be harmonized and united before applying any other measures. So, we can identify and eliminate any gap in the current supply chain system. Applying too many security measures and procedures usually leads to create uncertainty and confusion for port facilities' operators and traders. Consequently, those excessive security measures and procedures have to be reviewed to address and identify issues concerning duplication of certifications and effort as well as conflicting approaches.

The fourth approach is a reorganization of logistics operations of production warehousing, distribution as well as transport processes. This approach has some options such as: relocation of production and warehousing facilities to accomplish both minimizing dependencies on overseas sourcing and creating business continuity in the face of security risks. There are various alternatives for transport mode selection that shall be looked at as a vital means to confront any potential threat considering mode and carrier choice where supply chain security is the most critical criteria for carrier selection.

The fifth approach is the international mutual recognition and support global standards. In today’s globalized supply chain, the security of seaports and the maritime transport sector needs to be addressed as a critical global challenge. Against this background, national policies will be ineffective unless they are supported by enhanced international cooperation to guarantee

Their compatibility. Consequently, it is a joint responsibility of the maritime community to strengthen and enhance all elements of the security of port facilities as well as the security of the supply chain in order to minimize the chances of any potential attack. To achieve this goal, a key factor lies in the international cooperation as an integral part of the efforts to secure global maritime trade.

In the same context, the ship security, the port facility security and the containers security consist of a complex system of tangled and interrelated activities. These activities are represented in the flow of information and data capture, physical surveillance of the container and inquiries about the various entities in the supply chain. The global movement of containerized cargo engage many different entities across the supply chain network including terminal operators, ship owners, port facilities authorities, importers and exporters and government agencies. In order to harmonize all of these many different entities into a comprehensive security approach, the use of technologies is the most critical element. The modern technologies are represented in smart locks, tracking and tracing, sealing, detection and scanning technology. All of these technologies will support the multilayered risk-based security approach. To strengthen and enhance the use of those technologies in the different environments of global trade, the process of international standardizations shall be paid great attention. Therefore, any national security initiative or regional security initiative could be integrated into the required international standardization process.

The sixth and the final approach is to create and enforce the concept of "security culture" considered as a basic concept in dealing with supply chain security risks. The security culture usually establishes Supply Chain Security as a priority among company personnel through accepting and complying norms and values that support security-related activities and let all personnel to be always alert in undertaking SCS-related efforts. Those personnel who trained in security can better understand the normal state of business operations and can more readily Identify anomalies. In addition, those trained personnel are supposed to be more prepared for confronting any potential threat. It is found that port facilities with higher security performance, that pay more attention on security culture, are better able to detect and respond to security events. Consequently, it is advisable to conduct security training, drills and exercises on knowledge of the potential risk scenarios to support the concept of security culture.

Conclusions

The economic prosperity of nations worldwide is dependent upon the supply chain security system. No one in either the public or the private sector has the resources, the authorities or the full range of expertise to confront all vulnerabilities related to the global supply chains or even to address this problem in isolation. Protecting the global supply chain is therefore, a shared responsibility. By understanding what needs to be done, we can together assess which stakeholder is best positioned and has the tools and resources to do it .

This study concluded that the international community can apply all the six proposed approaches explained above and achieve all their objectives by establishing an international specialized entity responsible for supply chain security. This achievement is an urgent and important step to ensure the global maritime trade. The fragmented initiatives that have issued until now are not quite appropriate with the internationalized various nature of maritime sectors worldwide. These different initiatives encourage creation of an overregulated and bureaucratic scheme not aiming to achieving the desirable global supply chain security. Having one entity to support supply chain security will help increasing International cooperation and making security integral to other activities of business meanwhile this can overcome reducing excessive bureaucratization. Furthermore, the possibility in the future of assigning a competent international entity which could act as regulatory authority for supply chains security at international level may allow to overcome the limits of the current fragmented regulatory framework.

Recommendations

The study recommends establishing a Specialized Working Group concerning the Global Supply Chain Security composed of representatives from all concerned governments to support their unified efforts and develop a periodic "Global Supply Chain Findings and Recommendations Report" that leads to determine future efforts by the following:

- Determine the supply chain threats and risks by developing updated assessments of the system and analysis of the potential threats for the purpose of confirming the suitability of existing security policies and programs.
- Establish the priorities of technologies used in securing the supply chain such as tracking, intrusion detection capabilities and other related technologies. Then, develop the shipping process to enhance and develop programs to advance those priorities.
- Establish resilient critical infrastructures by creating new incentives to encourage industry stakeholders to build resilience into their supply chains, which then strengthens the system overall .
- Promote the development and utilization of supply chain standards through active engagement with relevant stakeholders to advance technical standards for radiation and nuclear detection technologies as well as global standards of best practices for supply chain security.
- Improve the commercial information analysis and sharing capabilities through innovative pilots with other related governments to assess data and inspect danger cargo hazardous materials prior to arrival at vital areas.
- Keep updating the security plans for all related port facilities and terminals to identify all vulnerabilities concerning operational security and physical security measures to implement any necessary countermeasures.
- Streamline and harmonize all universal processes and policies to facilitate global trade by completing mutual recognition arrangements with the related governments for air, land, and sea cargo security programs

Which lead to improve the uniformity of trade enforcement processes.

References

1. Acciaro, Michele. Serra, Patrizia, (2013). Maritime Supply Chain Security: A Critical Review. International Forum on Shipping, Ports and Airports (IFSPA) Trade, Supply Chain Activities and Transport: Contemporary Logistics and Maritime Issues. http://worldcat.org/isbn/9789623677677. (Accessed Mar 15, 2018).

2. Anderson, (2007). Securing the Supply Chain-Prevent Cargo Theft. Security 44(5), pp. 56-59.

3. Barnes, Paul. Oloruntoba, Richard. (2005). Assurance of Security in Maritime Supply Chains: Conceptual Issues of vulnerability and Crisis Management. Journal of International Management 11(4).

4. Department of Homeland Security (DHS), United States. (2007). Strategy to enhance international supply chain security. Washington, D.C.

5. Europol, 2009. Cargo theft report: Applying the Brakes to Road Cargo Crime in Europe. Europol, The Hague, Netherlands.

6. Europol, 2010. "EU Terrorism Situation and Trend Report 2010". The Hague, Netherlands.

7. Ekwall, Daniel. (2010)." On analyzing the official statistics for antagonistic threats against transports in EU: a supply chain risk perspective". Journal of transportation Security, Vol. 3, No. 4, pp 213-230.

8. Ekwall, Daniel. (2012). Supply Chain Security – Threats and Solutions. Business, Management and Economics. "Risk Management - Current Issues and Challenges", book edited by Nerija Banaitiene, Chapter 8. ISBN 978-953-51-0747-7.

9. Harrington, Lisa,2017. Supply Chain Security& Risk Management: Faculty Research Associate Center for Public Policy and Private Enterprise University of Maryland.

10. Hintsa, J., Gutierrez, X., Wieser, P., & Hameri, A. (2009). Supply chain security management: An overview. International Journal of Logistics Systems and Management, 5(3), 344-355.

11. Hassabou, Maged. (2016).” Somali Piracy” Causes, Consequences and Proposed Solutions. Arab Academy for Science & Technology and Maritime Transport, Maritime Post Graduate Studies Institute. Alexandria, Egypt.

12. Julie, E, Gould. Cathy, Macharis . Hans-Dietrich, Haasis.(2010). Emergence of security in supply chain management Literature. Journal of Transportation Security. Springer Science and Business Media, LLC. (3), 287–302.

13. Marlow, P. B. (2010). Maritime security: An update of key issues. Maritime Policy & Management, 37(7), 667-676.

14. Metaparti, P. (2010). Rhetoric, rationality and reality in post-9/11 maritime security. Maritime Policy & Management, 37(7), 723-736.

15. Park, Hong, Gyu. (2013). Impact of Supply Chain Security Orientation on Port Performance. Doctor of Philosophy, Transport and Shipping Research Group Logistics and Operations Management Section Cardiff Business School, Cardiff University.

16. Transportation & Logistics 2030 series, editorial board. (2011). Strategies to help companies take an active role in improving supply chain security. Transportation & Logistics 2030 series, the forth publication. www.pwc.com/tl2030. (Accessed Mar 19, 2018).

17. The Association of German Seaport Operators (ZDS). (2011). Port Security, A Perspective on Trade Facilitation in a Secure Supply Chain. www.zds-seehaefen.de/wp-content/.../20110121_Port_Security.pdf. (Accessed Mar 22, 2018).

18. United Nations Conference on Trade and Development. (UNCTAD). (2017). Review of Maritime Transport. United Nations publication. Geneva .

19. World Bank, (2009). Supply Chain Security Guide.

20. Yang, Y. (2010). Impact of the container security initiative on Taiwan's shipping industry. Maritime Policy & Management, 37(7), 699-722 .

21. Yang, Y. (2011). Risk management of Taiwan’s maritime supply chain security. Safety Science, 49(3), 382-393.

The Impact of Implementing the Autonomous Ships System On Seafarers

Prepared by

Capt. Ahmad Elnoury Capt. Salah Eldin Farag

Arab Academy for Science, technology and Maritime Transport (AASTMT)

Abstract:

In today's seafarer market, one of the main problems is the lack of seafarers, especially experienced officers. Although the global supply of officers is increasing steadily, the demand is still higher than the supply. In addition Shipping accounts for nearly 80% of global trade by volume, which in 2017 reached about 10.7 billion tons of cargo, the volume expanding by 4% (UNCTAD, 2018). In maritime researches and innovation studies, unmanned and autonomous ships have become a popular research subject. According to Burmeister et al., (2014) & Rodseth et al., (2012) the incentive behind autonomous vessels in the maritime sector is to contribute to all dimensions of sustainability; economic, ecological and social sustainability. From an economic perspective the introduction of unmanned vessels has the potential to reduce operating costs by removing the majority of crew-related costs .

Moreover, according to Bertram (2016) The absence of onboard crew may also lead to new innovative ship designs without the need for superstructures to house life-support facilities. Losing the superstructure means less air resistance and also a reduction in weight, which in turn may result in reduced fuel consumption. However, this new technology will lead to a great ratio of seafarers' unemployment. This paper analyzes the numbers of seafarers holding certificates of competency and proficiency in Europe and Egypt who depend on the maritime jobs to earn their living. By using (SPSS) method The questionnaire carried out by different marine experts ranks and nationalities who work in marine sectors reflecting their opinions regarding the autonomous technology. The research paper arrives at the conclusion that the marine sector should comply with the technology revolution which implies using the autonomous ships technology. The methodology used depends on descriptive analysis.

1.Introduction

According to the European Waterborne Technology Platform Implementation Plan (Waterborne TP) for 2020, the development of autonomous ships is one of the key exploitation outcomes to strengthen Europe's maritime sector. Waterborne TP (2011) defines an autonomous ship as a vessel with:

Next generation modular control system and communications technology [that] 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.

In order to bring the idea of autonomous ships to life, the research project Maritime Unmanned Navigation through Intelligence in Networks (MUNIN) was established by the European Commission. MUNIN investigates the feasibility of autonomous ships, and aims to develop required technology and business concepts (Kretschmann et al., 2017).

The terms "autonomous vessels" and " unmanned vessels" have not been defined neither nationally, nor internationally. "autonomous ships" are definitional considered the overall term for "ships capable of providing via automatic processes decision support or a possibility of taking over parts of or the entire human control and management of the ship, irrespective of whether the control is exerted from the ship or from somewhere else ".

Autonomous ship can also be a ship that uses technology allowing for, inter alia, an occasionally unmanned (physical) bridge/reduced manning or anti-collision systems .

The term covers "a person with the required qualifications who performs or monitors the navigation of one or more autonomous ships without being on board the ship in person and who is entitled to represent the ship vis-à-vis the authorities (Denmark analysis 2017).

2 Autonomous Infrastructure

Figure (1) illustrates the transition from manned vessels to autonomous vessels where the resulting autonomous ship is a combination of a remote and an automated ship. On a conventional manned ship, information from radars, navigation systems, Electronic chart display information system (ECDIS) and visual observations are interpreted by the onboard Officer on Watch, officer in charge of navigation watch (OOW) to take navigational actions. On the other hand, a remote ship transmits data to a navigational operator ashore where the information is processed. Navigational instructions are then transmitted back to the ship to take actions. The next level is the automated ship, where all navigational decisions are made onboard by a computer without any remote control. Finally, as defined by the MUNIN project, an autonomous ship is a combination of a remote and automated ship, where the vessel is completely unmanned for parts of the voyage. Navigational decisions are partially made by onboard automated systems and by navigational operators that are capable of controlling the ship remotely ashore (Salvasen, 2018).

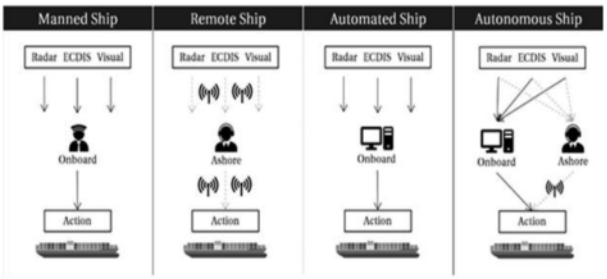


Figure 1: From manned to autonomous ships www.freepik.com (Rodseth et al., 2012).

In order to achieve safe unmanned and autonomous navigation it is necessary to implement newly developed systems on-board the vessel, and remote monitoring and control systems ashore (MUNIN, 2016). As proposed by the MUNIN project, autonomous operation requires voyage planning, navigation and collision avoidance systems that are constantly surveilled from a so-called Shore Control Centre (SCC) (MacKinnon et al., 2015). The monitoring and controlling tasks are conducted by an operator in the SCC, which is capable of operating up to six ships simultaneously (MUNIN, 2016). The SCC communicates with the autonomous ship by using available technology such as Global system for mobile communication (GSM), satellite, Very High Frequency (VHF), etc. From a socio-technical

perspective the SCC can either be managed by officials such as the Vessel Traffic Services (VTS) and port authorities, or ship management companies to attract seagoing professionals looking for jobs ashore (MacKinnon et al., 2015). This conceptual overview, as proposed by MacKinnon et al. (2015), is illustrated in Figure (2).

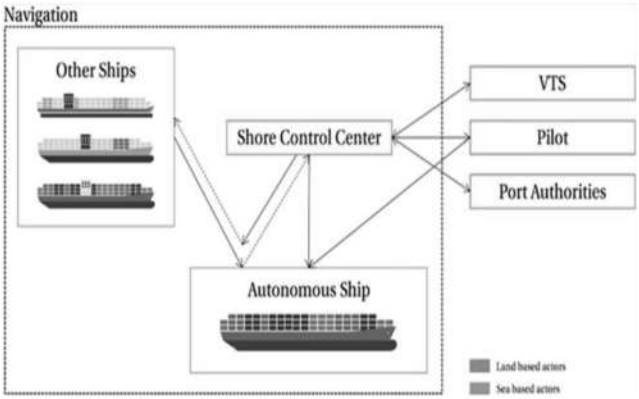


Figure2: Socio-technical overview of autonomous navigationwww.freepik.com
(adaptedfrom MacKinnon et al., 2015).

When necessary, it is possible to take direct control of the autonomous vessel from the SCC by using a Remote Maneuvering Support System (RMSS). The idea is that a team ashore directly operate the vessel from a replica of the ship's bridge, and the RMSS provide the team with situation awareness due to the actual distance between the SCC and the vessel(Salvasen,2018).

From a societal perspective, autonomous ships **present a number of different and great potentials**:

An environmental advantage due to fuel savings and new means of propulsion.

- Enhanced safety both in open waters and in ports.
- Significantly increased cost-efficiency and productivity.
- Optimization of the logistics chain via IT solutions.
- Improved infrastructure for, inter alia, transport to and from islands as well as for densely trafficked routes.

3 Autonomy levels

Lloyd's Register has developed a definition of ships' autonomy levels table(1) which reference is often made in the international dialogue about autonomous ships.

Lloyd's Register's definition of autonomy levels is based on differences between the technique used as well as the operator's role.

Table (1): Autonomy levels (adapted from Lloyd's Register)

Autonomy level	Description	Operators role
Al 0:	Manual steering. Steering controls or set points for course, etc. are operated manually.	The operator is on board or performs remote control via radio link.
AL 1:	Decision-support on board. Automatic steering of course and speed in accordance with the references and route plan given. The course and speed are measured by sensors on board.	The operator inserts the route in the form of "waypoints" and the desired speed. The operator monitors and changes the course and speed, if necessary.
AL 2:	On-board or shore-based decision support. Steering of route through a sequence of desired positions. The route is calculated so as to observe a wanted plan. An external system is capable of uploading a new route plan	Monitoring operation and surroundings. Changing course and speed if a situation necessitates this. Proposals for interventions can be given by algorithms
AL 3:	Execution with human being who monitors and approves. Navigation decisions are proposed by the system based on sensor information from the vessel and its surroundings.	Monitoring the system's function and approving actions before they are executed
AL 4:	Execution with human being who monitors and can intervene. Decisions on navigation and operational actions are calculated by the system which executes what has been calculated according to the operator's approval.	An operator monitors the system's functioning and intervenes if considered necessary. Monitoring can be shore-based
AL 5:	Monitored autonomy. Overall decisions on navigation and operation are calculated by the system. The consequences and risks are countered insofar as possible. Sensors detect relevant elements in the surroundings and the system interprets the situation. The system calculates its own actions and performs these. The operator is contacted in case of	The system executes the actions calculated by itself. The operator is contacted unless the system is very certain of its interpretation of the surroundings and of its own condition and of the thus calculated actions. Overall goals have been determined by an operator. Monitoring may be shore-based.
AL 6:	Full autonomy. Overall decisions on navigation and operation are calculated by the system. Consequences and risks are calculated. The system acts based on its analyses and calculations of its own capability and the surroundings' reaction. Knowledge about the surroundings and previous and typical events are included at a "machine intelligent" level.	The system makes its own decisions and decides on its own actions. Calculations of own capability and prediction of surrounding traffic's expected reaction. The operator is involved in decisions if the system is uncertain. Overall goals may have been established by the system. Shore-based monitoring.

Source: MASS Code of Conduct": The Maritime Autonomous Systems Surface. MAS(S) (July, 2016)

4Statistical processing of seafarers capacity in Europe

The data subject to review was extracted from the national registries on certificates and endorsements issued to seafarers maintained by the EU Member States. Taking into account the diversity of technologies used to register such data, each EU Member State developed a data extractor module to retrieve the information established in Annex V to Directive 2008/106/EC in a structured format defined by the technical specifications made available by European maritime safety agent (EMSA). The data extracted was subject to a validation process to ensure consistency and an anonymization process by which all personal data was made anonymous at the EU Member State site. The software module built by EMSA and made available to all EU Member States for anonymization of personal data at origin also allowed a preliminary **validation to be conducted to ensure that :**

- All mandatory fields were extracted and made available.
- All fields containing dates were registered in the agreed format.
- The relationship between the 'date of issue' and the 'date of expiry' of the documents followed the rules established by the STCW Convention.

After receiving the data in its anonymous format, EMSA conducted a further validation to ensure that only the documents with a valid status were considered (in principle a EU Member State may provide information on all documents registered, including those suspended, cancelled, declared lost or destroyed). Only the data successfully passing the validation and coding phases was considered for statistical review.

4.1Masters and officers holding valid Certificates of Competency (COC) in 2016

The total number of masters and officers holding valid CoCs at EU level was 161,419. Out of this number, 3.35% officers held CoCs entitling them to serve in both the Deck and Engine Departments and 0.04% of them were identified as holding multiple CoCs issued by different EU Member States.

4.2Distribution by EU Member State

The data in Figure (3) shows the distribution of masters and officers as registered by EU Member State :

- Between them six Member States, namely the United Kingdom, Poland, France, Croatia, Italy and Spain, accounted for 58.06% of the total number of masters and officers holding valid CoCs.
- 20Member States registered less than 10,000 masters and officers each.
- Luxembourg did not issue CoCs and consequently did not register masters or officers holding valid CoCs.

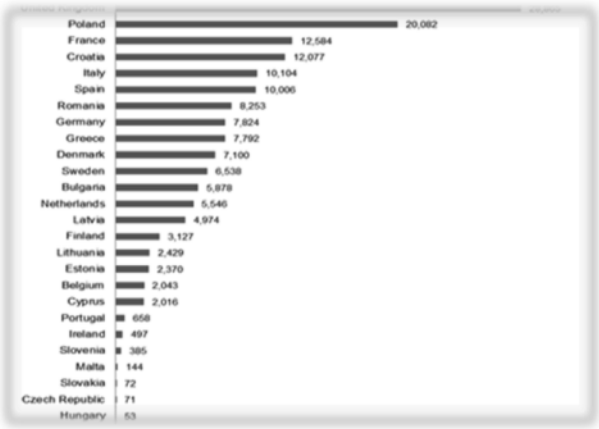


Figure 3 Masters and officers holding valid CoCs per EU Member State
WWW.EUR-LEx.europa.eu

4.3Distribution by department

The number of masters and officers holding valid CoCs in each department are presented in Figure (4). It illustrates that the number of masters and officers entitled to serve in the Deck Department (Chapter II of the STCW Convention) was 50% higher than the number of officers entitled to serve in the Engine Department (Chapter III of the STCW Convention). The officers grouped under 'Alternative certification' (Chapter VII of the STCW Convention) were reported as holding a multipurpose capacity.

- Deck Department 99,702
- Engine Department 66,387
- Alternative Certification 743

Figure 4 Distribution of masters and officers holding valid CoCs by department
WWW.EUR-LEx.europa.eu

5.Egyptian Masters, officers and Engineers holding valid certificates of competency.

The total number of masters and officers holding valid CoCs at Egyptian authority level was 7966, and the total number of chief engineers and engine engineers holding valid CoCs was 3760, till 2018, despite there are many invalid certificates of competency. Table (2) presents the capacity numbers distribution of Egyptian certificates of competences of officers and engineers.

Table (2): Egyptian Officers and Engineers holding valid COC 2018

Source: Egyptian authority for maritime safety, EAFMS 2019

The deck department obtained 68% and engine department obtained 32% as shown in figure 5

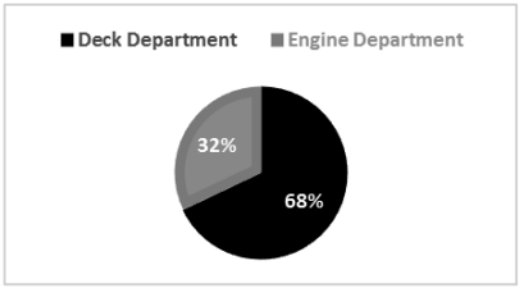


Figure 5 Distribution of masters, officers and engineer holding valid CoCs by department

The previous data shows that the marine sector in Europe and Egypt represents a high ratio of seafarers in deck and engine department holding the valid certificates of competency. This means that a large number of citizen in Europe and Egypt depend on the marine sector as a profession for living.

6Questionnaire analysis

Through the presented research paper, a Closed ended format question (importance questions type) was carried out by random group of 104 marine expertise who have more than 10 years marine experience on board ships, with different ages, nationalities (Egyptian, Nigerian and Syrian) and ranks (Captains, Chief engineers , Chief Mates , and Electric Engineers). It included general questions about the autonomous system and the effect of the implementation of this system on seafarer's future. The questionnaire was carried out in a very objective manner. It showed the following results.

According to table (3) the data distributed by using the statistical package for the social science program (SPSS) shows the mean and standard deviation for each question marked by high ratio between 2.69±0.76 and 3.27±0.95. The total agreement for using the new technology in seaborne trading scored 59.1 % and 40.9 % disagreed to implement the autonomous system. Hence, the majority are willing to improve the seaborne trading by high technology to increase the trading acceleration.

Figure (6) shows the higher agreement and strength for each question. Regarding the mean score, shown in figure 6, on the one hand, both questions 10 and 9 scored the highest mean as 3.27 and 3.13 respectively. This indicates that the autonomous ship technology will definitely affect the prospect of better job opportunities for seafarers, and the autonomous technology will increase the seaborne trade. On the other hand, question 5 scored the least mean as 2.75 . This is an indication that, the autonomous ships are incapable of reducing marine accidents and protecting the marine environment.

Table (3): Distribution of the studied samples according to autonomous ships satisfactory survey (n = 104)

	Autonomous ships satisfactory survey	Agree to great extent		Agree		Neutral		Disagree		Disagree to great extent		Mean ± SD.	Rank for higher agreement
		No.	%	No.	%	No.	%	No.	%	No.	%		
1	Would an unmanned "ship" face difficulty under you national law in registering as such on account of its unmanned orientation?	0	0.0	29	27.9	39	37.5	36	34.6	0	0.0	2.93 ± 0.79	9
2	Could other remote-controllers constitute the "crew" for the purposes of merchant shipping laws?	0	0.0	46	44.2	21	20.2	37	35.6	0	0.0	3.09 ± 0.89	3
3	Would the operation of an unmanned "ship" without any on board personnel, person, be contrary to the duty principle of "good seamanship" under the COLREGS, as interpreted internationally?	0	0.0	34	32.7	23	22.1	47	45.2	0	0.0	2.88 ± 0.88	12
4	As interpreted under international law, could the COLREG Rule 5 requirement tom maintain a "proper lookout" is satisfied by camera aural censoring equipment fixed to the ship transmitting the ship's vicinity to those "navigating" the ship from the shore?	0	0.0	39	37.5	13	12.5	52	50.0	0	0.0	2.88 ± 0.93	11
5	Would the autonomous ships reduce marine accidents and protect marine environment?	0	0.0	32	30.8	14	13.5	58	55.8	0	0.0	2.75 ± 0.90	15
6	Does the marine sector need an autonomous ships system?	0	0.0	35	33.7	18	17.3	51	49.0	0	0.0	2.85 ± 0.90	13
7	Is the autonomous ships system compatible with all countries and nationalities?	0	0.0	19	18.3	34	32.7	51	49.0	0	0.0	2.69 ± 0.76	16
8	Are there any nationalities that will be affected negatively in the implementation of this system?	0	0.0	45	43.3	13	12.5	46	44.2	0	0.0	2.99 ± 0.94	8
9	Is the usage of autonomous ships considered a factor in increasing the marine trade?	0	0.0	44	42.3	29	27.9	31	29.8	0	0.0	3.13 ± 0.84	2
10	Will the future technology impede the seafarers from having good job opportunities?	0	0.0	64	61.5	4	3.8	36	34.6	0	0.0	3.27 ± 0.95	1
11	Is it possible to dispose with the human factors in the future in ships operation?	0	0.0	39	37.5	26	25.0	39	37.5	0	0.0	3.0 ± 0.87	6
12	Will the maritime academies support implementing this system?	0	0.0	33	31.7	38	36.5	33	31.7	0	0.0	3.0 ± 0.80	6
13	Will the autonomous ships system benefit the marine sector?	0	0.0	32	30.8	30	28.8	42	40.4	0	0.0	2.90 ± 0.84	10
14	Is the human factor considered an obstacle which impedes the development of the marine field?	0	0.0	37	35.6	32	30.8	35	33.7	0	0.0	3.02 ± 0.84	5
15	Will the ships owners companies encourage the autonomous ships system since it reduces salary rates?	0	0.0	42	40.4	29	27.9	33	31.7	0	0.0	3.09 ± 0.85	4
16	Are you with or against the autonomous system?	0	0.0	32	30.8	18	17.3	54	51.9	0	0.0	2.79 ± 0.89	14
	Total	**0**		**602**		**381**		**681**		**0**		**1664**	
	Average	**0.0**		**37.63**		**23.81**		**42.56**		**0.0**		**16.64**	
	Percentage	**0.0**		**36.2**		**22.9**		**40.9**		**0.0**		**100.0**	
	Average	**% agreement**	**2.95**				**59.1%**						

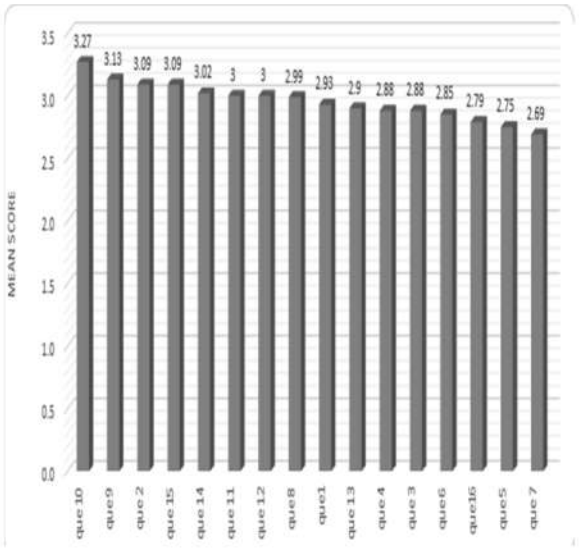


Figure 6: Distribution of the studied samples according to autonomous ships satisfactory survey (n = 104)

Table (4) shows the direct proportionality correlation between those who are against implementing the autonomous system and the effect of using this technology in the marine sector. The expertise who attempted to answer the questions 5,8,10,11,14 in the questionnaire with an approval are also those who agreed to use the autonomous system. While those who disagreed on the same questions are also those who disagreed to use the autonomous system. The table presents the positive relation which signifies the high probability ratio.

Table (4): Correlation between different items (n = 104)

		Are you with or against the autonomous system?	
		r_s	p
Q5	Would the autonomous ships reduce marine accidents and protect marine environment?	0.259*	0.008*
Q8	Are there any nationalities that will be affected negatively in the implementation of this system?	0.203*	0.038*
Q10	Will the future technology impede the seafarers from having good job opportunities?	0.602*	<0.001*
Q11	Is it possible to dispose with the human factors in the future in ships operation?	0.412*	<0.001*
Q14	Is the human factor considered an obstacle which impedes the development of the marine field?	0.384*	<0.001*

rs : Spearman coefficient
Statistically significant at $p \leq 0.0$:*

7 Conclusion

All practical scientific fields care for the implementation of new technology due to its importance in saving time and achieving accuracy. Therefore, the marine sector is interested in applying new technologies such as the autonomous system technology in order to cope with the new technology revolution. However, the human factor will fall as a victim under such technology, hence, this research paper aims to prove that the presence of the human factor in the maritime sector is of great importance. Although the human factor is liable to err, eliminating it is impossible. The statistical survey proved that the expertise are not against the autonomous concept as long as it does not lead to probabilities of seafarers unemployment.

Thus, it is possible to depend on the autonomous system but in a limited manner that will help in saving time and protecting the marine environment which will not affect the employment levels of seafarers negatively.

Reference:

–Amdahl, Jørgen, Anders Endal, Geir Fuglerud, Liv Randi Hultgreen, URL: https://www.bloomberg.com/news/articles/2014-02-25/rolls

–Adams, S.D., 2014. ReVolt – next generation short sea shipping. [Online] Available https://www.dnvgl.com/news/revolt-next-

-Allan, R., 2016, the Ramora tugboat design. [Online] Available http://www.ral.ca/designs/tugboats

–Bendall, H.B and A.F Stent (2001). "A Scheduling Model for a High Speed Container Service:AHubandSpokeShort-SeaApplication".In: International Journal of Maritime Economics 3 (3), pp. 262–277.

–Bertram, Volker (2016). Unmanned & Autonomous Shipping - A Technology Review. 10th Symposium on High-Performance Marine Vehicles, pp. 10–24.

–Bertram, V., 2008. Unmanned Surface Vehicles a Survey. s.l., s.n. Bertram, V., 2016. Autonomous ship technology – Smart for sure, unmanned maybe. London, RINA, Royal.

–Brouer, Berit D., Christian Vad Karsten, and David Pisinger (2016). Big Data Optimization: Recent Developments and Challenges.SpringerInternationalPublishing Switzerland. Chap. Big Data Optimization in Maritime Logistics, pp. 319–343.

–Burmeister, Hans-Christoph, Wilko C. Bruhn, Ornulf J. Rodseth, and Thomas Porathe (2014). "Can Unmanned Ships Improve Navigational Safety?" In: Transport Research Arena. Paris.

–Carlson, J. M. and J. Doyle (2000). "Highly Optimized Tolerance: Robustness and Design in Complex Systems". In: Physical Review Letters 84 (11), pp. 2529–2532.

–Christiansen, Marielle, Kjetil Fagerholt, Bjorn Nygreen, and David Ronen (2012). Ship Routing and Scheduling in the New Millenium. Elsevier.

–Drewry(2010). ShipOperatingCostsAnnualReviewandForecast.

–Drewry Publishing, Nigel Gardiner.

–Dalamagkidis, K., Valavanis, K. & Piegl, L.A., 2012, 2nd edition. On integrating unmanned aircraft systems into the national airspace.

–EMSA, 2016. Annual Overview of Marine Casualties and Incidents 2016, s.l.: European Maritime Safety Agency.

–Egyptian authority for maritime safety, EAFMS 2019.

–Grinyak, V., 2016. Fuzzy collision avoidance system for ships. Journal of Computer and Systems Sciences International.

–Herman, D., Galeazzi, R., Andersen, J.C. & Blanke, M., 2015.

–Hillier, Frederick S. and Gerald J. Lieberman (2001). Introduction to Operations Research. New York: McGraw-Hill.

–IMO, 2017 (convention from 1972). Convention on the International Regulations for Preventing

Collisions at Sea, 1972 (COLREGs). [Online] Available
http://www.imo.org/en/About/conventions

–Institution of Naval Architects. Blanke, M. & Thomsen, J.S., 2006. Blanke, M. and J.S. Thomsen: Electrical steering of vehicles.

–Kongsberg (2017). "Autonomous Ship Project, Key Facts about YARA Birkeland". https://www.km.kongsberg.com/ks/web/nokbg.

–Kretschmann, Lutz, Hans-Christoph Burmeister, and Carlos Jahn (2017).

–Kretschmann, Lutz, Ørnulf Rødseth, Bénédicte Sage Fuller, Helen Noble, Jeffrey Horahan, and Hugh McDowell (2015).

–Løfstedt, B., J. F. Alvarez, C. E. M. Plum, D. Pisinger, and M. M. Sigurd (2010.(
Integer Programming Model and Benchmark Suite for Liner Shipping Network Design. DTU Management Engineering Report 19. Kgs. Lyngby: DTU Management.

–Lun, Y.H Venus and Michael Browne (2009).

–Rodseth, et . (2012), Developments toward the unmanned ship, Proceedings of International Symposium Information on Ships.
– ISIS 2012, Hamburg, Germany, August 30-31, 2012.

Codes:

'–Maritime UK Industry Code of Practice", version 1.0, November 2017 .

–MASS Code of Conduct": The Maritime Autonomous Systems Surface, MAS(S) Industry Code of Conduct made by the UK Marine Industries Alliance, March 2016 .

– "Ship Right Procedure": Cyber-enabled Ships.

– Ship Right procedure – autonomous ships, Lloyd's Register, first edition, July 2016.

Experimental Analysis of Crash Stop on Intermediate Marine Shaft Journal Bearing

Prepared by

Eng. Nour Marey

Arab Academy for Science, Technology and Maritime Transport

Prof. El-Sayed Hegazy

Ex. Dean of Faculty of Engineering, Sues Canal UNI.

Dr. Amman Ali

Vice Dean of Maritime Upgrading Studies Institute, Arab Academy for Science, Technology and Maritime Transport

Abstract:

Hydrodynamic journal bearings are always liable to problems relating to lubrication during shaft rotation. It is at this phase that the hydrodynamic oil layers required for bearing the shaft weights begin to form. Many previous researchers have worked on reducing the negative effect of this phenomenon. On the other hand, strict operating conditions affect the hydrodynamic lubrication film necessary to bear the shaft loads, such as the abrupt changes of rotation direction, known in the marine field by "Crash stop". This technique is resorted to in large ships of slow speed diesel engines in some cases of marine maneuvering. In other words, as per ship trails, it is mandatory to carry out "Crash stop" test on all new vessels, with the purpose of testing the ability to avoid collision. In the course of this study a number of tests of different time rates, instigated at 50 rpm as representing the worst conditions regarding ship maneuverability, were experimentally conducted, utilizing the Journal Bearing Test Rig (JBTR). Those tests have involved the first procedure comprising a non-stop rapid speed alteration (from 50 rpm anti- clockwise to 50 rpm clockwise), at a change rate of 100 rpm per second. The tests have then extended to embrace a gradual speed change and which was (from 50 rpm anti clockwise to 50 rpm clockwise), at a change rate of 10 rpm per 20 seconds.

For conducting such high-risk experiments on the journal bearing, all necessary safety precautions have been taken. Also, there has been continuous monitoring, aiming at keeping the journal bearing safe, throughout the conduct of such tests. The conclusions drawn on the grounds of the experimental tests, regarding crash stop procedures, have culminated in a realization of the very grave consequences incurred in as far the lubrication oil film within the journal bearing is concerned. The impacts that would ultimately result in a complete deterioration, wear and possibly failure of the journal bearing.

Keywords: Hydrodynamic Journal Bearing, Pressure Distribution, Crash stop, Journal Bearing Test Rig "JBTR", Lubrication, Propulsion Shafting System, Boundary Lubrication.

1.Introduction

Hydrodynamic journal bearings installed with the aim of carrying the intermediate shaft relating to the shafting system, in as far as marine applications are concerned, are known to be instrumental components by means of which propeller shafts of ships are usually supported. When it comes to the issues regarding the operational safety, reliability and maneuverability of a ship, there emerges the crucial role of the journal bearing in the shafting system in guaranteeing and meeting the needs of such safety criteria properly and adequately. It is noteworthy that journal bearing hydrodynamic lubrication is often faced with numerous obstacles regarding the ship maneuverability, among of which those arising on carrying out crash stop procedures would come to the fore. Crash stop has always been recognized as one of the risky conditions that would in certain cases have negative repercussions in as far as the effective lubrication within the journal bearings is concerned. Furthermore, in order that the crash stop maneuvering could successfully be carried out, the measures taken ought to observe and stick to certain criteria plainly stated in the regulations regarding ship maneuverability, issued by The Marine Safety Committee "MSC", ANNEX 6, and which illustrate the concept of stopping ability which states that in the full astern stopping test the track reach should by no means exceed 15 ship lengths (IMO, 2002).

Besides, it is very crucial for the main propulsion systems to be subjected to certain tests with view to demonstrating the characteristics pertaining to the astern response. Those tests have to be implemented at least over the maneuvering range regarding the propulsion system encompassing all of the control positions. Moreover, the shipyard would be assigned with the task of providing a test plan that also ought to be accepted by the class surveyor. Besides, in case definite operational characteristics were defined by the manufacturer, they ought to be included in the test plan, according to General Astern Characteristics, American Bureau of Shipping "ABS" Steel Vessel Rules, Sec 4-1-1/7.5 (ABS, 2018). Moreover, crash stop measure is known to be accompanied with certain failures negatively affecting journal bearing performance. They would, in most cases, result in excessive wear of The journal bearing white metal. Hence, the need arises to tackle such negative consequences incurred as a result of taking such crash stop procedures and hindering the efficient performance of journal bearings. Furthermore, on doing a survey regarding crash stop, it was found out that numerous maneuvering tests as well as full-scale trials have been carried out with view to evaluating the performance of a ship stopping abilities. However, maneuvers required by "IMO" standards include full astern stopping tests, which are unfortunately still neglected by many shipyards and class societies (Jan Babicz, 2015). Such crucial issues were not likely given sufficient investigations in the previous studies dealing with the optimal performance relating to the journal bearing.

2.Literature Review

Measuring the friction torque working on hydrodynamic plain journal bearing during start-up was the orientation of an experimental a study launched by Bouyer and Fillon, 2011. It was mainly the measurement of bearing torque during start-up under continuous variations of the specific pressure that was focused on in the obtained outcomes. Maximum torque at start-up was proved to increase linearly with specific pressure as long as the geometry and the materials remained the same. The friction coefficient at start-up was found out to be dependent on the oil supply temperature, the surface finish and the materials used during the contact. Considering the shaft and housing roughness was thus proved to be of much importance if precise results were to be fully achieved. (Bouyer and Fillon, 2011).

A research was instigated by Pickering, 2011, with view to investigating the tribological characteristics of journal bearings under boundary and mixed lubrication. The research was focused on the behavior of journal bearings during shaft startup, shutdown and low speeds. The study has elaborated on the problem of bearing wear with its undesirable and negative consequences on the effective performance profile and pressure loads. To overcome that obstacle, the researcher recommended surface hardening, polymer liners together with utilizing lubrication fluids with additives and enhanced materials. Besides, the author argued for the

need of a better understanding of that wear with
The aim of introducing the optimal solutions possible to enhance bearing life and to reduce costs. (Pickering, 2011).
In 2014, Muzakkir. et al, worked on analyzing the tribological failure of a heavy loaded, slow speed hybrid journal bearing. The researchers have tested the consequences resulting from hybridizing a magnetic arrangement within the conventional journal bearing system under the operating conditions of slow speed but in the existence of a heavy load. It was noted that the best solution to contain the severity of the use of lubricants with a magnetic bearing arrangement. In this way, the wear of the rotor and stator could be minimized as it obviated rotor fracture thanks to the action of the lubricant. (Muzakkir. Et al, 2014).
In an attempt to suppress the vibrations in rotating shafts Chasalevris and Dohnal, 2015, have deliberated the possibility of developing a journal bearing with variable geometry. The suggested bearing element has proved to be quit efficient in vibration quenching during the passage through resonance. A journal bearing of variable geometry had the ability to limit the vibration amplitude by up to 70% if compared to a conventional journal bearing. The fluid film itself was able to absorb the major portion of the vibrational energy. Thus, changing the effective damping and stiffness of the system was accessible via selective activation of an additional fluid film during critical operation. (Chasalevris and Dohnal, 2015).
In 2015, Simon, et al, set off on studying the transient effects and phenomena observed in hydrodynamic bearings. The researchers have made use of the Reynolds equation besides capturing cavitation in steady-state lubricated contacts with the aim of studying the transient effects in lubricated textured bearings. The study has also extended to include elasto-hydrodynamic and mixed lubrication regimes. It was found out that the design parameters tended to have a mutual influence regarding the transient response of textured surfaces. Further, it was discerned that poorly chosen texture, or texture operating outside of its design range, would ultimately incur a dramatic decline in performance. In transient regimes further worsening could be expected and needed to be considered by designers. The Researchers suggested using unconditionally convergent and stable algorithm that do not required switch functions. The way which appeared to provide an ideal tool to study texture bearings by means of solver. (Simon, et al. 2015).
The behaviors of hydrodynamic lubrication films under non-steady state speeds was the center of attention of a study conducted by Liu, et al. On achieving the final steady speed, the rate of the film thickness was noted to reach its maximum regarding the startup/shutdown process. On the other hand, in accelerating/decelerating motions, there was a variation regarding the film thickness accompanied by some time lag to the speed, but the change rate coincided with the speed. It was thus concluded that the film thickness could attain its steady value asymptotically during startup and shutdown process. Also, the squeeze effect was observed to reach its maximum at about the same time the final steady speed was achieved. Moreover, increasing the motion frequency was observed to be accompanied by a decrease in relation to the amplitude of the film thickness variation but with an increase in the phase delay. Hence, smaller load and lower speed maximum could help give longer time delay. (Liu, et al. 2016).
In an attempt to understand the impact of the applied static loads and rotational speeds, on the behavior of a 160 mm diameter cylindrical journal bearing with two axial grooves, Chatterton. et al, 2017, launched a beneficial study. It was by means of one proximity probe and one pressure probe that measuring the oil film thickness and the pressure was conducted. The oil film thickness was inclined to decrease on increasing the rotational speed. The oil film thickness profiles were no longer similar to circles as a result of the thermal expansion of the shaft and the system deformation. (Chatterton. et al, 2017).
In 2018, Prölß, Maximilian et.al, focused on the effects occurring as a result of mixed friction and warming of the components of journal bearings during run-ups. The operating behaviour regarding journal bearings for industrial machinery was investigated via a

Numerical simulation code based mainly on Reynolds equation among others. The experimental studies have emphasized predictions regarding temperature evolution of the fluid film. Storage effects of the solid bodies have resulted in the inertia of temperature distribution in the bearing, an issue that was elaborately investigated for various run-up speeds. It was observed that the boundaries of the model were what predictions of heat flow within run-up strongly relied on. Further, there were significant differences in absolute values, which meant the necessity of further promotions in relation to both the experimental procedures and the theoretical model (Prölß, Maximilian et.al, 2018).

3.Experimental JBTR Design and Construction

The following is an exposition of the different components embraced by the "JBTR", and which contribute together in achieving the aspired experimental ultimate prospections, regarding the hydrodynamic lubrication oil film of the journal bearings, in as far as marine field applications are concerned, and for which the discipline has primarily been structured. It is a device that could facilitate conducting versatile experimental tests borne in mind at the time being, or those that are most likely to be carried out in the future for the sake of deriving more outcomes on the basis of certified evidence. As is shown in figures (1&2), the oil film lubricant is supplied to the bearing at an inlet port located on the vertical center line of the journal bearing. When journal shaft rotates, pressure created inside is measured via the ten pressure transmitters, distributed around the circumference of the single groove plain bearing and is hence displayed on Programmable Logic Controller "PLC" as is clearly discerned via figure (3) to follow. Among the advantages relating to the JBTR is that an "Inverter" is integrated into the structure so that speed could be manipulated and rotation direction could as well be easily reversed. Furthermore, the validity of the journal bearing test rig "JBTR" experimental results could be ensured via numerous comparisons, held to prove their consistency and accordance with their previously derived theoretical counterparts. Hence, the journal bearing test rig could safely provide satisfactory evidence in terms of validity Required for the potential experiments that are most likely to be conducted on it in the future, as pointed out in reference, (Marey Nour, et al, 2018). Table (1), provides the main dimensions of the "JBTR" at hand.

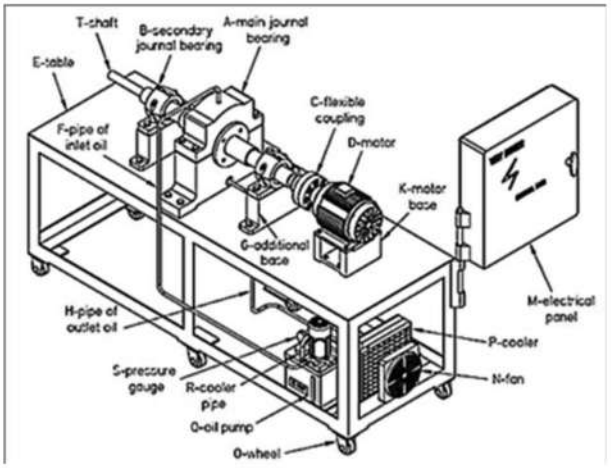


Figure 1: The Journal Bearing Test Rig "JBTR". (Marey Nour, et al, 2018)

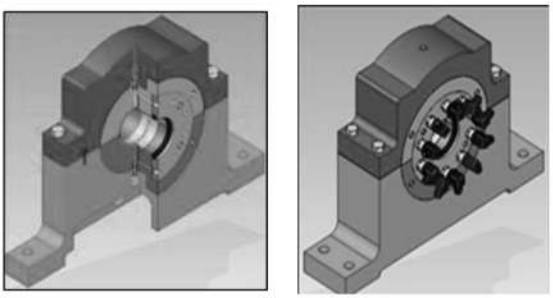


Figure 2: An outline of the distribution of the pressure transmitters around the journal bearing circumference. (Marey Nour, et al, 2018).

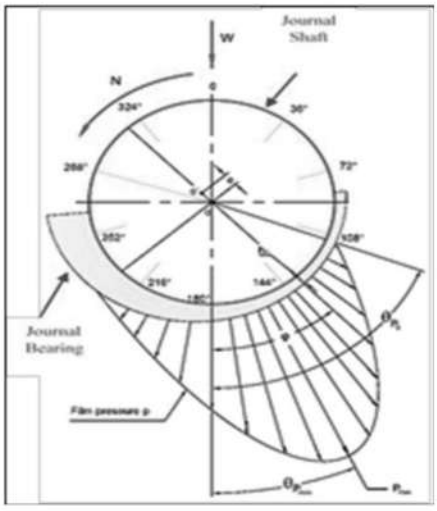


Figure 3: Journal bearing oil film pressure distribution

Table [1]: The dimensional data concerning the journal bearing test rig.

No	Discerption	Specification
1	L, bearing length	**58 mm**
2	d, inner diameter for plain bearing	**105.05 mm**
3	Φ_s shaft diameter	**104.97 mm**
4	W, Weight of journal shaft	**727.65 N**
5	C_0, total clearance	**0.08 mm**
6	C, radial clearance	**0.04 mm**
7	L/D ratio	**0.5**
8	Bearing material	**White metal**
9	Operating speed	**-50:+50 rpm**
10	Pressure Transmitter range	**0:10 bar**

4.Crash stop Procedures

For the sake of studying the impacts incurred as a consequence of applying the "Crash stop" maneuvering on the journal bearing, experimental tests have been carried out using a Journal Bearing Test Rig (JBTR). It is noteworthy that all safety precautions of the test rig have been taken due to the serious procedures that were to be conducted. The oil lubrication system has been prepared, checking that the oil level in the storage tank was normal. Further, the oil supply pressure has been adjusted to be 3.0 bar and at a temperature degree of 40 °C. The journal shaft direction has initially been anticlockwise. Besides, it is essential to note that conducting the experiment has entailed the

Use of a lubrication oil of grade SAE 5W30 as an optimal heavy duty option that is often utilized in numerous marine applications, and whose properties are given more detailed elaborations in table (2) to follow. The different experiments concerning the "Crash stop" measurement have hence been carried out and they came to comprise three main testing phases. The first phase has included a non-stop abrupt rapid speed alteration (from 50 rpm anti clockwise to 50 rpm clockwise), at a change rate of 100 rpm per second. The second phase has involved a gradual, speed change and which was (from 50 rpm anti clockwise to 50 rpm clockwise) at a change rate of 10 rpm per 20 seconds. The recorded values, relating to the oil film pressure distribution within the journal bearing under these conditions, have been recorded for further investigations. It is noteworthy that the third phase involving the normal operation test, concerning the pressure distribution within the journal bearing at a speed revolution of 50 rpm in both clockwise and anticlockwise directions passing through the stop position, has preceded launching the crash stop procedures. The next step has comprised holding versatile comparisons between the results obtained and their counterparts, acquired on the basis of the above mentioned testing phases relating to the crash stop procedures.

SAE 20W50 Parameters (Mobile, 2012)	Specification	Test Method
Density @ 15 °C	**0.855 g/ml**	ASTM D-7042
Kinematic Viscosity at 40 °C	**61.7 mm2/s**	ASTM D-7042
Kinematic Viscosity at 100 °C	**11.0 mm2/s**	ASTM D-7042
Viscosity index	**172**	ASTM D-7042
Flash point	**230 °C**	ASTM D-92
Pour point	**-42 °C**	ASTM D-97

Table (2): Properties of SAE 5W30 grade oil.

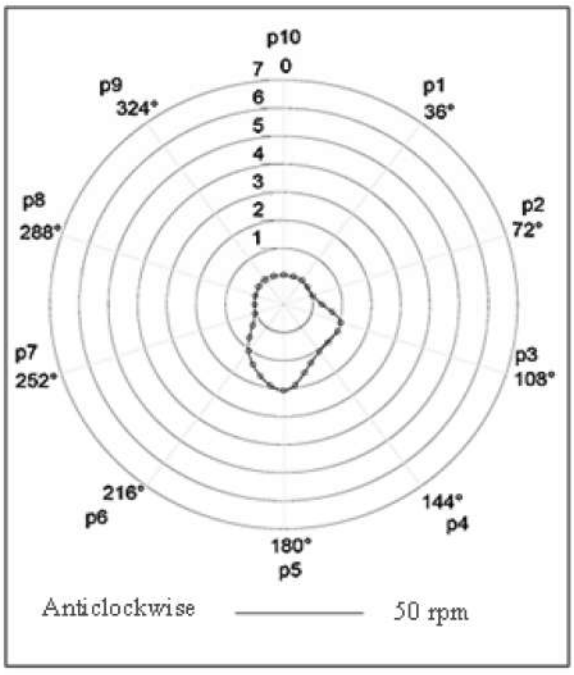
5. Results and Discussions

The study at hand has involved conducting numerous tests, pertaining to crash stop, with view to recognizing the extent of influence it might have on the performance of the journal bearings. Furthermore, identifying the oil film pressure distribution within the journal bearing, in such critical phases, as well as determining the type of lubrication have all been put into

much consideration on instigating the procedures, which in turn, have helped understanding the nature of deterioration that might be incurred, regarding the journal bearing, owing to the degradation of the lubrication oil film within it. All results acquired and registered on the basis of experimentally testing crash stop procedures, by means of Journal Bearing Test Rig "JBTR", are presented in polar diagrams concerning the oil film pressure distribution within the journal bearing using AUTOCAD (2010).

5.1Normal Operation Procedures

As shown in figure (4), it is clear that on testing, in either of clockwise or anticlockwise directions, the lubrication within the journal bearing has been of the type hydrodynamic lubrication, with the beneficial result of separating the moving surface from the stationary surface which indicates the existence of efficient lubrication.



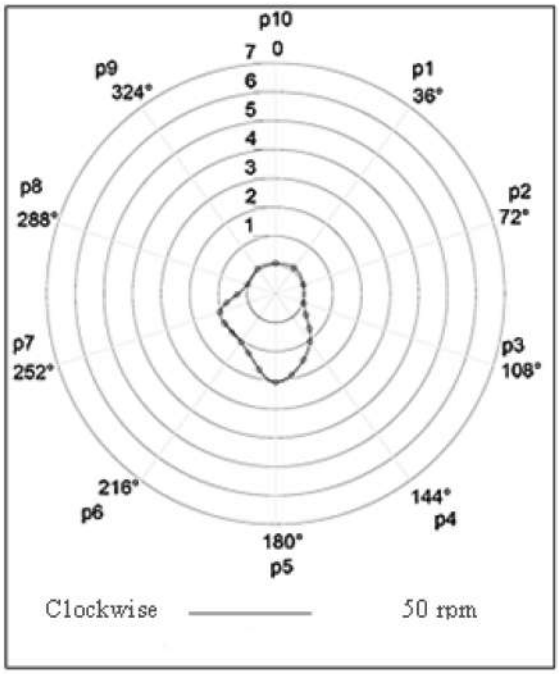


Figure 4: Oil film pressure distribution under normal operation procedures.

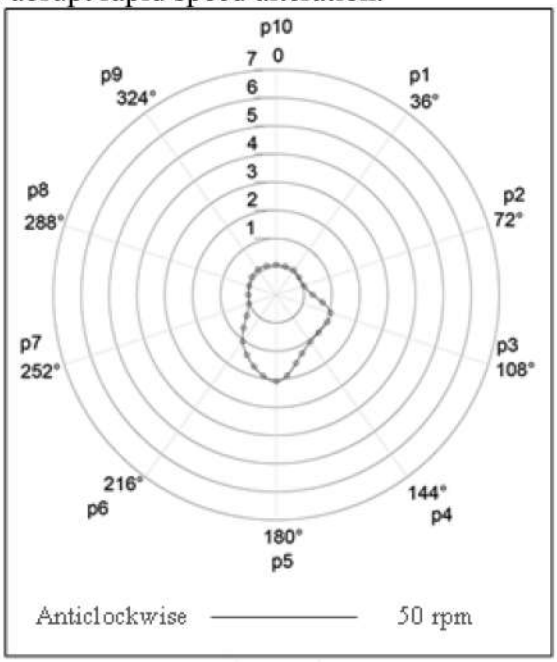
5.2Crash stop at a non-stop abrupt rapid speed alteration

The polar diagrams, pointed out below, would reveal all the recorded values relating to the lubrication oil pressure distribution within the journal bearing. Based on those polar diagrams, a number of observations could be discerned and could be illustrated as follows:

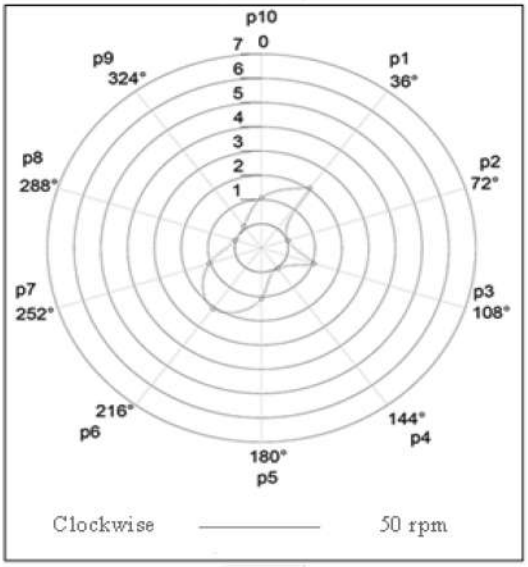
Figure (4) sheds light on the values relating to the pressure distribution within the journal bearing as obtained under normal operation procedures. Those values were found out to be in proportion with the slow speed of 50 rpm, in an anticlockwise direction, relating to crash stop procedures carried out at a non-stop abrupt rapid speed alteration figure (5, a). Further, it was observed that the highest value regarding the oil pressure profile at this speed limit has acquired a value of 2.075 bar. However, pressure values tended to feature a significant fall at an angle of 1440, incurred as a consequence of reversing the rotation direction in an abrupt and sudden way figure (5, b). That would indicate a deterioration in regard to the lubrication oil film at this region. Hence, the type of lubrication would turn from hydrodynamic lubrication type to boundary one.

That sudden shift would trigger some undesirable risks arising from metal-to-metal contact, which in turn, would result in hazardous deterioration of the journal bearing.

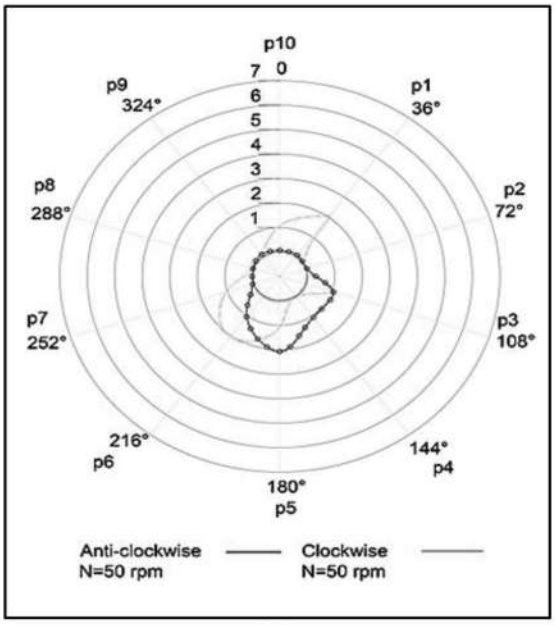
Furthermore, figure (5, b) would shed light on the fact that at an angle of 360, the pressure value tended to feature a sudden increase reaching 2.065 bar with the consequence of increasing the upper load exerted on the journal shaft. In addition, figure (5, c) would point out the consequences incurred on launching crash stop procedures under a non-stop abrupt rapid speed alteration.



(a)



(b)



(c)

Figure 5: A polar diagram regarding crash stop under a non-stop abrupt rapid speed alteration.

5.3Crash stop as undergoing a gradual speed change

Table (3) Oil pressure distribution discrepancies as incurred via gradual speed changes.

Journal shaft speed	Radial Pressure Variation Distribution at 10 Different Sensors (Bar) SEA 5W30									
RPM / 20 Seconds	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}
-50	0.075	0.042	1.054	1.065	2.074	1.052	0.035	0.034	0.116	0.062
-40	0.076	0.042	1.055	1.063	2.072	1.054	0.035	0.038	0.117	0.062
-30	0.076	0.042	1.055	1.062	1.071	1.055	0.036	0.041	0.117	0.063
-20	0.076	0.042	1.053	1.058	1.066	1.055	0.036	0.047	0.120	0.064
-10	0.075	0.041	1.052	1.044	1.062	1.084	1.044	0.058	0.123	0.065
Changing Speeds from Anticlockwise to Clockwise										
+10	0.076	0.041	1.051	0.037	1.065	3.091	1.045	0.058	0.124	0.068
+20	0.078	0.042	1.051	0.033	1.067	3.096	1.046	0.059	0.124	0.069
+30	0.078	0.042	1.051	0.033	1.068	3.096	1.048	0.061	0.124	0.071
+40	0.078	0.042	1.051	0.033	1.068	3.096	1.048	0.061	0.124	0.071
+50	0.078	0.042	1.051	0.033	1.068	3.100	1.048	0.062	0.124	0.071

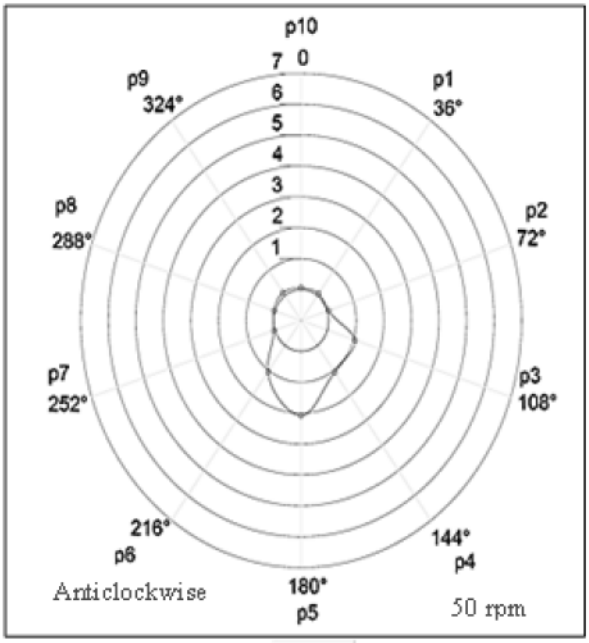
Noteworthy to say that the experiments, conducted to estimate the oil film pressure distribution in the course of the crash stop moments, have initially been conducted under a gradual, speed change from 50 rpm anti clockwise to 50 rpm clockwise, at a change rate of 10 rpm per 5 seconds. However, it was discerned that carrying out the tests under such circumstances would incur undesirable risks on the journal bearings of the test rig. Consequently, a decision has been made to implement the required tests at a change rate of 10 rpm per 20 seconds, which proved to be safer regarding the journal bearing test rig deterring any likelihood of the hazardous metal-to-metal contact phenomenon that would otherwise negatively affect the effective operation of the journal bearing test rig.

On the other hand, the polar diagram figure (6) gives further elaborations on the course crash stop procedures would take on conducting experimental tests, under a gradual speed change ranging from 50 rpm anticlockwise to 50 rpm clockwise, and at a change rate of 10 rpm per 20 seconds. It is noted that the lubrication oil pressure tends to feature a significant decrease on carrying out the test under a speed limit of 30 rpm in the basic rotation direction as shown in figure (6, c), which is anticlockwise. That reduction, concerning the oil pressure profile, would amount to 50 % indicating the existence of transient lubrication at this speed. The pressure value is observed to remain constant up till a speed limit of 10 rpm in the same direction figure (6, e).

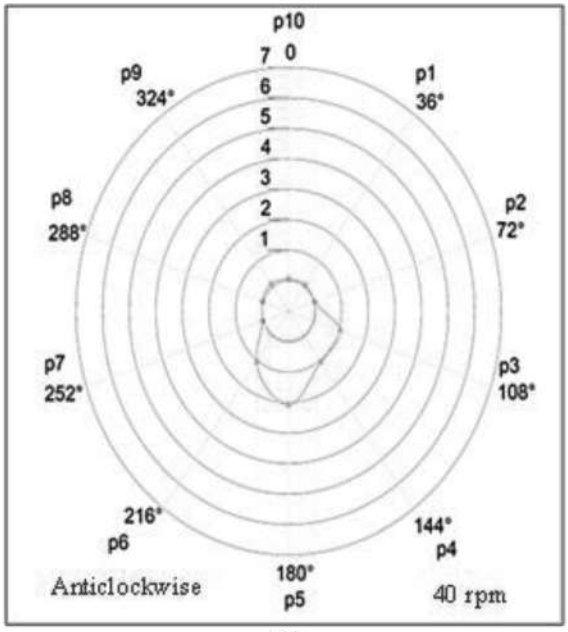
The previously mentioned observations would reflect the bad and inefficient lubrication throughout this stage. Maximum pressure is inclined to feature some increases at an angle of 1800 on reversing rotation direction gradually, where the oil pressure would acquire a value of 3.1 bar. That would mean an increment percentage of 50 %, where the lubrication oil would suffer a complete failure at an angle of 1440, obtaining a value of 0.0 bar. That sudden and abrupt failure would lead the cavitation phenomenon to show signs. Cavitation could be defined as the formation and collapse of bubbles on a surface due to rapid pressure changes, leading to the collapse of the journal bearing with the possibility of metal-to-metal contact between the bearing angles of 1080 and up till 1800.

That state is noted to remain constant at a speed limit of 10 rpm and until the gradual speed increments reach the value of 50 rpm as illustrated in figure (6, k). However, the steady state condition would be reached after the passing of 4 minutes, where the maximum pressure would return to assume its original value of 2.07 bar at an angle 1800, and where the cavitation phenomenon which showed signs at an angle of 1440 would disappear. At this point the pressure value would rise and obtain its previous value of 1.07 bar .

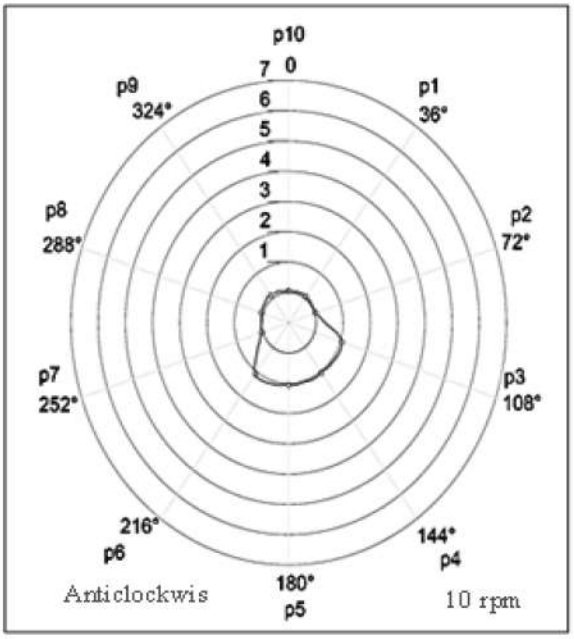
Based on the outcomes of the investigation, it is discerned that the crash stop procedure would constitute a major risk regarding the performance of the journal bearing. The reason is that carrying out crash stop would negatively affect the lubrication oil film, which in turn, would ultimately lead to journal bearing erosion and failure. Moreover, more conclusions could be drawn from figure (7), which clarifies the course crash stop would take on being subjected to a gradual speed change.



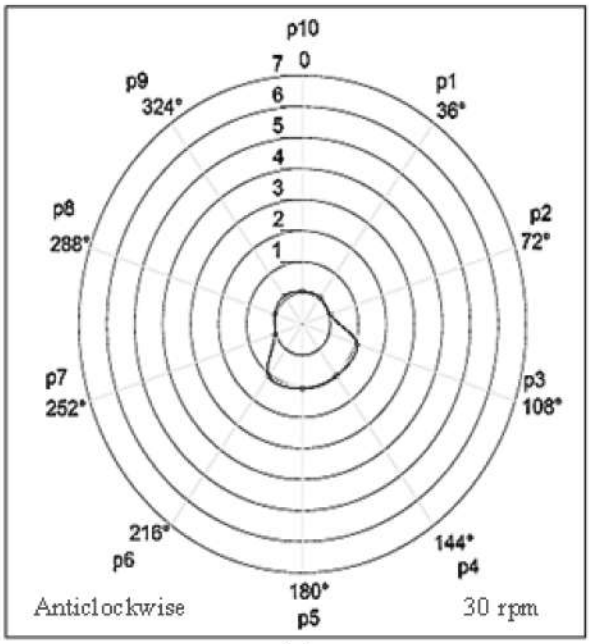
(a)


p10
7 0
p1
36°
p2
72°
p3
108°
144°
p4
180°
p5
216°
p6
p7
252°
p8
288°
p9
324°
Anticlockwise
40 rpm

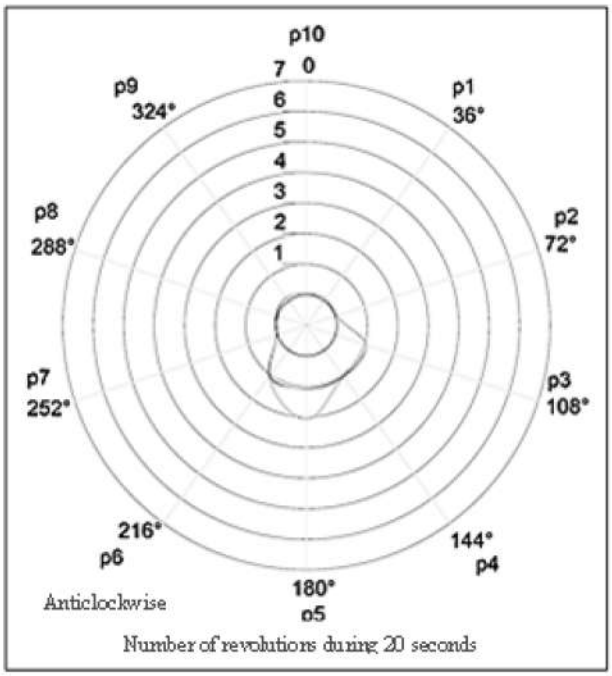
(b)


p10
7 0
p1
36°
p2
72°
p3
108°
144°
p4
180°
p5
216°
p6
p7
252°
p8
288°
p9
324°
Anticlockwis
10 rpm

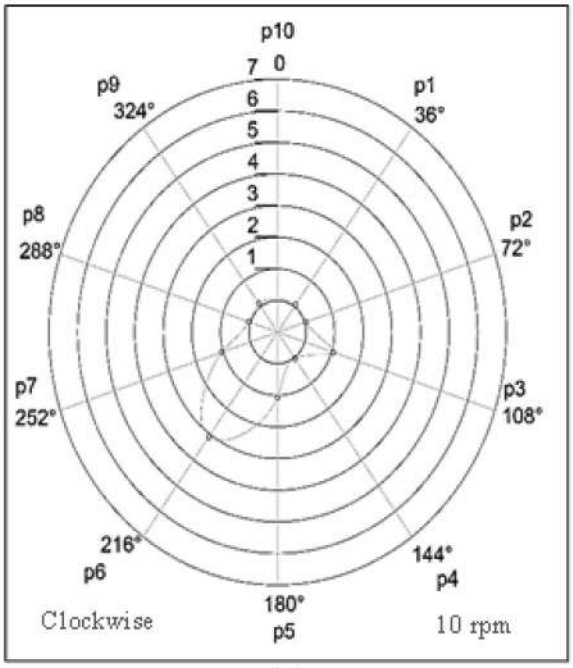
(e)


p10
7 0
p1
36°
p2
72°
p3
108°
144°
p4
180°
p5
216°
p6
p7
252°
p8
288°
p9
324°
Anticlockwise
30 rpm

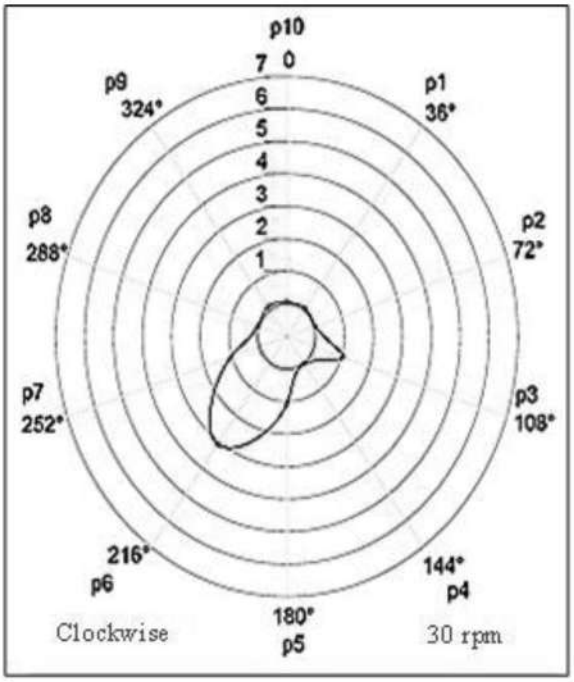
(c)


p10
7 0
p1
36°
p2
72°
p3
108°
144°
p4
180°
p5
216°
p6
p7
252°
p8
288°
p9
324°
Anticlockwise
Number of revolutions during 20 seconds

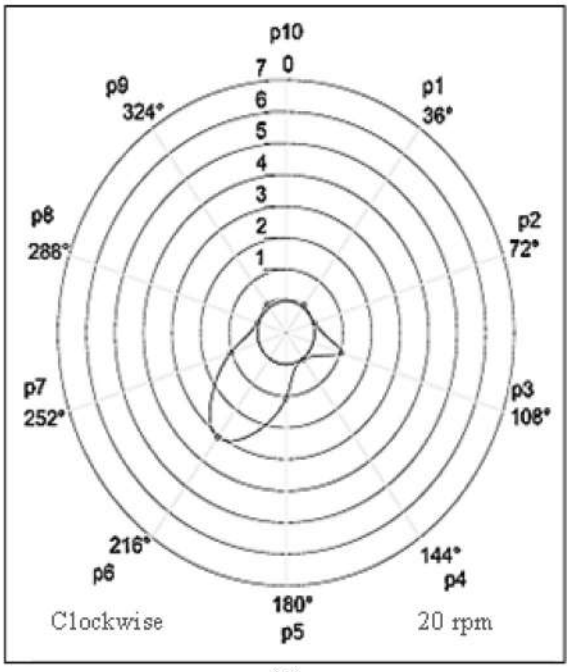
(f)


p10
7 0
p1
36°
p2
72°
p3
108°
144°
p4
180°
p5
216°
p6
p7
252°
p8
288°
p9
324°
Clockwise
10 rpm

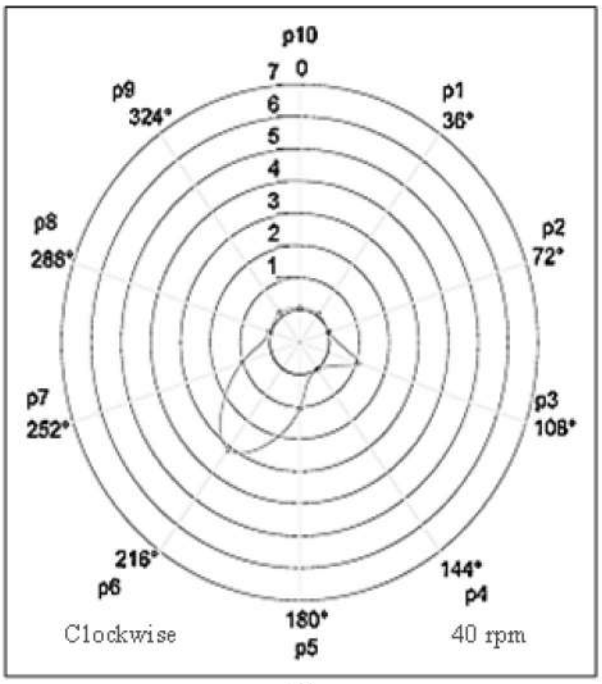
(g)


p10
7 0
p1
36°
p2
72°
p3
108°
144°
p4
180°
p5
216°
p6
p7
252°
p8
288°
p9
324°
Clockwise
30 rpm

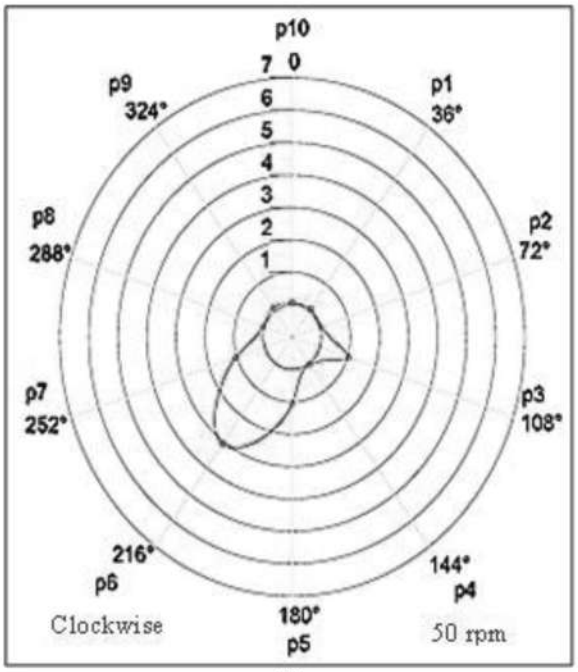
(i)


p10
7 0
p1
36°
p2
72°
p3
108°
144°
p4
180°
p5
216°
p6
p7
252°
p8
288°
p9
324°
Clockwise
20 rpm

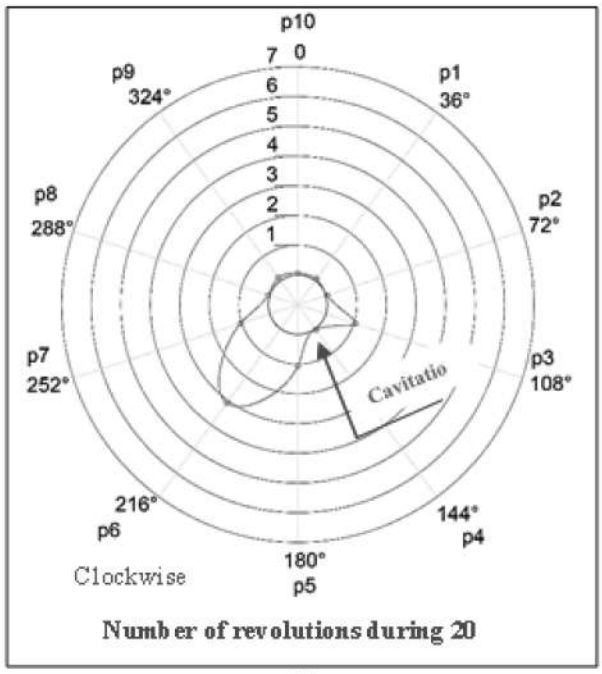
(h)


p10
7 0
p1
36°
p2
72°
p3
108°
144°
p4
180°
p5
216°
p6
p7
252°
p8
288°
p9
324°
Clockwise
40 rpm

(j)

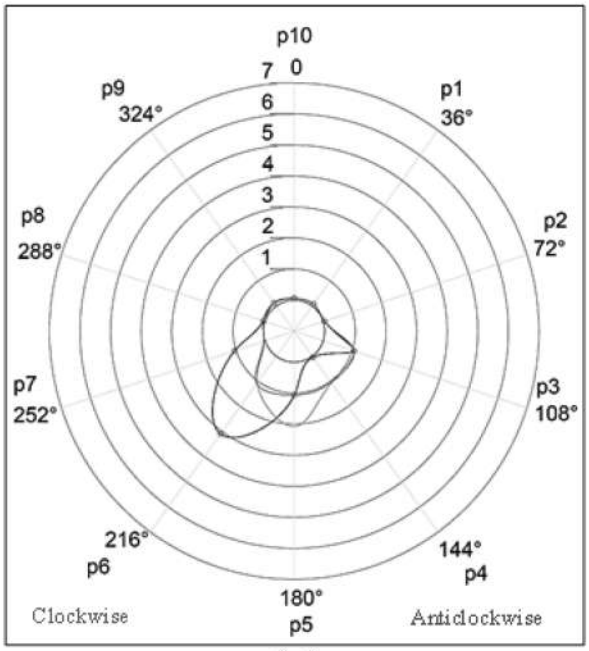


(k)



(l)

Figure 6: An illustration of the oil film pressure distribution during a gradual, speed change from 50 rpm anti clockwise to 50 rpm clockwise, at a change rate of 10 rpm per 20 seconds.



(m)

Figure 7: An outline of the behavior relating to crash stop under a gradual speed change.

6.Conclusion

Crash stop procedures could safely be deemed to have very negative consequences on the lubrication oil film. It could lead to the failure of the lubrication oil film, assigned with separating the stationary surface from the moving surface within the journal bearing. That realization is true for all crash stop conditions, whether the change in reversing the movement was rapid or gradual. In other words, the failure of the journal bearing would be rapid and hazardous for the shafting system discipline, in charge of the ship thrust transmission efficiency, in case the change in direction was fast and abrupt .

On the other hand, carrying out the crash stop procedures at a gradual change rate would possibly lead to minimizing the risks endangering the lubrication oil film, responsible for the performance of the journal bearing. Reducing the risks threatening the lubrication oil film within the journal bearing could particularly be an attainable goal, if the speed change rate was slowed down until it reaches a complete stoppage and then rotating in the other direction in a normal way.

In addition, previously carried out trials have ignored the issue of the ship propelling

Discipline as related to the journal bearing. The reason behind that neglect was the apprehension of the bad and negative consequences on the performance of the diesel engine main bearings, the journal bearing shafting system together with the failure of the lubrication oil film. Such consequences would also involve issues like vibration and twisting moment regarding the shafting system. Thus, shipyards have confined their testes to sea trials, despite the fact that ship captains would sometimes be obliged to resort to crash stop procedures as a means of protecting ships from collision.

7.Recommendations

In order that the beneficial requirements, clearly stated by The Marine Safety Committee "MSC" of the International Maritime Organization "IMO", and aspiring to deterring the negative repercussions incurred on resorting to the crash stop procedure could be properly met, it is crucial for the journal bearing of the shafting system to be provided with a fully controlled additional lubrication oil system, that could be made active at a shaft speed ranging from 0 up till 30 rpm in both directions, with view to carrying out the lubrication process of the journal bearing by force, besides creating an oil feeding discipline that is located in the mid bottom position of the plain bearing. Also, the need arises for a future study, aiming at enhancing the lubrication oil pressure distribution in the journal bearing during crash stop procedures, with the aim of meeting the requirements of the "IMO", plainly stated in "MSC", ANNEX 6 (IMO, 2002). Finally, if these prerequisites were to be achieved, it would surely lead to realizing the final aspired most beneficial goal of increasing the ship energy efficiency.

Nomenclature

ABS	American Bureau of Shipping
C	Radial Clearance (mm)
C0	Total Clearance (mm)
d	Inner Diameter For Plain Bearing
e	Eccentricity (mm)
JBTR	Journal Bearing Test Rig
L	Bearing Length (mm)
MSC	Marine Safety Committee
N	Speed (rpm)
P0	Terminating Film Pressure (bar)
Pmax	Maximum Film Pressure (bar)
W	Weight of Journal Shaft (N)
Φs	Shaft Diameter (mm)
μ	Dynamic viscosity (C.st)

8 References

American Bureau of Shipping. (2018). Rules for Building and Classing Steel Vessels, Part 4, Vessel Systems and Machinery. https://ww2.eagle.org/en/rules-and-resources/rules-and-guides.html.

Bouyer, J., & Fillon, M. (2011). Experimental measurement of the friction torque on hydrodynamic plain journal bearings during start-up. Tribology International, 44(7–8), 772–781. https://doi.org/10.1016/j.triboint.2011.01.008

Chasalevris, A., & Dohnal, F. (2015). A journal bearing with variable geometry for the suppression of vibrations in rotating shafts: Simulation, design, construction and experiment. Mechanical Systems and Signal Processing, 52–53(1), 506–528. https://doi.org/10.1016/j.ymssp.2014.07.002

Chatterton, S., Dang, P. V., Pennacchi, P., De Luca, A., & Flumian, F. (2017). Experimental evidence of a two-axial groove hydrodynamic journal bearing under severe operation conditions. Tribology International, 109(November 2016), 416–427. https://doi.org/10.1016/j.triboint.2017.01.014.

International Maritime Organization. (2002). Resolution MSC.137(76), (adopted on 4 December 2002) Standards For Ship Maneuverability.

Liu, H. C., Guo, F., Zhang, B. B., & Wong, P. L. (2016). Behavior of hydrodynamic lubrication films under non-steady state speeds. Tribology International, 93, 347–354. https://doi.org/10.1016/j.triboint.2015.09.026

Marey, Nour. Hegazy, El- Sayed & Ali, Amman. (2018). Design and Setup for a Journal Bearing Universal Test Rig. Port-Said Engineering Research Journal, Vol. (22), No. (1) March, ISSN 1110 – 6603

Muzakkir, S. M., Lijesh, K. P., & Hirani, H. (2014). Tribological failure analysis of a heavily loaded slow speed hybrid journal bearing. Engineering Failure Analysis, 40, 97–113. https://doi.org/10.1016/j.engfailanal.2014.02.016

Mobil, (2012). Mobil 1 5W30, Advanced Full Synthetic Engine Oil. www.mobil.com/USA-English/Lubes/PDS/GLXXENPVLMOMobil1_5W-30.aspx

Prölß, Maximilian. Schwarze, Hubert. Hagemann, Thomas. Zemella, Philipp. Winking, Philipp. (2018). Theoretical and Experimental Investigations on Transient Run-Up Procedures of Journal Bearings Including Mixed Friction Conditions, Lubricants 2018, 6, 105; doi:10.3390/lubricants6040105.

Simon Medina, Mark T. Fowell, Sorin-Cristian Vladescu, Tom Reddyhoff, Ian Pegg, Andrew V. Olver, and Daniele Dini. (2015). Transient Effect in Lubricated Textured bearings. Archive Proceedings of the Institution of Mechanical Engineers Part J Journal of Engineering Tribology 1994-1996 (vols 208-210).

Pickering, S. (2011). Tribology of Journal Bearings Subjected to Boundary and Mixed Lubrication. Mechanics of Contact and Lubrication.

Agreement on the Demarcation of the Northern Maritime Boundaries and its Impact on the Egyptian Economy

Prepared by

Captain Essam El-Din Youssef Abdel-Raouf

Captain Ahmed Raafat Riad NasrEl-Din

Arab Academy for Science, Technology and Maritime Transport

Abstract:

Maritime boundaries are clearly defined in the United Nations Convention on the Law of the Sea, in 1982. Some countries dispute their maritime borders. That is why the United Nations has paid much attention to this issue, and how disputes that may arise between countries in conflict over their maritime borders can be resolved. Egypt is one of the countries that have common maritime borders with many countries, whether in the Mediterranean or the Red Sea.

Thus, the Egyptian state has the right to exploit all of its marine resources in accordance with international law. In order to avoid any future conflict and the freedom to exploit and extract those riches, an agreement must be made to demarcate the maritime borders of the Egyptian state. In this paper, authors discussed the state of the Egyptian maritime borders, and how Egypt was one of the first countries in the region to demand the delineation of maritime borders since 1951. As well as the size of large and good discoveries of marine resources as a result of the demarcation of borders and excavations within the Egyptian maritime borders and their great benefits that lead to improvement in the Egyptian economy in general.

This paper discussed the issue of demarcation of maritime boundaries of offshore States and the rules for delineation of maritime boundaries of coastal States in accordance with the 1982 United Nations Convention on the Law of the Sea.

Key words maritime, boundaries, borders, UNCLOS, territorial, economic.

1.Introduction

The seas have always been a battleground for sovereignty struggles by coastal states, long ago since the vast natural resources have been discovered beneath the sea. As a result, the principle of freedom of the sea has been significantly modified since its adoption in the seventeenth century, thus allowing coastal States to claim jurisdiction over waters adjacent to their coasts, and the boundaries of the coastal State's jurisdiction over their coasts have varied over the years. From 3 nautical miles to what they are now as defined in the (UNCLOS, 82).

In view of the historic evolution of the authority of the coastal States, it began in 1958, when the first United Nations Conference on the Law of the Sea was convened, which brought together 86 States, and adopted four international treaties covering regional seas, the deep seas, and region's economic zone and human resources. In 1960, the Second United Nations Conference on the Law of the Sea was convened in order to create an agreement on territorial sea boundaries and fishing rights. In 1967, the UN General Assembly decided that the change in technology and modern variables in the world made it imperative for the international community to focus on the legal issues governing the regions of the sea beyond the jurisdiction of the costal state. Meetings continued from 1970 to 1982, when the UNCLOS, 82 was promulgated in 1982. This Convention set out the rules that reflected the recent trends in the law of the sea. The coastal State extended its jurisdiction towards the high seas and consequently the high seas region have been contracted.

2. Maritime Boundaries:

Maritime boundaries are clearly defined in the United Nations Convention on the Law of the Sea, 1982. Articles 2 to 16 define territorial waters, while Article 33 sets out what is a contiguous zone (regional adjacent), Articles 55 to 75 specify what is an exclusive economic zone, and finally articles 76 to 85 defines limits of the continental shelf. All of the above-mentioned areas are measured towards the sea from the baseline, with the exception of inland waters being measured towards the ground. These four areas are often an important subject during the delimitation of the maritime boundary of the coastal state. (UN, 2000).

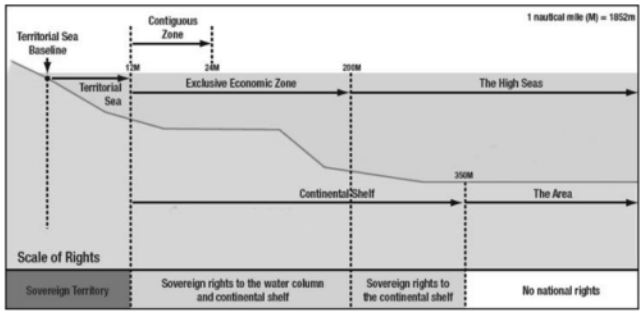


Figure (1): The various regions of the ocean over which a State may exercise sovereignty
Source: https://www.civilsdaily.com

3. Egyptian Maritime Boundaries division:

Egypt has been interested in maritime boundaries since the beginning of deliberations and was a member of the 1930 Hague Conference (UN, 1930). The process of declaring the Egyptian maritime borders began in 1951 and ended in 1990 through a set of national decrees and decisions.

3-1 Egyptian decrees:

A Royal decree on the territorial waters of the Kingdom of Egypt was issued on January 15, 1951 and published in (the Official Gazette) Al-Waqaae Newspaper, Issue No. 6 dated 18/1/1951. Article (4) stipulates that the water under national jurisdiction of the territory of the Kingdom of Egypt shall include all any Gulf waters along the coasts of the Kingdom, the above-ground waters not more than twelve nautical miles from the land or from any Egyptian island, as well as the water between it and the land, the water between the land and any Egyptian island not far from the land 12 nautical miles, as well as the water between the Egyptian one of which is 12 nautical miles away, and that the costal sea of the Kingdom is located beyond waters nder national jurisdiction of the Kingdom extends towards the sea to a distance of six nautical miles.

Presidential Decree No. 27 of 1990 concerning the baselines from which the maritime areas of the Arab Republic of Egypt are measured, Published in the Official Gazette No. 3 of January 18, 1990, Article 1 of which stipulates that the maritime areas under the sovereignty and jurisdiction of the Arab Republic of Egypt,

Including its territorial sea, shall be measured, including its regional sea, and shall begin from the straight baselines, which are related to the total points identified by the coordinates in that resulotion. Article 2 refers to two annexes, one defining the coordinates relating to the Mediterranean Sea and the second coordinates of the Red Sea, provided that the annexes are an integral part of this resolution. Article III provides that the lists of coordinates contained in this resolution shall be announced in accordance with the rules in force in this regard and shall be notified to the Secretary-General of the United Nations.

3.2 Inland waters:

Article 8 of the 1982 United Nations Convention on the Law of the Sea stated in paragraph 1 "water that is confined beyond the State's baseline towards the shore is part of inland waters."

Article 4 of the 1951 decree, as amended in 1958, stated:

The inland waters of the Republic include:

(A) Water bays on the coasts of the Arab Republic of Egypt;

(B) Water above any low elevations located 12 nautical miles from the mainland or any Egyptian island, as well as water between these lowlands and the mainland;

(c) Water between the mainland and any Egyptian island not more than 12 nautical miles from the mainland;

(D) Water between the Egyptian islands at distance between each other does not exceed 12 nautical miles.

Obviously, Egypt chose the straight baseline system, and in fact Egypt was the second Mediterranean country after Yugoslavia to implement straight baselines (Letalik, 1988) because of the nature of the coastline and the presence of bays, and high tides.

However, by examining the 1951 decree, the following were found to be incompatible with **UNCLOS and may affect the baselines created:**

(A) The decree defines the bays as "any bay, entrance or arm of the sea". In accordance with Article 10 of the Convention, the Gulf is considered a Gulf only when a certain ratio Between width and water within it is specified. Article 10/2 of UNCLOS,1982 defines the Gulf as a clearly defined dent which, by analogy to the Width of its entrance, in such a way it contains water confined to the land, and constitutes more than one curve"shall not be considered as a bay unless it is an area equal to half a circle with a diameter drawn through or beyond the entrance of that dent." (UN, 1983)

(B) Another erroneous definition is the definition of the Island; "Island means any island, coral reef, rock or any permanent man-made structure not submerged at low tide". The island is defined in the United Nations Convention on the Law of the Sea in Article 121, "its plots of land are naturally formed, surrounded by water, and above water at high tide". Furthermore, in Article 60, paragraph 8, "artificial islands, installations and structures do not have the status of islands."

(C) The decree equates the lowlands with the islands 12 nautical miles from the mainland. Although Article 13 provided equitably in Paragraph 1 of UNCLOS states that "the low water line at that altitude can be used as a baseline for the measurement of the territorial sea width"; Article 7 provided equitably in Paragraph 4 considers only low tidal elevations as points Reference when there are beacons or similar structures built on them.

(D) Although Egypt has delta, considered to be highly unstable, it has not declared its right to change baselines in the future if the nature of the coastline changes, in accordance with Article 7, paragraph 1.2 of the Convention.

3.3 Territorial waters:

In the statement accompanying the Egyptian ratification of the United Nations Convention on the Law of the Sea in 1982, the opening statement was:

"Egypt determines the width of its territorial sea to 12 nautical miles, pursuant to Article 5 of the Order of 18 January 1951, as amended on February 17, 1958, in line with the provisions of Article 3 of the Convention." The territorial waters have been defined as the waters spanning 12 nautical miles to the sea of "inland waters", this is theoretically true, but in order to conform the convention it would be more appropriate to

Say that it extends towards the sea from the "baseline". Furthermore, the Decree continues to establish baseline mapping rules in a mix of regular and straight baselines, rather than article 14 of the Convention.

3.4 Contiguous area:

The contiguous area was originally claimed in the decree of 1951, with a width of 6 nautical miles beyond the territorial sea "to enforce security, navigation and other financial and health laws and regulations." Although later in 1983 it was extended to 12 nautical miles, but the decree has not been amended since then, leaving a contradiction between the decree and the Declaration. In addition, the decree must detail the sovereign rights of the state in the region, rather than the vague statement above. It is mentioned in Article 33, paragraph 1, of the Convention, which states that the State has the right to exercise controls in the Area to prevent violation of customs, financial, immigration and health laws.

3.5 Continental Shelf:

In the 1958 decree, Egypt claimed the continental shelf to width of 200 miles instead of the 1956 Bill of the Sea, this has not yet been updated ratification of the United Nations Convention on the Law of the Sea, mainly because of the Declaration of ratification in 1983, Egypt has recognized that economic waters 200 Nautical miles, which implicitly claims the continental shelf for the same width. As described by Hollis & Rosen (2010), "UNCLOS contains provisions for States to claim a continental shelf of 200 nautical miles from the baseline."

3.6 Exclusive Economic Zone:

The idea of an exclusive economic zone is that the coastal state has the right to extend its economic control to large areas adjacent to its shores, where it has the right to explore and exploit unilaterally the living and non-living wealth of that area. In 1983, Egypt ratified the United Nations Convention on the Law of the Sea, and reached to the Declaration of ratification stating that from the day on which it ratified the Convention, sovereignty rights shall be exercised over the exclusive economic zone adjacent to the territorial sea in the Mediterranean Sea and the Red Sea likewise. With Parts 5 and 6 of the Convention, the right to explore and exploit the seabed, groundwater and contiguous waters, for living or non-living resources, to establish structures, or all other activities relating to the exercise of their rights. Interestingly, the announcement did not specify exactly the breadth of the exclusive economic zone.

3.6.1 Sovereign and jurisdiction Rights of the Coastal State over the Exclusive Economic Zone:

The purpose of establishing the exclusive economic zone is to ensure that the coastal State controls the entire wealth of the seas adjacent to its shores. Living resources in the area mean natural resources of all kinds, whether plant or animal, whether found on the surface of the water, or within its column, or on the bottom, or below the bottom of the area, and the definition given in Article 55 of the Convention for the region shows that the coastal State sovereign and jurisdiction rights over it.

Sovereign rights are limited to Article 56 of the provision stating that the coastal State in the exclusive economic zone shall have sovereign rights for the purpose of exploring, exploiting, conserving and managing living and non-living natural resources of the water above the seabed, seabed and subsoil thereof, as well as other exploration activities and economic exploitation of that region, such as the production of energy from water, currents and wind.

4. Delimitation of Maritime Boundaries

The delimitation of a maritime boundary is intended to establish the boundary between two maritime zones. This determination is usually the result of negotiations between the States concerned and is governed by the international law of the sea (as per the 1982 United Nations Convention). In the event of a dispute, the delimitation of the boundary is to be made by an arbitral tribunal if the parties to the dispute accept it, Therefore, the demarcation of maritime boundaries relates to territorial waters, the continental shelf, and the exclusive economic zone of each coastal State.According to the Law of the Sea and the International Court of Justice.

The International Court of Justice (1969) noted that the demarcation of maritime boundaries was a process "to delineate the boundaries of an already existing region, in principle, and not to define a new one." As in the Mediterranean, where no one country out of 20 oversees it, far from the other, either opposing or adversely over a distance of 400 nautical miles (Attard, 2001). Egypt is no different. Mixing maritime borders with Cyprus, Turkey and Greece in opposition to Libya and neighboring Israel. Not to mention the interference in the Red Sea with the Kingdom of Saudi Arabia, Jordan and Sudan. All these issues are related to the Egyptian maritime borders.

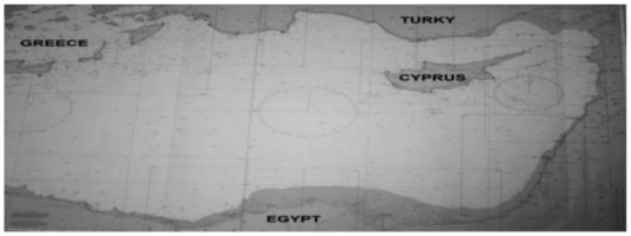


Figure (2): BA Chart 183 Ra's at Tin to Iskenderun
Source: United Kingdom Hydrographic Office, (1992)

4.1 Bilateral Agreement between Egypt and Cyprus

In 2003, the two countries agreed to define the exclusive economic zone for each contry by drawing a middle line based on the principle of equality of baselines on both parties (Arab Republic of Egypt and Republic of Cyprus, 2003). This meridian line consists of 8 points with fixed coordinates (Annex 1 of the Agreement) from 1 to 8 (West to East) as shown in Figure 3, as stated in Article 1 of the Agreement.

In Article 2 of the Agreement, the two States agreed that natural resources that might extend from one Party's exclusive economic zone to the other's exclusive economic zone, so another agreement should be undertaken to modify the exploitation of these resources. In Article 3, the Agreement clearly stated that "if either party would be involved in the demarcation of a border with a third party in contact with the meridian line, the notification and consultation With the other party should be subject to notification".

Article 4 provides that in the event of disputes that may arise from the implementation of this Agreement, diplomatic channels shall be used first and, if not, the dispute shall be referred to arbitration.

Figure (3): The maritime boundary line between Egypt and Cyprus.
Source: (UN, 2003)

4-2 Dispute:

As soon as the bilateral agreement was signed, the State of Turkey objected in 2004 to the Secretary-General of the United Nations on the grounds that the intermediate line agreed in points 1 to 6 had overlapped with other EEZ countries in the region (UN, 2004).

Cyprus responded to this objection in 2005, and correspondence between Turkey and Cyprus through the United Nations continued until 2006, ceasing without serious action to abolish the Convention (UN, 2005a, 2005b, 2006). Interestingly, Egypt had no role in this correspondence.

In a similar way, but relatively late, in 2013 the Egyptian parliament approved draft law 3 recommending the abolition / revision of the above-mentioned convention due to various points of non-compliance with UNCLOS, violation of the Cyprus Convention, and neglect **by the Egyptian government. Points are as follows:**

A. Article A endorsed equivalence as a principle in the Convention, and its use in further conflicts, without reference to Egypt's historical rights in the region and does not fit the length of the coast.

B. Although the agreement stipulates that the

Future amendment may be applied in the meridian line if it is mixed with other parties, Egypt has not been in contact with other countries in the region to confirm this situation.

C. Based on the Turkish position, points 1 to 6 are mixed with the Turkish and Greek economic zones, which means that Egypt and Cyprus are not entitled to reach an agreement without considering all parties involved.

D. It was discovered that in 2011 the area concerned was rich in natural resources according to geologist Khaled Odeh (Abdel Aziz, 2013), and according to the text of the agreement, this may cause a revision of the agreement, or at least an important amendment agreement.

E. In 2010, Cyprus signed an agreement with the State of Israel on the demarcation of the border (Republic of Cyprus and the State of Israel, 2010), without consulting the Egyptian side, although this agreement affects point 8 of the meridian line, in clear violation of the text of the Convention.

The agreement stipulated that if diplomatic efforts to resolve the dispute fail, the case will be referred to arbitration, without specifying the arbitration board. This violates the 1983 Declaration of Ratification, which states: "Egypt declares that it accepts the arbitration procedure, whose parties are specified in Annex VII to the Convention." The Annex, clearly stated in article 2, paragraph 1, provides that "each State Party shall be entitled to nominate four arbitrators."

4.3 Maritime Delimitation Agreement between Egypt and Cyprus 2013.

In 2013, Egypt and Cyprus concluded an agreement to demarcate the maritime boundaries between the two countries to benefit from the natural resources of the two countries' exclusive economic zone in the Eastern Mediterranean. On the bases of the meridian line, which makes each point along its equally spaced length from the nearest point on the baselines of both parties.

The border demarcation agreement between Egypt and Cyprus concluded in 2013 was founded on the rules and principles of international law, specifically the UN Convention on the Law of the Sea in 1982.

The agreement was deposited, published and Registered with the Secretary-General of the United Nations, in accordance with Article 102 of the Charter of the Organization. Although, The Egyptian navy, at the time, official data on the demarcation of the border was to help the two countries reuse the shared marine resources in the territorial waters of both the Egyptian and Cypriot countries, and this agreement coincided with the announcement that the gas explored in the Mediterranean Sea.

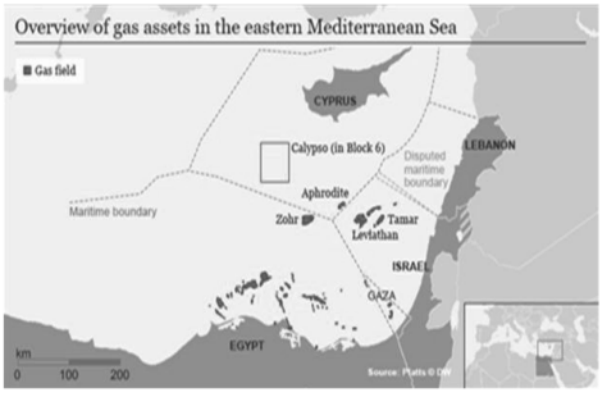


Figure (4): Overview Of Gas Assets In The Eastern Mediterranean sea.
Source: info@dw.com, 2019

4.3.1 The Economic Importance of Maritime Delimitation Agreement between Egypt and Cyprus 2013.

This agreement is the main reason for the discovery of a lot of untapped wealth, especially the "Field of Zohr", the largest field in the Mediterranean area of 100 square kilometers with reserves estimated at 30 trillion cubic feet of natural gas. And The Egyptian state could not go ahead and exploit these riches without Agreement on the Demarcation of the Northern Maritime Boundaries. .(Ministry of Petroleum – Egypt, 2019).

5. Egyptian gas fields in the Eastern Mediterranean:

Following the signing of the border demarcation agreement between Egypt and Cyprus, the General Petroleum Corporation and the Holding Company for Natural Gases started in 2013 to launch international bids for research and production of gas and oil. In 2013, Gas Holding presented 22 sectors in the Gulf of Suez, Western Sahara, the Mediterranean and the Nile Delta,

According to the Ministry of Petroleum. In 2015 «Gas Holding» launched 8 sectors for research in the Mediterranean. Since the end of 2013, Egypt has signed a number of oil agreements with huge investments and drilled 254 wells, according to the Ministry of Petroleum. (Ministry of Petroleum – Egypt, 2019).

British BP, Italy's «ENI» and Dutch Shell account for the majority of Egypt's oil and gas exploration and production. The volume of investment in the oil and gas field is 9.5 billion dollars, and the target is to reach 18 billion dollars by 2023, according to the Egyptian Minister of Petroleum. Egypt's gas production is 6.8 billion cubic feet per day, according to the Egyptian Ministry of Petroleum. (Ministry of Petroleum – Egypt, 2019).

Figure (4): Map of Oil and Gas Concession Areas in Egypt. Source: .(Ministry of Petroleum – Egypt, 2019)

5-1 Western Abu Madhi:

On July 20, 2015, the Ministry of Petroleum announced that the Italian company «ENI» discovered in the Delta region in Egypt a gas field with reserves of up to 15 billion cubic meters, and the new discovery in the west region of Abu Madhi, 120 km northeast of Alexandria, and «ENI» through Its Egyptian company International Egyptian Oil Company is 75 % of the West Abu Madi concession, while british petroleum owns 25%.

5-2 Nawras Field

It was discovered in July 2015, in the West Abu Madi concession in the Nile Delta, and is one of the largest Egyptian gas fields, producing 180 million cubic feet of gas and 1,500 barrels per day of condensate. (Ministry of Petroleum – Egypt, 2019).

5-3 Shorouk field

It was announced in August 2015, in the deep waters of the Mediterranean in the Shurooq concession area (Egyptian economic waters), and contains reserves of 30 trillion cubic feet of gas, equivalent to about 5.5 billion barrels of oil equivalent. .(Ministry of Petroleum – Egypt, 2019).

5-4 Nour field

It was unveiled in 2018 and is located in the Nour area of the North Sinai concession area in the Mediterranean Sea, about 50-60 square kilometers from the Mediterranean coast.

The field is located in the southeast of the Shorouk offshore area, which includes the giant Zohr field, one of the largest gas fields in the Eastern Mediterranean. .(Ministry of Petroleum – Egypt, 2019).

5-5 North Alexandria Field

The Torres, Libra, Fayoum, Giza and Rivin a set of fields which are the discovery of DIA. The planned production of Torres and Libra will be 600,000 cubic meters per day, and the Giza and Fayoum fields will produce 400 million cubic meters per day. .(Ministry of Petroleum – Egypt, 2019).

5-6 Northeast Delta Wells

It is a group of "wells West 2" and its production is estimated at 100 million cubic feet of gas per day, and increased the production of the company's Nawras field to 670 million cubic feet of gas per day, in addition to the wells Nidoko Northwest 6 Northeast Delta, belonging to "Petrobel" At a production rate of 140 million cubic feet of gas per day, the Nidoko West 2 well has a production rate of 100 million cubic feet per day. (Ministry of Petroleum – Egypt, 2019).

5-7 Atoll well 1:

On March 9, 2015, BP Egypt announced a new gas in the North Damietta offshore area in the eastern Nile Delta of the Mediterranean. Drilling at the Atoll-1 deepwater exploration well, which is currently being drilled using the sixth-generation Maersk Discovery rig for offshore drilling rigs, has reached a depth of 6,400 meters below sea level, penetrating a high-quality sand-bearing layer of Oligocene Era wihic is a gas-

Carrying layer with a thickness of 50 Meters. (Ministry of Petroleum – Egypt, 2019).

5-8 The field of "Malik":

The Ministry of Petroleum and Mineral Resources announced on February 27, 2015, the discovery of a new oil field in the south of the country, known as «Malik» through South Valley Petroleum Holding Company, with reserves estimated at 9.6 million barrels of light crude oil.

The ministry of Petroleum said that the field currently produces 430 barrels per day of high-quality light crude oil, and it plans to increase production rates by drilling 7 new wells. (Ministry of Petroleum – Egypt, 2019).

5-9 West Meleiha well:

In January 2015, the Italian company «ENI» announced a petroleum discovery in the deep west of Meleiha in the Meleiha development area of Western Sahara, about 300 km west of Alexandria.

A deep well west of Meleiha was drilled at a depth of 4,175 meters, where oil was discovered at a high quality 40 API in an oil-bearing layer 20 meters thick in the formation of the flag of the lower Web, and the drilling showed thick overlaps of gas and condensate in the formations of deep Safa, according to a statement For the Italian company.(Ministry of Petroleum – Egypt, 2019).

5-10 Field of Zohr:

The discovery, which was described as the largest in Egypt's history, came on August 30, 2015, when Italian company «ENI» announced the discovery of a field that appeared in the Mediterranean, with reserves of 30 trillion cubic feet of natural gas, confirmed by the Egyptian Ministry of Petroleum in its statement. The Italian company said the discovery is the largest ever in the Mediterranean and may become one of the largest gas discoveries in the world. This discovery covers an area of 100 square kilometers at a depth of 4757 feet (1450 meters) and reaches a maximum depth of about 13553 feet (4131 meters) and this field is one of the largest fields discovered in the Mediterranean, exceeding the Israeli Leviathan gas field.

In March 2016, the Ministry of Petroleum announced the start of the first phase of the production of the Zohr field, through the injection of investments worth $ 4 billion, and expected to increase production, within two years, providing energy to the local market and meet the needs of development plans. .(Ministry of Petroleum – Egypt, 2019).

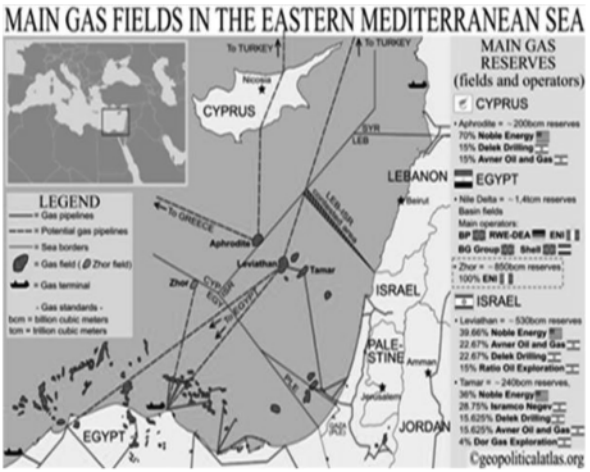


Figure (5): Map of Natural Gas Fields in the Eastern Mediterranean Infographic.
Source: Infographic, 2019)

The production of the Zohr field reached about 1.750 billion cubic feet per day of gas in August, before reaching about 2 billion cubic feet per day before the end of 2019, and 2.7 billion cubic feet by mid 2020. This production will constitute about 40% of Egypt's production from Gas. According to the plan, Egypt's Zohr field will export part of its gas to Europe and the Middle East.(Ministry of Petroleum – Egypt, 2019).

This discovery resulted in achieving self-sufficiency, which is the first step towards export, but not through the export of natural gas as crude, but to maximize the benefit. With an investment of about 1.5 billion dollars, to increase exports and expand the delivery of gas to homes. The Ministry of Petroleum pointed out that the state has a clear plan to establish two petrochemical complexes first in Ain Sokhna and begin production in the first quarter of 2020, and the second in El Alamein to double the production of petrochemicals Egypt to about 13 million tons compared to about 4.5 million tons currently, where it is expected to achieve revenues up To a value of between 4.5 and 5 billion dollars a year. . (Ministry of Petroleum – Egypt, 2019).

6. Conclusion and Recommendations:

The maritime boundaries of any coastal State and the right to exploit the wealth within it is a legitimate right of the coastal State under international conventions in this regard. That is why the United Nations has paid much attention to this issue and how to resolve these conflicts that may arise between rival states on their maritime borders. In this paper, the authors clerifind the state of the Egyptian maritime boundary, and how Egypt was one of the first countries in the region to claim maritime boundaries since 1951.

Egypt could not prospect for gas in the Mediterranean waters until after the signing of the border demarcation agreement. Therefore it is necessary and important for the countries Start the limitation of their, because the companies will not prospect in a maritime area what a state claims ownership and then turns out to be the property of another country as happened between many countries in this part.

Therefore, after discussing the current situation of the Egyptian economy after the marine discoveries in the Eastern Mediterranean, it became clear that the recent discoveries have a positive impact on the Egyptian economy through the establishment of a number of projects that serve these discoveries, which are estimated at billions in the field of liquefaction and others, To be in a state of full compliance with the 1982 United Nations Convention on the Law of the Sea.

The paper generally recommends:

*Demanding to maintain a fast pace in the delimitation of all Egyptian maritime boundaries and the adoption of rules governing them and not to slow down the procedures, because the slowdown leads to the loss of large areas of water, especially in the exclusive economic zone.

*Issuing a national decree declaring the exclusive economic zone of the country and re-revising and defining the bays and islands in article 1 of the 1951 decree to conform to those in the United Nations Convention on the Law of the Sea, and revising the baselines accordingly. Collects all declarations issued by the Egyptian state and conforms to the standards of International agreements.

*Review the Egypt Cyprito agreement with Turkey, Greece and Israel as third parties to determine the true boundaries of the Egyptian state and recover the looted ones.

References:

Abdelaziz, A. (2013). Re-Delimitation of EEZ between Egypt and Cypress. Alshaab. Retrieved, http://elshaab.org/thread.php?ID=57347

Arab Republic of Egypt & Republic of Cyprus (2003). Agreement between the Republic of Cyprus and the Arab Republic of Egypt on the Delimitation of the Exclusive Economic Zone.

Arab Republic of Egypt. (1990). Decree of the President of the Arab Republic of Egypt No. 27 (1990) concerning the baselines of the maritime areas of the Arab Republic of Egypt.

Attard ‹D. J. (2001). The delimitation of maritime zones: Some Mediterranean experiences. In David ‹M (Eds.) ‹ICTS 2001: zbornik referatov = proceedings (pp. 1-17). Portorož: Fakulteta za pomorstvo in promet.

Carrera ‹G. (Director) (2013). The law ‹technical aspects and State practice of international maritime boundary delimitation. Maritime Delimitation.

East Mediterranean Gas and the future of the regional conflict, 2018. http://www.mena-acdp.com

Hollis ‹D. ‹& Rosen ‹T. (2010). The various regions of the ocean over which a State may exercise sovereignty. [Diagram]. Retrieved Aug. 16 ‹2019.

Hollis ‹D. ‹& Rosen ‹T. (2013). United Nations Convention on Law of the Sea (UNCLOS) ‹ 1982. Encyclopedia of Earth. Retrieved Aug. 16 ‹ 2019.

League of Nations. (1930). League of Nations, Treaty Series, vol. 179, p. 89, No. 4137. Convention on Certain Questions Relating to the Conflict of Nationality Law. Retrieved Aug 16, 2014, http://www.refworld.org/docid/3ae6b3b00.html

Letalik, N. G. (1988). Boundary making in the Mediterranean. Ocean boundary making: regional issues and developments (p. 109). London: Croom Helm.
Ministry of Petroleum -Arab republic of Egypt, 2019.

ICJ. (1969). North Sea Continental Shelf (Federal Republic of Germany / Netherlands). International Court of Justice. Retrieved Aug 1 ،2019.

Redefining the borders of the exclusive economic zone between Egypt and Cyprus, Abdel Aziz, a. (2013).

Republic of Cyprus & State of Israel. (2010). Agreement between the Republic of Cyprus and the State of Israel on the Delimitation of the Exclusive Economic Zone. Retrieved June 18 ،2019.

The Arab Center for Research and Studies, d. Mohamed Shawky 2014.
The Egyptian Ministry of Defense website - Zohr field - the Mediterranean gas icon, December 26, 2018.

The geopolitical implications of the Israeli gas discoveries in the Eastern Mediterranean, the Arab Center for Research and Policy Studies. 2012.

Truman ،H. (1945). President Truman's proclamations on US policy concerning natural resources of sea bed and fisheries on high seas.

Treves ،T. (2008). 1958 Geneva Conventions on the Law of the Sea. United Nations - Office of Legal Affairs. Retrieved July.11 ،2019.

United Arab Republic. (1958). Presidential decision no. 1051 of 1958 concerning the continental shelf. Retrieved on 2th of July 2019.

United Arab Republic. (1958). Presidential decision no. 1051 of 1958 concerning the continental shelf. Retrieved on 9th of October 2014. United Kingdom Hydrographic Office. (1992). BA Chart 183 Ra's at Tin to Iskenderun.

United Nations [UN]. (1956). Yearbook of the International Law Commission ،vol. II. http://legal.un.org/ilc/publications/

United Nations [UN]. (1983). The Law of the sea: official text of the United Nations Convention on the Law of the Sea ،with annexes and index: final act of the Third United Nations Conference on the Law of the Sea; introductory material on the convention and the conference. London: C. Helm.

United Nations [UN]. (2000). Handbook on the delimitation of maritime boundaries. New York: UN.

United Nations [UN]. (2003). Bulletin No. 52; Law of the sea. New York: UN.

United Nations [UN]. (2004). Bulletin No. 54; Law of the sea. New York: UN.

United Nations [UN]. (2005a). Bulletin No. 57; Law of the sea. New York: UN.
United Nations [UN]. (2005b). Bulletin No. 59; Law of the sea. New York: UN.

United Nations [UN]. (2006). Bulletin No. 62; Law of the sea. New York: UN.

United Nations [UN]. (2010). Communication from the Government of the Arab Republic of Egypt. Retrieved June 12 ،2019.

United Nations [UN]. (2013a). Declarations or Statements upon UNCLOS ratification. United Nations.

United Nations [UN]. (2013b). UNTC. United Nations Treaty Collection.

Opportunities of Egypt as an international bunkering hub for Natural Gas-Powered Ships

Prepared by

Chief Engineer: Mohamed El-Sayed El-Sayed El-Bawab

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

MSc. In Maritime Energy Management, the World Maritime University (WMU) Malmo, Sweden

Abstract:

In 2015, the Italian Oil Company (Eni) discovered the Mediterranean's largest gas field (Zohr) gas field, with an estimated 30 trillion cubic feet. Recently, in April (2019) the output of gas from the Noras gas field South East of Zohr gas field improved to about 1.2 billion cubic feet per day (bcf / day). These discoveries turn Egypt from a gas importer to a country with a vast surplus reserve. Moreover, in 2019 the Egyptian Ministry of Petroleum announced, that Egypt has signed many oil and gas exploration contracts in several fields, including east the Mediterranean, Western desert, Nile Delta and Suez Gulf (The Egyptian Ministry of Petroleum, 2019).

Recently, the LNG use onboard ships for main propulsion purpose has increased as the most convenient transitional fuel to cope with current emission limits such as 2020 sulphur cap and NOx Tier III. (Andersson et al., 2016).

The LNG Bunker Occupies a significant storage volume onboard ships although, it is relatively insufficient for all the days of the ocean-going voyages. Consequently, the need for multiple bunkering operation will be a must.

The LNG bunkering stations is a new model of ship fueling, hence its numbers worldwide still limited. Therefore, this considers one of the significant contributed and motivating factors may lead Egypt with its surplus LNG and its control a vital transit motorway like Suez Canal to prepare and establish LNG bunkering service. Such a service would greatly reward on both the Egyptian national economy as well as the efficiency of the international seaborne trade and will serve the international efforts to preserve the environment.

This research paper from the literature will descriptively discuss the possibility of utilizing the Egyptian new gas discovered resources to create an international LNG refuelling hub. Also, the great benefits to the international LNG powered fleet and international legislations implementation.

Keywords: Egypt LNG infrastructure, natural gas exploration, fuel source, LNG bunkering hub, legislation and international requirements.

1.Introduction

Scientists began to take an interest in studying the impact of human activities on the environment in the 1970s. They looked under the name of global warming or climate change, both named as two sides of one coin(Conway, 2008). By the time passing better understanding of the causes has built up and much efforts have been made to remedy it. In the maritime field, the last legislative effort was adding chapter four to Annex VI of MARPOL convention, which includes a basket of technical and operational measures towards efficient merchant ships at lower GHG Emissions_ In addition, mandating energy efficiency design index (EEDI) for all the new vessels and Ship Energy Efficiency Management Plan (SEEMP) for all vessels .

According to the second IMO GHG study in 2009 that ships Exhaust gases are the primary source of GHG in the maritime sector and all the other sources may be neglected if compared with ship engine emissions (Cabezas & Kasoulides, 2009). The following IMO GHG study in 2014 revealed that with the rapid growth in the international global GDP and consequently increasing the use of ships which carries approximately 90% of the world goods by volume that will lead to increase on parallel the GHG Emissions especially in the high traffic coastal areas(Smith et al., 2015).

The same study left no doubt that the emissions from vessels directly bonded to the type of fuel in use onboard ships and that makes the alternative fuel as one of the most reliable solutions to reduce ship emissions from all kinds(Smith et al., 2015). LNG use as a marine fuel has been growing recently especially in the Baltic area to meet the restricted international environmental rules and the upcoming NOx Tier III and reducing all the other kinds of emissions such as PM, Sox and 25% of the CO2 too. Furthermore, LNG usage is best practice if a wider implementation range developed that will help not only to meet the international regulation but also more beyond (Adamchak & Adede, 2013; Lammons et al., 2015;Choi & Yap, 2017).

This research paper will discuss LNG as a marine fuel and evaluate the Egyptian model in this field from different key aspects such as Infrastructure, training, Organization and Logistics and will high light the need for creating bunker station in a central location country like Egypt.

Why LNG as a marine fuel?

To meet the January 2020 IMO regulatory framework for the Sulfur cap with a percentage of 0.1 inside Sulfur Emission Control Area (SECA) and 0.5 %out of SECA. In addition to, the NOx Tier III for marine engines exhaust as per marine environmental protection committee (MEPC) recommendations in its seventeenth convening, and to cover the MEPC 72 ambitious targets too (IMO, 2018b). The LNG price difference is a significant advantage as per the

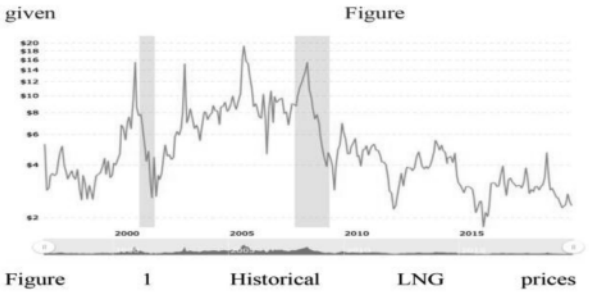


Figure 1 Historical LNG prices

(1)

Source:https://www.macrotrends.net/2478/natural-gas-prices-historical-chart

With the increase in the infrastructure of LNG bunkering stations all over the world, the price of LNG expected to be dropped significantly and the best prove mid of December 2019 price 2.34 US dollar per cubic meter in figure (1) compared to its price three years earlier.

The need to support the maritime sector to implement such environmentally friendly practice and make it be used in a broader range. Furthermore, following the Europe Union (EU) 2014 decision number 94 which stated that all the countries within the Europe Zone should provide LNG bunkering in its all ports by 2025 as per Trans-European Transport Networks (TEN-T) under the EU law (European Parliament and Council of the European Union, 2014).

The growing in the ships LNG consumption reflects the increase in the LNG retrofitting and/or new building of LNG operated ships year after year the percentages between 2015,2016 and 2017 indicates growth with minimum 20's% yearly (Corkhill, 2017).

Of course, when it comes to energy efficiency and environment sustainability every little effort counts and LNG as an alternative fuel is a great step towards sustaining our planet for the next generations as a good place to live in, and protect the future human resources until the technological development of the renewable energy convertors became mature enough to take over from the fossil fuel in energy generation and consumption.

The temptations and snags of using LNG onboard ships.

LNG is cleaner than the traditional fossil fuels, by using LNG the SOx and PM emissions will be almost fully eliminated. Besides, reducing Nox emissions significantly due to the difference of the working principles (Otto cycle) from diesel engines. Also, the CO2 emissions will be reduced by approximately 30% what will lead to comply with international regulations like 2020 Sulphur Cap and Nox tier III (Rynbach, Briers, & Delgatto, 2018). Simultaneously, the use of LNG will reduce the fuel price volatility risk due to the lower price. On the other hand, LNG required more storage space and produced less power in addition to, the expensive system and more routine maintenance besides the common LNG problem "methane slip"(Rynbach et al., 2018).

The Egyptian Model in LNG maritime field:

Infrastructure and Equipment.

The LNG fuel cycle contents of extraction operation followed by transportation then processing and storage at this stage the LNG is ready to be delivered to the end-user through all the mains of transporting methods such as Trucks and ships or pipelines(Thomson, Corbett, & Winebrake, 2015).

Egypt status regard LNG infrastructure (the newly added reservoir capacity, number of ports on the Mediterranean Sea).

In 2015, Eni discovered the Zohr gas field in figure (2), the Mediterranean's largest gas field, with an estimated 30 trillion cubic feet. On the other side, the output of gas

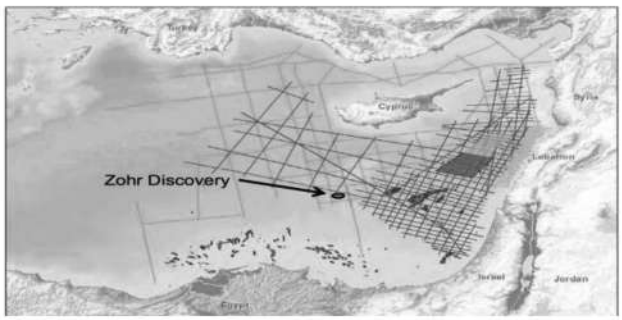


Figure 2 Zohr Discovery
Source: http://d8d673da5f0d55e3ea5a-6496b70fad7e6663b590babbc0242de1

From the Noras gas field in April improved to about 1.2 billion cubic feet per day (bcf / day).
This unexpected discovery of 2015 in the eastern Mediterranean of the gas field (Zohr) turns Egypt from a gas importer to a country with a vast surplus reserve have increased by 850 billion cubic meters(bcm). Furthermore, Egypt signed a deal to import four billion cubic meters (bcm) per year to about 2030 for uncertainty while disclosing the size of the field and its capabilities (Carlson, 2016). The field has begun to produce, which will self-sustain and provide quantities for export and establish projects such as the proposed LNG bunkering hub .
Moreover, in March 2019 Italian Oil Company (Eni) announced a fresh gas discovery under assessment in the Nour prospect of exploration situated in the Nour North Sinai Peninsula, in the Eastern Egyptian Mediterranean, about 50 km north of Egypt .
Egypt has three ports prepared to export and import LNG which are (IDCO, Dimiata and Ain sukhna) and charter two 170000 cubic meter capacity LNG powered LNG carriers berthing at Ain sukhna Port as storage ships figure(3) one of them the charter contract will expired by April 2020.

Figure 3 Egyptian LNG ships at Ain Sokhna
https://www.rivieramm.com/news-content-hub/egypt-poised-to-regain-net-lng-exporter-status-25701

In addition to, huge pipeline net for domestic usage like houses cooking purposes, furthermore, most of the power planets are working on natural gas (Corkhill, 2018; Nikolaou, 2016; World maritime news, 2015).

The Egyptian huge natural gas discoveries in the East Mediterranean have made the experts and literature grantees that this exploration will lead to significant change in the world LNG map since the expected amount of gas in this gas field will be between 30 to 100 trillion cubic feet (TFC) (Esestime, Hewitt, & Hodgson, 2016). According to the international gas union 2017 report, Egypt in 2017 was ranked the world 7th gas importer figure (4) and reported the doubts of finding Egypt in the next year in the exporters list (International gas union, 2017).

Moreover, currently European Union is studying support the infrastructure phase in the developing and LNG importing countries to increase the bunkering stations around the world which may secure the required funds for Egypt to implement such project(Calderón, Illing, & Veiga, 2016).

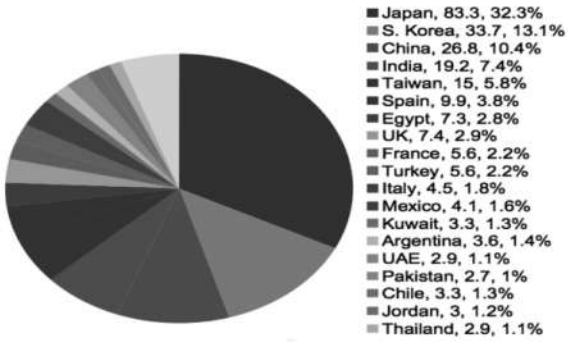


Figure 4 world LNG importers and market share by country https://www.igu.org/sites/default/files/103419-World_IGU_Report_no%20crops.pdf)

That high rank could be a definite proof of the infrastructure and equipment existence at a sufficient level to handle about 2.8% of the world LNG volume professionally.

Egypt seems to have a strong potential after the last gas findings to establish new LNG hub in the east of Mediterranean Sea especially with optimistic outlook for the LNG reservoirs within the Egyptian Exclusive Economic Zone (EEZ) figure(5).

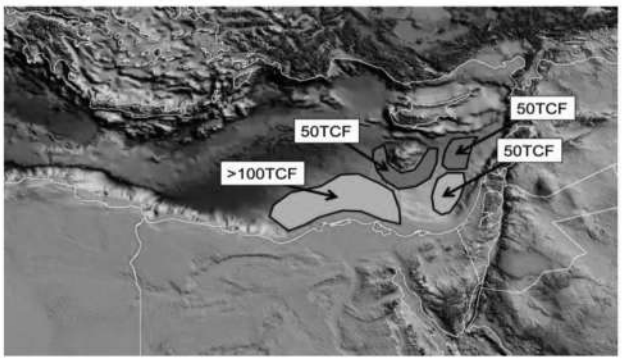


Figure 5 Storage expectations for the east of the Mediterranean
http://d8d673da5f0d55e3ea5a-6496b70fad7e6663b590babbc0242de1.r89.cf1.rackcdn.com/FP 20.10.2015 Neil Hodgson_Spectrum presentation.pdf

Egyptian production Vs consumption

According to the International Energy Agency (IEA, 2020) latest statistics Egypt has LNG surplus of 1367455TJ in year 2017. The production was 1994593TJ figure (6) while, the consumption reached 627138.0TJ for the same year figure (7).

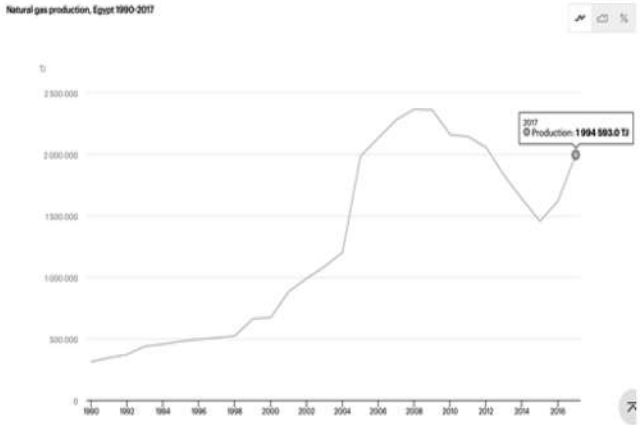


Figure 6 Egypt Natural Gas historical production https://www.iea.org/data-and-statistics?country=EGYPT&fuel=Natural%20gas

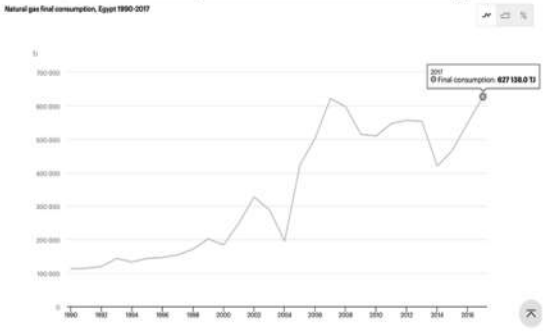


Figure 7 Egypt Natural Gas historical consumption https://www.iea.org/data-and-statistics?country=EGYPT&fuel=Natural%20gas

Regulatory framework

Ships are using LNG or handling LNG all over the world are following regulations, codes and standards such as:

- National regulation for some countries, for example (Canada, EU and US).
- ISO/TS 18683:215 standards for inland bunkering pipeline suppliers.
- Codes (IGC-IGF-MSC.285(86)) the first code for construction and equipment the others are for safety.

And those codes and standard and will not vary from country to another (ABS, 2014; IMO, 2018a).

With such regulatory framework and binding conventions like MARPOL Annex VI chapter 4 which came into force on all ships have built after 2015. All the working ships is required to have Ship Energy Efficiency Management Plan (SEEMP), besides, the same ships emissions are monitored by Energy Efficiency Operating Indicator (EEOI). in addition, SECA and NECA requirements.

Logistics

Egypt has a shortage in the LNG bunkering stations only non-confirmed news about a plan to initiate LNG bunkering facility in Suez Canal economic zone with co-operation of Clarkson Shipping Agency but no pieces of evidences of the project starting (EMEA, 2017.(

Bunkering facilities shortage will lead to broke the LNG logistics chain in Egypt. Furthermore, the world in need of more LNG bunkering stations to support the global LNG shipping fleet since a lot of places (Svensen, 2012) like the east of Mediterranean. The LNG ships fleet cannot reach that far and continue to red sea to link Asia with Europe without in operation refuelling stations in between. That reflects the interest to fund more bunkering stations, as mentioned earlier. Egypt, after the new Suez Canal national project completion the annual transit ships expected to reach approximately 35000 ships by 2023 the mentioned number in literature not considering LNG fleet (Molouk Kenawy, 2015). By providing the bunkering service that will be a value add to the international maritime transportation and Logistics(Adamchak & Adede, 2013).

Furthermore, the LNG bunkering hub will increase the national income from the Suez Canal transit fee after adding the potential use by the LNG fleet; besides, LNG will return benefits to the Egyptian national income.

To conclude this part Egypt, have a central location and important waterway (Suez Canal) if such project successfully created it will be beneficial not for Egypt only but also for the world LNG powered vessels and the owning companies.

Training

The International Maritime Organization (IMO) gave a task to the International Standardization Organization (ISO) to create new model of standards for LNG bunker handling in year 2017 which includes the required trainings and mandatory certification for safe and successful operations with coverage of the missing areas in the IGC code (ISO, 2017). The requested ISO standard already produced successfully and called "New ISO standard for the safe bunkering of LNG-fueled ships" ISO 20519 (2017) covering also the requirement from the LNG providers which is not covered yet by any of the Egyptian Training Universities or training institutes due to the recent release of the new standards.

If Egypt is willing and has the training capability in some of the world recognized universities located in Egypt like Arab Academy for Science, Technology and Maritime Transport, Cairo University and Alexandria university the training to meet ISO 20519 must have the highest priority because through complying with ISO 20519 the training standards will coop with all the International regulations.

All the LNG fields workers and engineers or vessels crew will take their training at the Arab Academy for Science, Technology and Maritime Transport (AASTMT) as the regional leading university and training center which equipped with the latest petrochemical and LNG Kongsberg simulators leading the Middle east and Africa training facilities(AASTMT, 2018.(

To conclude this part, Egypt, have several well-recognized universities but need to stress and direct those capabilities to serve the national projects.

Conclusion

The LNG usage as a marine fuel is growing worldwide due to the current international environmental mature knowledge and a better understanding of the side effects of using the high sulfur content traditional fossil fuels. Moreover, the existence of restricted binding international rules and conventions coming into force day after day also can be considered a motivator towards the implementation. However, there is still a shortage in the number of the bunkering terminals or supplier's world widely due to the poverty of LNG resources for some countries and the topic novelty.

All the above mentioned indicates the necessity for more international cooperation and facilitation towards the initiation of more LNG bunkering terminals to help the maritime industry stakeholder with the implementation smoothly.

Egypt has the natural resources and mature infrastructure to provide such a service and gain the expected benefits to vast the national income not only from LNG market but also by attracting more vessels to use Suze Canal.

Recommendation for Egypt:

- The high traffic in Suze Canal will grantee the benefits from a LNG strategic Bunkering stations in Mediterranean and Suez Canal.
- Filling the training gap, for example with the latest ISO 20519 for the terminals handling LNG bunkering operations.
- The regulatory framework to be updated with the latest regulations and Marpol Annex VI to be signed and ratify towards higher air quality.
- Create incentives for the vessels passing the Suez Canal and cause less pollution to improve the involving citizens health and avoid or minimize any hidden social cost not considered by the Egyptian decision-makers.
- Encourage research and direct it towards the country national goals and aimed at projects to ensure success and profits.

References:

AASTMT. (2018). Integrated Simulators Complex. Retrieved June 11, 2019, from AASTMT website: http://www.aast.edu/en/complexes/isc/

Adamchak, F., & Adede, A. (2013). LNG As Marine Fuel. LNG-17 Conference, 1–10.

Andersson, K., Baldi, F., Brynolf, S., Lindgren, J. F., Granhag, L., & Svensson, E. (2016). Shipping and the environment. In Shipping and the Environment: Improving Environmental Performance in Marine Transportation. https://doi.org/10.1007/978-3-662-49045-7_1

Cabezas, P. R., & Kasoulides, G. (2009). Second IMO GHG Study 2009. The International Journal of Marine and Coastal Law, 3(3), 235–245. https://doi.org/10.1163/187529988X00184

Calderón, M., Illing, D., & Veiga, J. (2016). Facilities for Bunkering of Liquefied Natural Gas in Ports. Transportation Research Procedia. https://doi.org/10.1016/j.trpro.2016.05.288

Carlson, S. (2016). Pivoting energy relations in the eastern mediterranean. Turkish Policy Quarterly, 15, 67–78. Retrieved from http://turkishpolicy.com/files/articlepdf/pivoting-energy-relations-in-the-eastern-mediterranean_en_3043.pdf

Choi, G., & Yap, H. (2017). Future powering options for container vessels. ARPN Journal of Engineering and Applied Sciences.

Conway, E. (2008). NASA - What's in a Name? Global Warming vs. Climate Change. Retrieved June 10, 2019, from NASA.

Corkhill, M. (2017). LNG-fuelled fleet hits 200 ship mark. Retrieved June 11, 2019, from LNG World Shipping.

Corkhill, M. (2018). Egypt poised to regain net LNG exporter status. Retrieved June 11, 2019, from LNG World Shipping.

EMEA. (2017). New Bunkering Facility Planned for Egypt - Ship & Bunker. Retrieved June 11, 2019, from EMEA News

https://shipandbunker.com/news/emea/318447-new-bunkering-facility-planned-for-egypt

Esestime, P., Hewitt, A., & Hodgson, N. (2016). Zohr – A newborn carbonate play in the Levantine Basin, East-Mediterranean. First Break, 34(2), 87–93. Retrieved from https://www.spectrumgeo.com/wp-

European Parliament and Council of the European Union. (2014). Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure Text with EEA relevance. Official Journal of the European Union, L 307(28.10.2014), 1–20.

IMO. (2018a). IGC Code. Retrieved June 11, 2019, from IMO.
IMO. (2018b). Marine Environment Protection Committee (MEPC), 72nd session, 9-13 April 2018. Retrieved June 11, 2019, from

International Maritime Organization (IMO) International gas union. (2017). 2017 International gas union World LNG Report. Retrieved from https://www.igu.org/sites/default/files/103419-World_IGU_Report_no crops.pdf

ISO. (2017). New ISO standard for the safe bunkering of LNG-fuelled ships. Retrieved October 8, 2019, from ISO https://www.iso.org/news/2017/02/Ref2161.html

Lammons, R., Baiche, R., Bax, M., Burignat, D., Choquette, S., Chrz, V., … Zandieh, S. (2015). LNG as a fuel. International Gas Union World Gas Conference Papers, 2, 789–908. Retrieved https://www.scopus.com/inward/record.uri?eid=2-s2.0-

Lee, T.-J., & 李宗仁. (2015). A Study on Applying Fuzzy Multi-Criteria Decision Making for Selecting Shipping SOx Emission Control Technologies 應用模糊多準則決策方法於船舶SOx排放控制技術評選之研究.

Molouk Kenawy, E. (2015). The expected economic effects of the new Suez Canal project in Egypt. European Journal of Academic Essays, 1(12),13–22. Retrieved from www.euroessays.org

Nikolaou, K. A. (2016). The Discovery of Zohr Gas Field in Egypt … A Game C hanger …' Impacts - Opportunities. 9th SE Europe Energy Dialogue.

Rynbach, E. A. Van, Briers, K. E., & Delgatto, N. J. (2018). Analysis of Fuel Alternatives for Commercial Ships in the ECA Era-There is no Silver Bullet.

Smith, T., O'Keeffe, E., Aldous, L., Parker, S., Raucci, C., Traut, M., … Pandey, A. (2015). Third IMO Greenhouse Gas Study 2014 Executive Summary and Final Report. In International Maritime Organization (IMO).

Svensen, T. (2012). Technical feasibility makes LNG fuel the best solution. The Naval Architect.

The Egyptian Ministry of Petroleum. (2019). Facts about the number of oil and gas discoveries. Retrieved August 28, 2019, from The Egyptian Ministry of Petroleum website: http://www.petroleum.gov.eg/en/Pages/Facts.aspx
Thomson, H., Corbett, J. J., & Winebrake, J. J. (2015). Natural gas as a marine fuel. Energy Policy, 87, 153–167. https://doi.org/10.1016/j.enpol.2015.08.027

Applied technologies for low emission shipping: case study for container ship in Baltic Sea region

Prepared by

Capt. Fawzy Dekinesh

Integrated Simulators Complex

Capt. Salah Farid

Institute of Maritime Upgrading Studies

Arab Academy for Science, technology and Maritime Transport (AASTMT)

Abstract:

Recently there is an increasing concern on the environmental impact of ship operations and development due to pressing global issues such as climate change. International Maritime Organization (IMO), as United Nations maritime agency has paid attention to environmental sustainability and energy efficiency of ships. To achieve United Nation Framework Convention on Climate Change (UNFCCC) target, IMO adopted long term strategies and environmental regulations represented by the International Convention for the Prevention of Pollution from Ships (MARPOL) annex VI for prevention of air pollution from ships. Currently, there are several Emission Reduction Technologies (ERTs), this research aims to investigate two of them, namely: speed reduction/optimization and LNG as fuel oil. The quantitative analysis was undertaken by utilizing the Monte Carlo methodology through crystal ball software program based on data obtained from final project report Technologies, and Scenarios for Low Emission Shipping (TEFLES) for container ship run in Baltic Sea region to build a model utilized for calculating, fuel oil consumption, Green House Gas/Carbon Dioxide (GHG)/(CO_2) emission and air emissions/pollutants Sulfur Oxides, Nitrogen Oxides, Particulate Matters (SO_X, NO_X, PM) which would hopefully aid decision-makers in shipping sector upon selection of most appropriate ERTs. The study findings indicate possible potential of reduction of both oil consumption and air emission when applying LNG as alternative fuel and speed reduction measure. The total reduction for fuel oil consumption (36%) and the reduction in the emissions of CO_2 (42.6%), NO_X (83.6%), SO_X (58.5%) and PM (26.6%).

Keywords: Climate change, UNFCCC, IMO, ERTs, Air Emission, SECA, Baltic Sea.

1. Introduction

Under the UNFCCC IMO was assigned the responsibility to control and limit air emissions from international shipping. In response, in 2005, MARPOL Annex VI-regulations for the prevention of air pollution from ships entered into force, in 2013 a new chapter on energy efficiency entered into force with Energy Efficiency Design Index requirements (EEDI). In 2015, IMO adopted short, medium and long term measures to reduce air emissions. In 2018, initial comprehensive strategy to reduce GHG emissions from international shipping was agreed. Moreover, IMO set a GHG emission reduction target to at least 40% by 2030 and 70% by 2050 compared to 2008 level (International Council on Clean Transportation, 2018). International shipping accounted for 3.1% (CO_2), 13% (NO_X) and 12% (SO_X) of the annual global emissions for the 2007-2014 period (Third IMO GHG Study, 2014). Shipping companies are currently facing stringent environmental legislation to improve their energy performance since ship operations damage not only the ecological balance of nature but also cause the adverse effect on global climate change and health-related impacts on the surrounding population. Besides the legislation, some shipping companies are embracing sustainable operations for a positive social image, which consequently improves their market value (Lam & Van de Voorde, 2012). Currently, there are several technologies applied onboard ships towards emission reduction such as, after treatment (Dry Scrubber+ Selective Catalytic Reduction (SCR)), heat recovery, wake adapted rudder, maneuvering improvement, batteries for hybrid propulsion/generation, paints, air lubrication, trim optimization, dry-docking for hull and propeller cleaning, weather routing, alternative fuel Liquefied Natural Gas (LNG) and speed reduction, etc. This study will focus on two of these technologies, namely; speed reduction and use of LNG as an alternative fuel after applying them on container vessel Cap San Nicolas fully operated in the Baltic sea region to calculate the amount of reduced fuel consumption and air emissions.

2. Literature review and theoretical background

2.1 Motorways of the Baltic sea

The amount of goods transported among the Baltic Sea is estimated by 21% of the volume of goods transported in the world, which indicates the intensity of seaborne trade in the Baltic Sea (Maritime transport of good- Eurostat, 2019). Motorways of Baltic sea connect Baltic seaports to central and western Europe and extend further to the North Sea and sea canal; the majority of the transported cargo is bulk raw materials oil, coal and general cargo, container and RORO ship ferry boats (Profir, 2011).

2.2 Developments of environmental regulation for shipping in the Baltic Sea region

The shipping traffic congestion in the Baltic sea caused air pollution specially from NO_2 in air, accounting for more than 50% of the NO_2 concentrations in central parts of the Baltic Sea. Drive the EU to establish a communication path with the IMO to adopt a set of regulations to reduce air pollution from shipping in North Sea and Baltic Sea (SO_X, NO_X, PM, and carbon dioxide (GHG) (Jonson, Gauss, Jalkanen, & Johansson, 2019).

In 2005 sulfur Emission Control Area (SECA) was introduced with a maximum of 1.5% sulfur concentration in the fuel oil used for ship proportional until reached to further restriction 0.1% maximum sulfur content in 2015. In 2015, EU adopted the MRV regulation provides requirements for the Monitoring, Reporting and Verification of (CO_2) from ships calling EU ports (EU Commission -Climate Action, 2019). Moreover, by 2021, NO_X Emission Control Area (NECA) will be introduce to limit nitrogen emissions from shipping. In 2011, the European Commission has set a target to reduce carbon emissions by at least 40% by 2030 (Claremar, Haglund, & Rutgersson, 2017).

2.3 Emission reduction technologies selection based on:

The reasons for the selected two ERTs for this study are, LNG as cleaner fossil fuel has immediate reduction on air emission SOx, NOx, PM, CO_2, while speed reduction measure has immediate reduction on fuel oil consumption, hence reduction on SOx, NOx, PM, CO_2.

2.4 Use of LNG in the EU

The main drivers for converting to LNG are the significant emission reductions and reduced cost of LNG compared to heavy fuel oil and marine gas oil.

Baltic sea area has a new promise of developing LNG infrastructure to incentivize the ship's owner to invest in LNG fuel rather than other technology. There are different projects running for LNG which have been funded by EU, for example, GO LNG it's focused on the development of demand and accessibility of LNG in Baltic Sea Region (BSR), the project activity is aimed at the implementation of the EU clean fuel strategy (European union regional fund, 2016).

In addition, the Blue Baltic project awarded 15 million Euro to support the network of liquefied natural gas (European union, 2019). Furthermore, the several incentives regimes from Danish maritime authorities, Nox funds, reduced port fees, and clean ship index (Albrecht, 2015). On the other hand there are some issues related to LNG should be considered such as methane slip, the main component of LNG is methane (CH_4), methane slip is the unburned methane emitted into the atmosphere. Methane is a potent greenhouse gas; therefore, methane slip must be kept under control in order to ensure reductions in GHG emissions when using LNG, moreover, the boiling point of LNG is about (-163°C) at atmospheric pressure. Therefore, LNG must be stored in insulated tanks for cryogenic application, which is associated with high capital cost compared to conventional fuel storage and supply systems, added to that LNG require more space for storage (Anders, 2019).

2.5 Speed reduction

The speed of ships has been shown to be a key variable for both shipping costs and emissions. The costs of energy, speed reduction, and revenues are strongly related because energy is a dominant cost element, and speed reduction may provide energy saving (Corbett, Wang, & Winebrake, 2009). According to Psaraftis and Kontovas (2013), optimal speed has received substantial growth with a number of speed models developed as a result of rising bunker costs and increased environmental issues.

Greenhouse gas is the key- element responsible for climate change from shipping, tightly bonded with the fuel consumption by ships, along with the existence of a cubic relation between fuel consumption and ship speed. The rise in fuel prices and the shipping market recession have driven shipping companies to adopt and optimize ship speed for reducing ship operating costs (Li, Sun, Guo, Du, & Li, 2020). Maritime shipping is a massive contributor to air emission particularly SOx emissions which emitted from the conventional fuel burned by ship engines; that is, mainly Heavy Fuel Oil (HFO) contains a high sulfur, in 2015, after new stringent requirement by SECAs came into force, the use of low sulfur oil with maximum sulfur content of 0.1% became mandatory, therefor ships are required to burn compliant fuel primarily Marine Gas Oil (MGO) which is obtained through the distillation process, it is more expensive than HFO consequently increased operation cost (Doudnikoff & Lacoste, 2014). Containerships identified as the top fuel-consuming ships and hence air polluters, due to their high sailing speed. In 2007, container ships represent 4% of the total fleet and responsible for 22% of CO_2 emissions from international shipping (Corbett et al., 2009).

Based on the literature review, the author has selected LNG and speed reduction. Firstly, the LNG has been selected because it is suitable for the Baltic Sea region due to the significant potential adopted by EU of providing LNG infrastructure for many ports in Europe and the recently adopted LNG projects such as GO LNG project. Secondly, speed reduction became an effective method, especially after new enforcement and implementation of SECA with 0.1% maximum sulfur content, which can be obtained through the use of Marine Gas Oil (MGO) associated with high production cost.

3. Methodology

3.1 Data collection

This research examined the effect of emission reduction technologies on air emission in the Baltic sea region by investigating the applied two ERTs, namely, LNG as fuel and speed reduction/optimization for motorways of Baltic

Sea for a particular container ship named CAP SAN NICOLAS. The data collected for this research mainly came from the European Commission website (CORDIS) final report of a collaborative project, under a grant agreement, Technologies, and Scenarios for Low Emission Shipping (TEFLES). The project covered the period from February 2011 to January 2014.

Quantitative analysis was undertaken by utilizing the Monte Carlo methodology through crystal ball software based on data obtained from final project report TEFLES as mentioned above to build a model used for calculating, fuel oil consumption, GHG emission (CO_2) and air emission pollutants (SO_X, NO_X, PM) which will hopefully aid decision-makers in shipping sector, company manager's/ policymakers to select the most appropriate ERTs for their fleets consistent with the trading area.

3.2 Data analysis

Model Assumptions

The analysis is based on the following assumptions:

- The vessel at Baltic sea SECA area (motorway of the sea).
- The vessel uses MGO as a fuel (basic case) scenario 1;
- The vessel uses LNG as alternative fuel scenario 2;
- The vessel uses a speed reduction measure from 25 kts to 22 kts scenario 3;
- The vessel uses the combination of two ERTs LNG and speed reduction scenario 4;
- Lifetime assumption is 30 years and fuel oil unit in tons ;
- Lifetime calculations for fuel oil consumption and air emission have been calculated as the sum of ship at sea time, at maneuvering time, and at port time.

Table 1 ship characteristics

SHIP CHARACTERISTICS		
Ship Name	Cap San Nicolas	
Length over all	250.550	m
Breadth	32.200	m
Depth	19.300	m
Design Draft	10.100	m
Design speed	25.0	Kts
Design Displacement	67,000.0	tons
Design DW	51,101.0	tons

Source: (TEFLES, 2018)

Table 2 Main Engine characteristics

Main Engine Characteristics		
Main Engine Type	Low Speed Diesel	LSD
Main Engine Regulation	(IMO Tier)	1
Main Engine No	-	1
Main Engine Power	kW	28348.95
Main Engine rpm	rpm	102

Source: (TEFLES, 2018)

Table 3 Voyage Calculation Parameters at Sea

VOYAGE CALCULATION PARAMETERS AT SEA		
MoS	Baltic	
Distance	530	miles
Cargo Weight	50,100.0	tons
Cargo Load	100	%
Draft	10.100	m
Trim	0.000	m
Speed	22.000	knots
Distance Sailed	530.3	miles
Time for Sailing	24.2	hours

Daily fuel (MGO) consumption 23 tons (main and axillary engine)

Source: (TEFLES, 2018)

4 Results/findings and discussions

4.1 MGO basic case

Table 4 illustrates the amount of fuel consumption and air emission for the lifetime of the ship, which extended to 30 years' fuel consumption (170,014) tons, and air emissions for, NOx (13,994) tons, SOx (47.9) tons, PM (263.9) tons, and CO_2 (540,514) tons.

Table 4 MGO basic case Scenario 1 (Lifetime Fuel consumption / Emissions)

Lifetime fuel consumption/ Emission	Result	No of Sim	Avrg	St Dev	
Lifetime fuel consumption	170,014.6	3,000	189,122.2	33,147.8	tons
Lifetime NOx	13,994.7	3,000	15,547.2	2,447.5	tons
Lifetime SOx	47.9	3,000	48.7	6.3	tons
Lifetime PM	263.9	3,000	292.3	0.0	tons
Lifetime CO2	540,514.2	3,000	601,337.4	105,480.9	tons

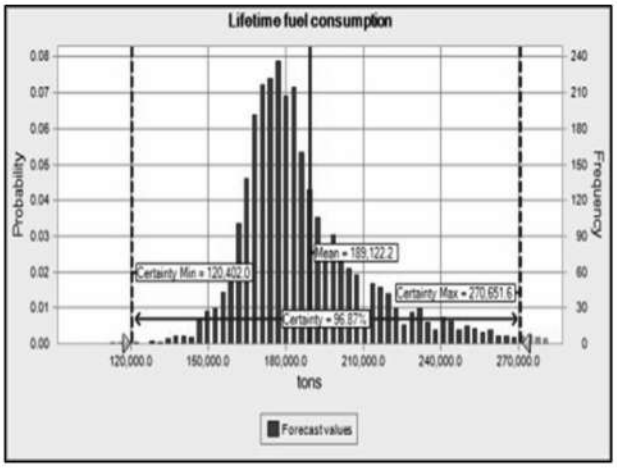


Fig.1. Lifetime Fuel Consumption

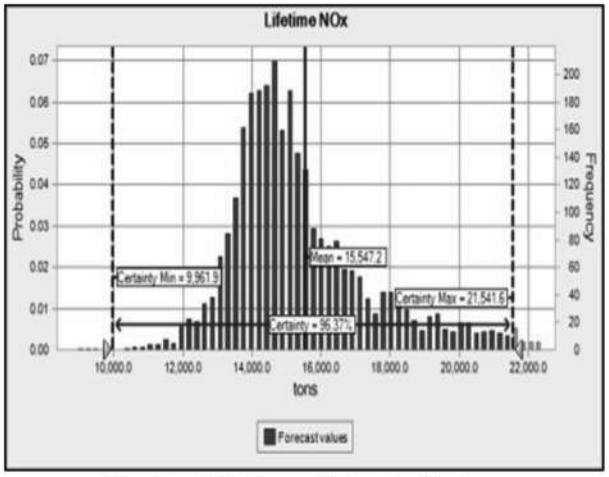


Fig.2. Lifetime NO_X Emissions

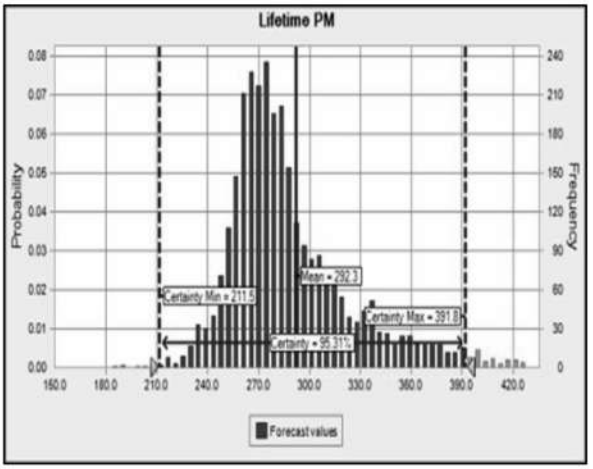


Fig.3. Lifetime PM Emissions

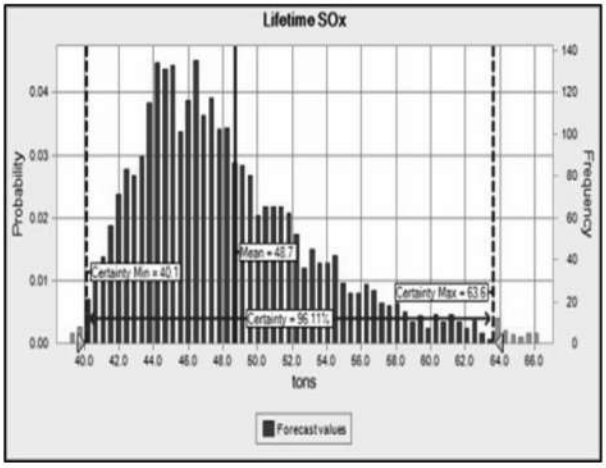


Fig.4. Lifetime SO_X Emissions

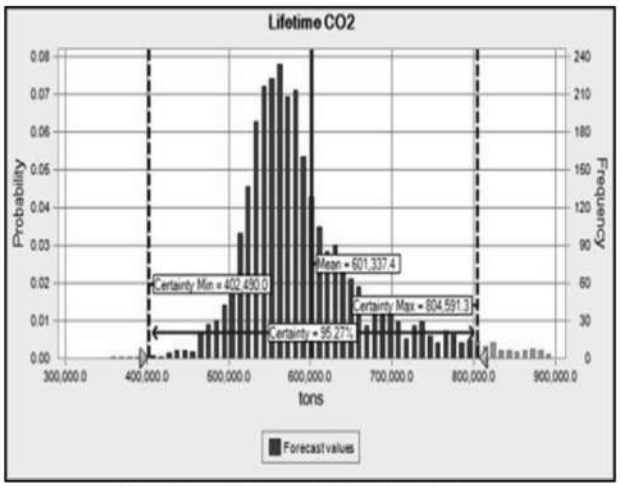


Fig.5. Lifetime CO_2 Emissions

4.2 LNG as an alternative fuel (ERT 1)

Table 5 illustrates the amount of fuel consumption and air emission for the lifetime of the ship, which extended to 30 years' fuel consumption (147,512) tons, and air emissions for, NOx (2,953) tons, SOx (22.2) tons, PM (263.9) tons, and CO_2 (421,206) tons.

Table 5 LNG ERT 1 Scenario 2
(Lifetime Fuel consumption/ Emissions)

LIFETIME EMISSION	Result	No of Sim	Avrg	St Dev	
Lifetime fuel consumption	147,512.8	3,000	162,214.5	28,411.1	tons
Lifetime NOx	2,953.2	3,000	3,169.9	384.0	tons
Lifetime SOx	22.2	3,000	20.2	6.6	tons
Lifetime PM	263.9	3,000	289.6	0.0	tons
Lifetime CO2	421,206.7	3,000	462,567.0	79,875.0	tons

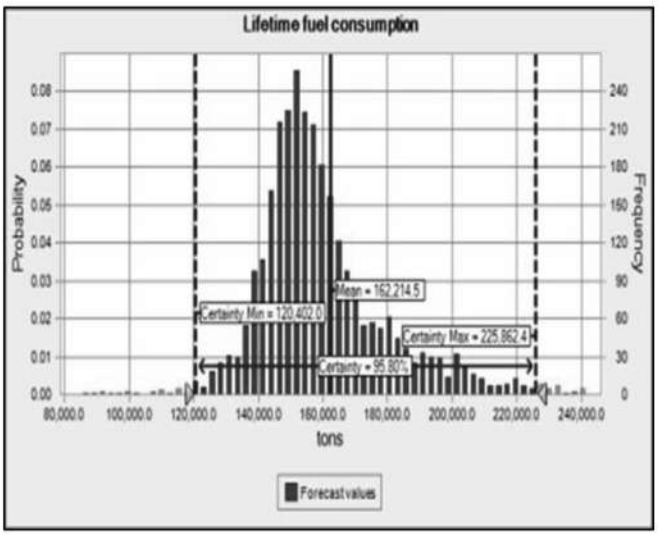


Fig.6. Lifetime Fuel Consumption

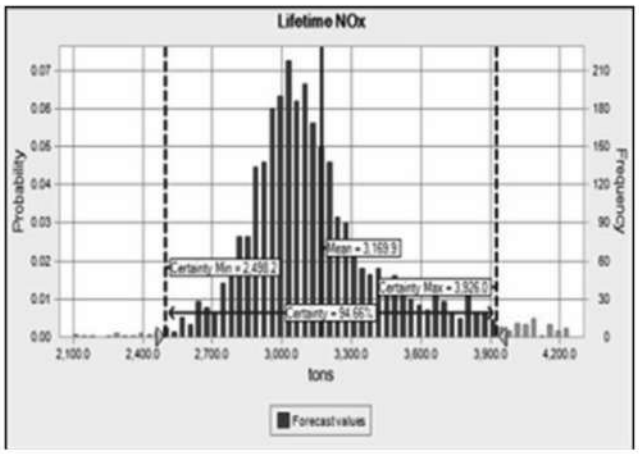


Fig.7. Lifetime NO_X Emissions

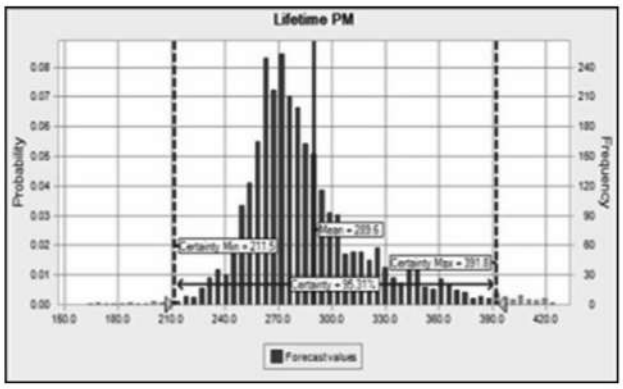


Fig.8. Lifetime PM Emissions

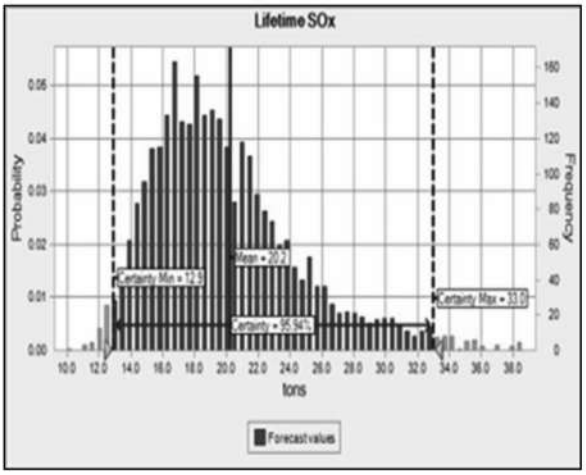


Fig.9. Lifetime SO_X Emissions

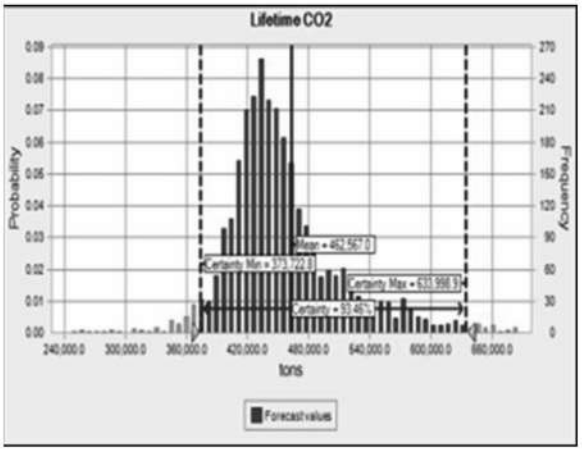


Fig.10. Lifetime CO_2 Emissions

4.3 Speed reduction/OPtimization (ERT 2)

Table 6 illustrates the amount of fuel consumption and air emission for the lifetime of the ship, which extended to 30 years' fuel consumption (125,589) tons, and air emissions for, NOx (10,136) tons, SOx (40.3) tons, PM (195.5) tons, and CO_2 (399,178) tons.

Table 6 Speed Reduction Measure ERT2 Scenario 3 (Lifetime Fuel Consanption/ Emissions)

LIFETIME EMISSION	Result	No of Sim	Avrg	St Dev	
Lifetime fuel consumption	125,589.0	3,000	138,667.5	23,052.5	tons
Lifetime NOx	10,136.3	3,000	11,269.5	1,999.5	tons
Lifetime SOx	40.3	3,000	40.4	5.6	tons
Lifetime PM	195.5	3,000	215.1	0.0	tons
Lifetime CO2	399,178.7	3,000	440,818.3	73,369.8	tons

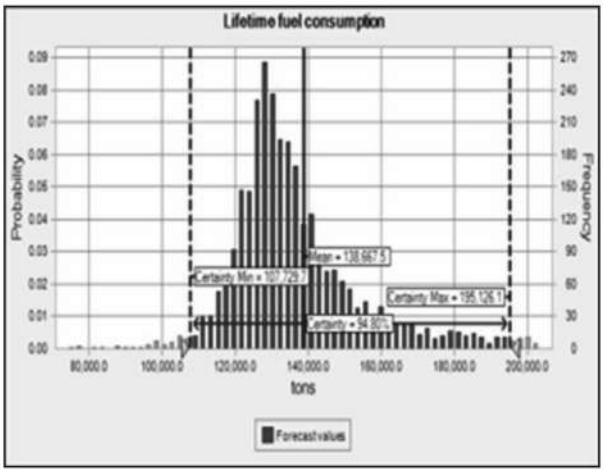


Fig.11.Lifetime Fuel Consunption

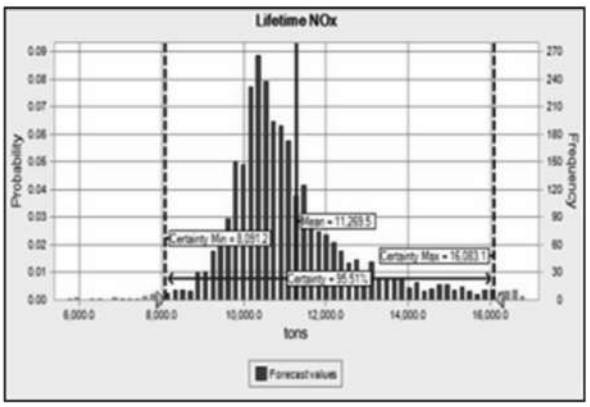


Fig.12. Lifetime NO_X Emissions

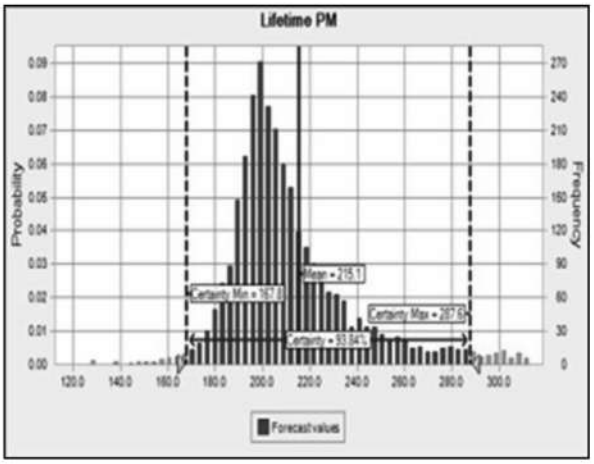


Fig.13. Lifetime PM Emissions

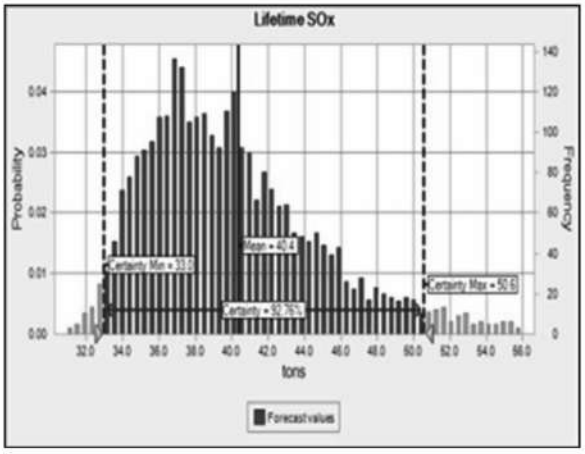


Fig.14. Lifetime SO_X Emissions

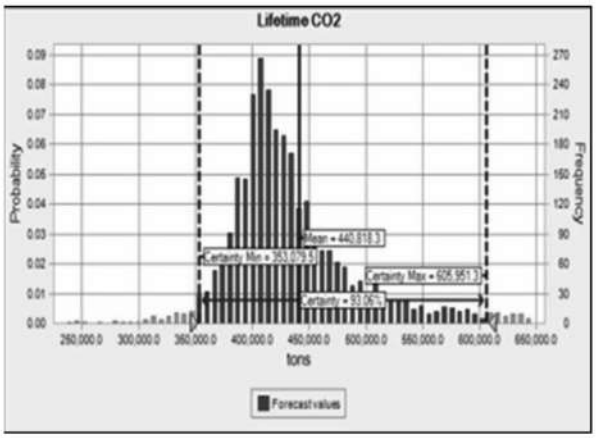


Fig.15. Life CO_2 Emissions

4.4 Combination of two ERTs LNG and Speed reduction

Table 7 illustrates the amount of fuel consumption and air emission for the lifetime of the ship, which extended to 30 years' fuel consumption (109,751) tons, and air emissions for, NOx (2,374) tons, SOx (22.3) tons, PM (195.5) tons, and CO_2 (315,205) tons.

Table 7 Combination of two ERTs LNG and Speed Reduction(Lifetime Fuel Consunption/ Emissions)

LIFETIME EMISSION	Result	No of Sim	Avrg	St Dev	
Lifetime fuel consumption	109,751.0	3,000	120,439.5	18,423.5	tons
Lifetime NOx	2,374.5	3,000	2,544.6	289.3	tons
Lifetime SOx	22.2	3,000	20.2	5.5	tons
Lifetime PM	195.5	3,000	214.3	0.0	tons
Lifetime CO2	315,205.1	3,000	345,300.7	51,811.2	tons

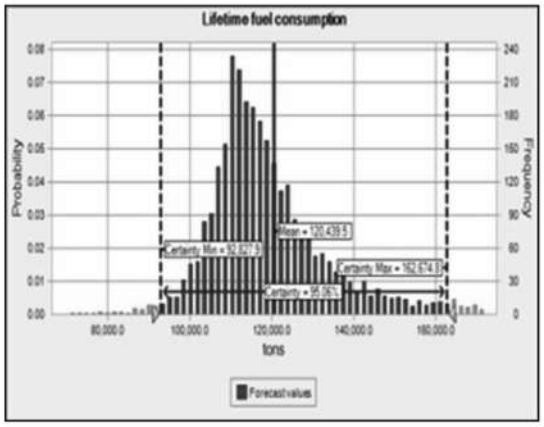


Fig.16. Lifetime Fuel Consunption

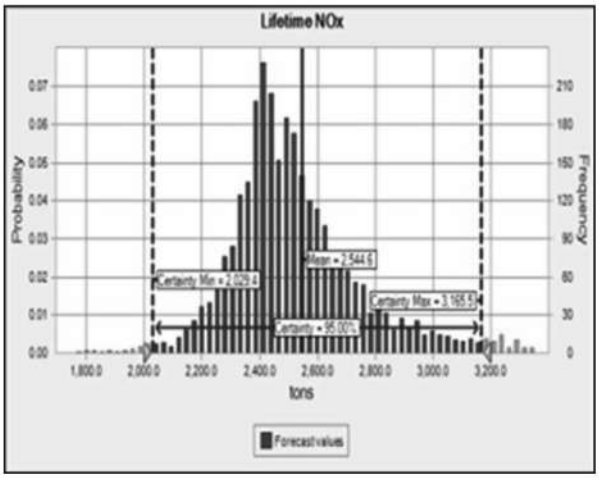


Fig.17. Lifetime NO_X Emissions

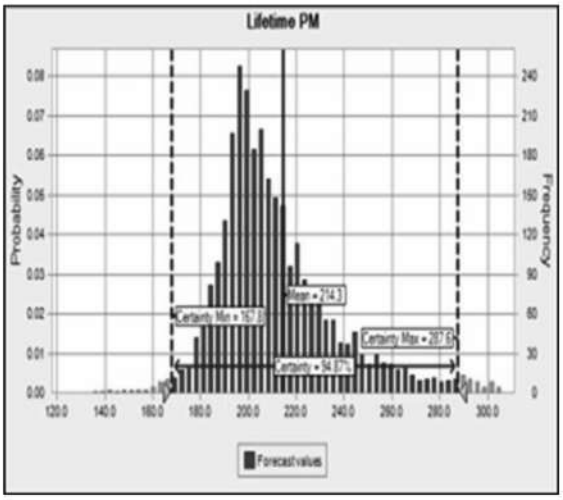


Fig.18. Lifetime PM Emissions

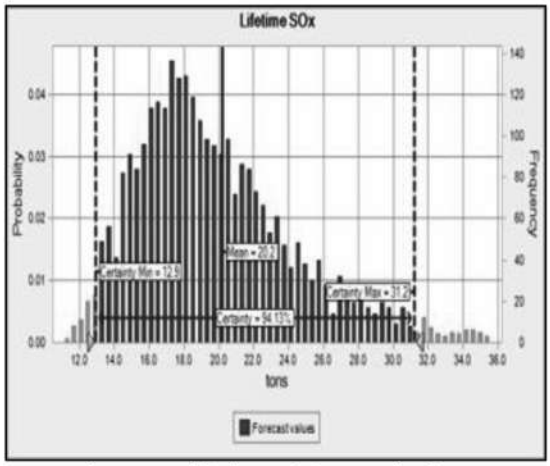


Fig.19. Lifetime SO_X Emissions

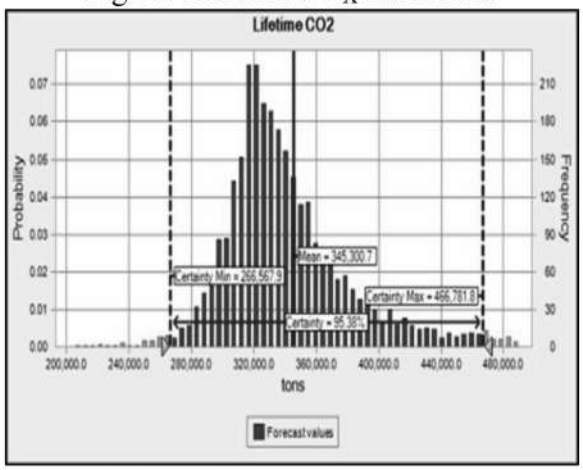


Fig.20. Lifetime CO_2 Emissions

4.5-Comparative analysis between scenarios

Table 8 The difference between selected ERTs options and their effects on air emissions and fuel consumption. Note that these figures represent the average result mentioned in the above tables.

Lifetime assumption 30 years / all units in Tons	MGO Basic case	LNG ERT1	Speed Reduction ERM 2	Combination ERT 1 & ERM 2	% off less figure from base case
Fuel oil consumption	189,122	162,214.5	138,667.5	120,439.5	63.68
SO_X	48.7	20.2	40.4	20.2	41.48
PM	292.3	289.6	215.1	214.3	73.32
NO_X	15,547.2	3,169.9	11,136.3	2,544.6	16.37
CO_2	601,122	462,567.0	440,818.3	345,300.7	57.44

The result shows that reducing speed from 25kts to 22 kts, has reduced fuel oil consumption (26.7%) and reduction in air emissions for, SO_X (17%), PM (26.4%), NO_X (28.4%) and CO_2 (26.6%) for 30-year ship life cycle from basic case MGO.

Use of LNG as fuel oil has reduced fuel oil consumption (14.2%), and reduction in air emissions for, SO_X (58.5%), PM (0.9%), NO_X (79.6%), and CO_2 (23%) for 30-year ship life cycle from basic case MGO.

Use of selected ERTs simultaneously, reducing speed and use of LNG as fuel oil, have reduced fuel oil consumption (36.3%) and reduction in air emissions for, SO_X (58.5%), PM (26.6%), NO_X (83.6%) and CO_2 (42.6%) for 30-year ship life cycle from basic case MGO.

Fuel consumption is very sensitive to ship speed, as the daily consumption of fuel oil is approximately proportional to the third power of its sailing speed. Which has a significant reduction on fuel consumption, hence air emission reduction, while air emissions are very sensitive to LNG fuel which known as the cleanest fossil fuel due to its low carbon content, LNG consumption is lower than MGO consumption for 30-year ship life cycle which means energy content of LNG is higher than energy content of MGO.

Based on the above results, ERTs like speed reduction measure has a tremendous fuel oil saving. However, there are several stakeholders, such as cargo owners and customer challenging speed reduction implementation, as they expect the same level of cargo amount when applying new rules or technologies. Although speed reduction measure shows a significant reduction in fuel oil consumption and air emission, it is feasible only for high-speed ships like containers and passengers ships. LNG as fuel has a significant reduction potential for air pollutants/emissions SO_X, NO_X, PM, and CO_2. However, the infrastructure for LNG stations required tremendous investment and time.

5. Conclusions/recommendations

5.1Conclusions

The aforementioned data was processed using Monte Carlo methodology through the Crystal Ball software program at four different scenarios, scenario one represent use of MGO basic case, scenario two represent use of LNG as fuel oil, Scenario three represent use of speed reduction measure, scenario four represent a combination between LNG and speed reduction, the fuel-saving outcomes after compared with scenario one MGO as basic case are as follow, scenario two (14.2%), scenario three (26.7%), and scenario four (36.3%). Air emissions reduction outcomes after compared with scenario one MGO as basic case are as follow, scenario two (58%) for SO_X, (0.9%) for PM, (79.6%) for NO_X and (23%) for CO_2, scenario three (17%) for SO_X, (26.4%) for PM, (28.4%) for NO_X and (26.6%) for CO_2 and scenario four (58.5%) for SO_X, (26.6%) for PM, (83.6%) for NO_X and (42.6%) for CO_2.

From the above results, it can be concluded that the use of ERTs LNG and speed reduction have a significant potential reduction in fuel oil consumption hence air emissions. Although there is concrete support from the European Union toward emissions reduction technologies in the Baltic Sea region, the outcomes of these technologies need time to become visible as these new technologies challenged by different stakeholders like cargo owners and customers.

5.2 Recommendations and future research suggestions

It is recommended that future research could focus on different ERTs applied to different types of ships and routes to enable decision-makers to take optimum technology related to their trading pattern.

References:

Albrecht, J., (2015). LNG as a ship fuel in the Baltic Sea region – study for LNG supply chain. Retrieved https://www.zerovisiontool.com www.zerovisiontool.com/files/baltic_so 2lution_activity_2_lng_study.pdf Accessed 2019-07-15

Anders, J. (2019). Comparison of Alternative Marine Fuels SEA\LNG Ltd. Retrieved https://sea-lng.org/wp-content/uploads 16_Alternative-Marine-Fuels-Study_final_report.pdf

Claremar, B., Haglund, K., & Rutgersson, A. (2017). Ship emissions and the use of current air cleaning technology: contributions to air pollution and acidification in the Baltic Sea. Earth Syst. Dynam, 8, 901–919. https://doi.org/10.5194/esd-8-901-2017

Corbett, J. J., Wang, H., & Winebrake, J. J. (2009). The effectiveness and costs of speed reductions on emissions from international shipping. Transportation Research Part D: Transport and Environment, 14(8), 593–598. https://doi.org/10.1016/j.trd.2009.08.005

Doudnikoff, M., & Lacoste, R. (2014). Effect of a speed reduction of containerships in response to higher energy costs in Sulphur Emission Control Areas. Transportation Research Part D: Transport and Environment, 28, 51–61. https://doi.org/10.1016/j.trd.2014.03.002

European union regional fund (2016)About GO LNG project http://www.golng.eu/en/about-the-project/ Accessed: 2019-07-16

European union (2019) Blue Baltics | News - BLUE BALTICS WAS AWARDED AN IMPORTANT ENVIRONMENTAL AWARD https://www.blue-baltics.eu/en/news/blue was-awarded-an-important-environmental-award-14879.html Accessed: 2019-07-16

EU Commission -Climate Action (2019) Reducing emissions from the shipping sector | Climate Action. (n.d.). Retrieved https://ec.europa.eu/clima/ policies/ transport/ shipping_en

IMO, Third IMO GHG Study 2014: Executive Summary and Final Report, International Maritime Organization (IMO) London, UK, 2014. Retrieved from www.imo.org

International Council on Clean Transportation, T. (2018). The International Maritime Organization's Initial Greenhouse Gas Strategy. https://theicct.org/sites/default/files/publications/ IMO%20GHG%20strategy%20rapid%20analysis

Jonson, J. E., Gauss, M., Jalkanen, J.-P., & Johansson, L. (2019). Effects of strengthening the Baltic Sea ECA regulations. Atmos. Chem. Phys, 19, 13469–13487. https://doi.org/10.5194/acp-19-13469-2019

Li, X., Sun, B., Guo, C., Du, W., & Li, Y. (2020). Speed optimization of a container ship on a given route considering voluntary speed loss and emissions. Applied Ocean Research, 94(October 2019), 101995. https://doi.org/10.1016/j.apor.2019.101995

Lam, J. S. L., & Van de Voorde, E. (2012). Green port strategy for sustainable growth and development. Paper presented at the Transport Logistics for Sustainable Growth at a New Level, International Forum on Shipping, Ports and Airports (IFSPA), 27-30.

Maritime transport of goods Eurostat (2019)-quarterly data – Statistics Explained. https://ec.europa.eu/eurostat/statisticsexplained /index.php/Maritime_transport _of_goods_-_quarterly_data Accessed: 2019-07-10

Psaraftis, H.N., Kontovas, C.A. (2013). Speed models for energy-efficient maritime transportation: a taxonomy and survey. Transport. Res. C: Emerging Technol. 26, 331–351.

Profir, I. (2011). Motorways of the Sea. Analele Universitatii Maritime Constanta, 12(16), 51–56. Retrieved http://search.ebscohost.com/login.aspx direct=true&db=a9h&AN=78047698 &site=ehost-live

The Appropriateness of Applying ISM Code to Autonomous Ships

Prepared by

Capt. Ahmad Elnoury

Capt. Salah Eldin Farag

Arab Academy for Science, Technology and Maritime Transport

Abstract:

The development of autonomous ships is aiming to create an evolution in the shipping and maritime industry, by increasing the efficiency of vessels and bring forward benefits for the maritime companies which invest in the technology. The Autonomous means the next generation modular control system and communications technology that 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. Moreover, autonomous and unmanned ships are new concepts that will challenge the conventional methods for designing, testing and approving ships and their systems.

Generally, approval of this type of ship will require major changes in marine conventions and regulations, especially in the International Safety Management (ISM) code, mainly because there is no longer any equivalence to the master or other officers on board and also recently the merchant ships and marine companies are still blamed for many deficiencies in implementing the ISM code to provide the safety on board ships and marine environment, and in introducing a new safety culture to improve the seafarer's skill. In addition, taking adequate measures against the paper work routine will help in preventing accidents due to unknown human errors. The ISM code and its implementation should be adapted to achieve its target goals to be up to date with the autonomous ships.

The research is based on a descriptive approach, the qualitative methodology, as this methodology is the most capable of providing a comprehensive picture of the efficiency of the code. The research aimed to present the amendment that should take place in the ISM code and use a new technology for tracking the performance and effectiveness of the code and to create a spirit of credibility among the bodies supervising the implementation of the Code to convey the marine technology.

Keywords: Autonomous ships, ISM code.

1.Introduction

The purpose of the ISM Code is to provide an international standard for the safe management and operation of ships and for pollution prevention. The Code's origins go back to the late 1980s, when there was mounting concern about poor management standards in shipping. Investigations into accidents revealed major errors on the part of management, and in 1987 the IMO Assembly adopted resolution A.596 (15), which called upon the Maritime Safety Committee (MSC) to develop guidelines concerning shore-based management to ensure the safe operation of RO-RO passenger ferries .

The Code establishes safety-management objectives and requires a Safety Management System (SMS) to be established by the Company, which is defined as the owner or any other organization or person, such as the manager or bareboat charterer, who has assumed responsibility for operating the ship and who, on assuming such responsibility, has agreed to take over all duties and responsibility imposed by the Code.

The Company is then required to establish and implement a policy for achieving these objectives. This includes providing the necessary resources and shore-based support. Every company is expected to designate a person or persons ashore having direct access to the highest level of management in order to provide a link between the company and those on board. The procedures required by the Code should be documented and compiled in a Safety management manual, a copy of which should be kept on board.

Much of the literature confirms that the ISM Code has, to some extent, had positive impacts on the shipping industry despite associated problems, which hinder the effective implementation of the Code. The literature regarding the ISM Code has focused primarily on the impact and effectiveness of the Code on the shipping industry, along with the challenges associated with its proper implementation. Chauvel, (1997) compared the ISM Code and the quality management system; ISO 9002, Chauvel specified that the Code is established "based on a structural and controlled approach similar to ISO 9000 standard relating to the quality control system". In addition, Anderson (1998) studied The potential impact on the shipping industry from a legal perspective and practical aspects of the Code.

The SMS would be significant evidence when an accident occurs, for government investigators, underwriters, and courts regarding how the company had a positive approach as to safety as well as a useful management tool for prudent ship owners.

This paper concluded that the ISM code has drawbacks related to its implementation on board ships and marine companies. Goals like preventing pollution and saving the environment aren't achieved, thus it does not comply with the new technology of the new generation of ships operations 'autonomous ships'.

1.1IMO Encourage the ISM

Many IMO's studies showed that the ISM Code has a positive impact, and has contributed to the enhancement of the safety of ships and protection of the environment. IMO, (2005) confirmed that the ISM Code is heading in a positive direction through report 5, submitted at the 81st session of the MSC, the first work on evaluating the effectiveness of the Code in 2005. Moreover, the expert group, established by IMO, concluded that the "overwhelming majority of responses were supportive of the ISM Code" and "the ISM Code is embraced as a positive step toward efficiency through a safety culture, tangible positive benefits are evident" (IMO, 2005).

1.2The Lack of ISM Effectiveness

However, bearing in mind that one of the purposes of the ISM Code is to eliminate human error in shipping, the study carried out by Nautical Institute, (2004) confirmed that the introduction of the ISM Code proved to be effective for the enhancement of safety in the shipping industry, and contributed to the identification of challenges arising during the implementation of the ISM Code. A number of studies claimed that too much paperwork demotivated the seafarers' involvement in the safety management system. The typical off-the-shelf safety management system in the shipping company does not help safety management and seafarers are complaining about increased paperwork, including vetting inspection, and PSC (Nautical institute, 2004).

This could be clarified as:

I. The lack of safety culture such as no blame, in the shipping company, has constantly been pointed out. Seafarers are still reluctant to report hazardous occurrences for fear of being blamed for the mistake, which undermines the continuous improvement of the SMS (Lappalainen, et al., 2012).

II. The key organizational factor causing ineffective implementation of the Code is poor support of personnel and resources by the company, for example it was found that two ships in same company with different maintenance conditions.

III. The lack of seafarer participation in the safety management of one company. It is caused by poor employment conditions, lack of organizational supports and low-trust relationship with managers.

IV. The lack of preconditions to achieve effective safety management in the shore-based workplace. Anderson,(2003) also pointed out that insufficient company support relating to resources, including physical, human resources, and training, causes unsatisfactory implementation of the ISM Code.

V. Owing to the flexibility nature of the ISM Code, a slackness in its implementation is likely to happen since the code does not mention clear instructions related to the designated person ashore Designated Person Ashore (DPA) personality skills and his experience. In addition, it does not manage and determine the capacity of DPA numbers on company fleet. Thus giving the implementation of the code more flexibility.

2-Statistical Analysis of Ships Detained by PSC (ISM Code)

Table (1) shows ships detainable due to deficiencies recorded in Australia, China, and Indonesia which are top 3 countries of the number of ISM detention cases in 2017.DeficiencyCodes of ISM deficiencies specified by Tokyo MOU these countries participating in are as following table 1.

Table 1 Deficiency Code per ISM Code Element (Tokyo MOU)

Def.Code	ISMCodeElement	Defective Item
15101	2	SafetyandEnvironmental Policy
15102	3	CompanyResponsibility and Authority
15103	4	Designated Person(s)
15104	5	MastersResponsibility and Authority
15105	6	ResourcesandPersonnel
15106	7	Shipboard Operations
15107	8	EmergencyPreparedness
15108	9	ReportsofNon-conf.,accidents&hazardousoccur.
15109	10	Maintenance oftheshipandequipment
15110	11	Documentation-ISM
15111	12	CompanyVerification,ReviewandEvaluation
15112	13	Certification,VerificationandControl
15199	-	Other(ISM)

Source: (NK, 2018)

2.1Australia

As seen from the Table (2), in 2017, ISM detainable deficiencies are spotted in ISM code in rule 6 (Resources and Personnel), rule 7 (Development of plans for ship board operation), rule 8 (Emergency Preparedness), rule 9 (Reports and Analysis of Non- Conformities, Accidents and Hazardous Occurrences) and rule 10 (Maintenance of the Ship and Equipment). This means the main domain of the ISM code includes drawbacks which affects its implementation. The deficiencies categorized into“15106-Shipboard operations” and “15199-Other (ISM)” were frequently recorded just like 2016. Typical evidences of each ISM detainable deficiency are as follows. For the case there were plural ISM code elements corresponding to the evidences of ISM detention, “15199 –Other (ISM)”was recorded.

(- 15106Shipboard operations)

- Unofficial Charts (photocopy) are used.
- Crew not follow the vessel voyage plan, in relation to frequency and method of position fixing.
- Recorded rest hours of deck and engine room personnel do not reflect actual hours of rest.
- Un-familiar with the operation of ECDIS.
- Engineer officers are not in charge of Engine room watch keeping at port

(15199-Others).

- Crew unable to demonstrate rescue boat or life raft davit launching.
- Crew unable to demonstrate “under keel

clearance" in voyage plan.

- Life boat or rescue boat's engine not started
- Port and Starboard lifeboat launched and maneuvered in water overdue.

Table 2 Number of ISM Detainable Deficiencies per Deficiency Code

Code	Item	2015	2016	2017
15105	Resourcesandpersonnel	1	1	1
15106	Shipboard operations	16	26	11
15107	Emergencypreparedness	3	1	2
15108	ReportsofNCs,accidentsandhazardousoccur.	1	-	-
15109	Maintenance oftheshipandequipment	1	2	-
15199	Other(ISM)	27	15	9
Total		49	45	23

Source:(NK, 2018)

Table 3 Number of Deficiencies Regarded as the Evidences of ISM detainable Deficiencies per Deficiency Code.

Code	Item	No.	Remarks
03108	Ventilators,airpipes,casings	15	
03199	Other(loadlines)	4	Load linenotclear
04102	EmergencyFire Pump anditspipes	4	
04103	Emergencylighting,batteriesandswitches	6	
04114	Emergencysourceofpower-Emergency Generator	4	
07105	Fire doors/openingsinfire-resistingdivisions	14	
07114	Remote Meansofcontrol (opening,pumps, ventilation etc.)Machinery spaces	4	
07115	Fire-dampers	4	
10116	Nauticalpublications	6	
11101	Lifeboats	21	
11124	Embarkation arrangementsurvivalcraft	9	
13101	Propulsion mainengine	9	
13102	Auxiliary engine	8	
13103	Gauges,thermometers,etc	9	
13199	Other(machinery)	12	Excessiveoilin E/R
14402	Sewage treatmentplant	5	
Others		137	

Source: (NK, 2018)

2.2China

Table (4) shows the number of ISM detainable deficiencies per Deficiency Code. Table 5 shows the number of deficiencies regarded as the evidences of ISM detainable deficiencies per Deficiency Code.

As seen from the Table 4, in 2017, "15109 - Maintenance of the ship and equipment" was mostfrequentlyrecordedas ISM detainable deficiencies.Typicalevidences of theISM detainabledeficiencyare as follows.

(15109Maintenance of the ship and equipment)

- Corrosion of air pipe head.
- Self-closed fire doornotclosed tightly.
- Anengine oflifeboator rescue boatnotstart.
- Wastage ofembarkation ladder.
- Leakage offueloilfrommainengine and auxiliaryengine orexcessive oilleakage fromthe line.

Table 4 Number of ISM Deta in able Deficienciesper Deficiency Code.

Code	Item	201	201	201
1510	Safetyandenvironmental policy	-	1	-
1510	Companyresponsibilityandauthority	-	1	-
1510	Mastersresponsibilityandauthority	-	1	-
1510	Resourcesandpersonnel	6	4	5
1510	Shipboard operations	9	10	3
1510	Emergencypreparedness	5	1	6
1510	ReportsofNCs,accidentsandhazardousoccur.	-	1	1
1510	Maintenance oftheshipandequipment	5	8	16
1511	Certification,verificationandcontrol	1	2	-
1515	ISM	1	-	-
1519	Other(ISM)	2	3	1
Total		29	32	32

Source: (NK,2018)

Table 5 Number of Deficiencies Regarded as the Evidences of ISM detainable Deficiencies per Deficiency Code.

Code	Item	No.	Remarks
03108	Ventilators,airpipes,casings	15	
03199	Other(loadlines)	4	Load linenotclear
04102	EmergencyFire Pump anditspipes	4	
04103	Emergencylighting,batteriesandswitches	6	
04114	Emergencysourceofpower-Emergency Generator	4	
07105	Fire doors/openingsinfire-resistingdivisions	14	
07114	Remote Meansofcontrol (opening,pumps, ventilation etc)Machinery spaces	4	
07115	Fire-dampers	4	
10116	Nauticalpublications	6	
11101	Lifeboats	21	
11124	Embarkation arrangementsurvivalcraft	9	
13101	Propulsion mainengine	9	
13102	Auxiliary engine	8	
13103	Gauges,thermometers,etc	9	
13199	Other(machinery)	12	Excessiveoilin E/R
14402	Sewage treatmentplant	5	
Others		137	

Source: (NK, 2018)

The above tables show the high ratio of vessels that are detained under PSC. The ISM represents one of the highest ratios whereas these detain caused by lifesaving, pollution and structures, machinery & electrical scored the less ratio of detain although these items are more operational.

3-What are the Features of Autonomous Ship?

According to the European Waterborne Technology Platform Implementation Plan for 2020, the development of autonomous ships is one of the key exploitation outcomes to strengthen Europe's maritime sector. Defines an autonomous ship as a vessel with:

"Next generation modular control system and communications technology that 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." (EMSA,2016).

In order to bring the idea of autonomous ships to life, the research project Maritime Unmanned Navigation through Intelligence in Networks (MUNIN) was established by the European Commission. MUNIN investigated the feasibility Of autonomous ships, and aims to develop required technology and business concepts (Kretschmann, et al., 2017). As outlined in the definition of an autonomous ship, the vessel should be able to operate remotely under semi or fully autonomous control. The MUNIN project's core task is to develop and validate the required technology to achieve semi or fully autonomous control (Rodseth et al., 2012). According to the MUNIN project a ship is said to be autonomous if it is completely unmanned at least for parts of a particular voyage.

Japan's Nippon Yusen Kabushiki Gaisha (NYK)has launched first autonomous ship, Dead weight (DWT) 70,826-tonne pure car truck carriers (PCTC) Iris Leader, sailing from China to Japan. Using the Sherpa System for Real ship (SSR) navigation system, the Maritime Autonomous Surface Ship (MASS) trial was performed from 14-17 September 2019 from China's Xinsha to Japan's Nagoya, and then from Nagoya to Yokohama from 19-20 September 2019. (NYK line, 2019).

3.1Autonomous Level

Table (6) show the Lloyd's Register's definition of autonomy levels based on differences between the techniques used as well as the operator's role.

Fully autonomous ships (level A) without any human involvement in navigation and steering will not comply with ISM code, regarding that the ISM code preambles:

A-The cornerstone of good safety management is commitment from the top. In matters of safety and pollution, prevention it is the commitment, competence, attitudes and motivation of individuals at all levels that determines the end result purpose.

B-The Code expressed in broad terms so that it can have a widespread application. Clearly, different levels of management, whether shore-based or at sea, will require varying levels of knowledge and awareness of the items outlined.

Thus, this new technology (autonomous level A) is not compatible with the International Labour Conference (ILO)'s Maritime Labour Convention, 2006- MLC .Thus it is very difficult to implement the ISM code by this version.

Autonomy Level	Operator's Role
M-Manual navigation with automated processes and decision support	The operator (master) is on board controlling the ship which is manned as per current manning standards. Subject to sufficient technical support options and warning systems, the bridge may at times be unmanned with an officer on standby ready to take control and assume the navigational watch.
R-Remote-controlled vessel with crew on board	The vessel is controlled and operated from shore or from another vessel, but a person trained for navigational watch and maneuvering of the ship will be on board on standby ready to receive control and assume the navigational watch, in which case the autonomy level shifts to level M.
RU-Remote-controlled vessel without crew on board	The vessel is controlled from shore or from another vessel and does not have any crew on board.
A-Autonomous vessel	The operating system of the vessel calculates consequences and risks. The system is able to make decisions and determine actions by itself. The operator on shore is only involved in decisions, if the system fails or prompts for human intervention, in which case the autonomy level will shift to level R or RU, depending on whether there is crew on board or not.

Source: (DMAR, 2017)

4-Modifications that facilitate the implementation of ISM on Autonomous Ships.

I. A special assessment of the operational risk management for remotely controlled ships should be included as part of ship owners' Safety Management System under the ISM Code. The ISM code should state that the ship owner must have addressed cyber security risk management as part of its safety management system (SMS).

II. The DPA no longer links between ship and shore, hence his responsibilities and tasks should be related to shore operators only.

III. An amendment to the ISM Code should be considered to establish the principles for remote operators. Such regulation could cover organizational and decision structures, means of communication and emergency procedures and should be based on the principles and requirements made in relation to the" Master's Responsibility and Authority" in part A, regulation 5, of the ISM Code. (DMA, 2017).

IV. The flag state should clearly state its role is issuing the new certificates for autonomous ships company and shore operators with new liabilities and responsibilities.

5-How the technology is improving safety in the autonomous ships

It is highly predicted that the maritime surveillance and drones will act as the new navigations aids on board the autonomous ships which will guarantee maritime domain awareness. These means of technology will substitute the ISM code in following up and implementing the safety levels on board the Autonomous .

Drones can safely go where humans can't. Improving safety, reducing costs, speeding up processes and making access challenges easy are just some of the benefits of using drones in the maritime industry.

Conclusion

In conclusion, the ISM code currently has some deficiencies regarding its implementation, which hinders achieving its required goals. The ISM code should cope with the new technology in its new frame; autonomous ships, since the process of the implementation should be paperless and computerized. The policy of the code should be changed to include the cyber security which is considered one of the major threats that the code will face .

The concept of hand writing routine (paper work) does not comply with the new autonomous ships. The use of modern technology of ship surveillance cameras and drones will not need to use the ISM code in carrying out its objectives and responsibilities in a clear and effective manner. The follow up system for this technology needs mathematical based software. Hence, the ISM code is not compatible with the autonomous ships technology since the requirements of this technology are not met by the ISM code.

References

–Anderson, P. (1998). ISM Code: A practical guide to the legal and insurance implications. London; Singapore: LLP.

–Anderson, P. (2003a). Cracking the code: the relevance of the ISM Code and its impact on shipping practices. London: Nautical Institute.

–Anderson, P. (2003b). Managing Safety at Sea - The findings and conclusions of an international survey. Retrieved from Middlesex University's Research Repository.

–Chauvel, A.-M. (1997). Managing safety and quality in shipping. London: The Nautical Institute.

–Danish Maritime Authority (2017).

–EMSA, 2016. Annual Overview of Marine Casualties and Incidents 2016, s.l.: European Maritime Safety Agency.

–IMO Assembly adopted Guidelines on implementation of the International Safet MSC 81/17/1.

–Management (ISM) Code by Administrations (resolution A.788(19)).

–Kristensen, Hans Ot to and MarieLützen(2013).“Prediction of Resistance and Propulsion Power of Ships”. In: 2.4.

–Lappalainen, J., Kuronen, J., &Tapaninen, U. (2012). Evaluation of the Ism Code in the finnish shipping companies. Journal of Maritime Research, 9(1), 23–32.

–Lloyds list. (2017). Let seafarers light way forward on ISM Code: The effectiveness of the ISM Code requires an urgent review.

–Nautical Institute, (2004). Paperwork, what paperwork ?Alert!, (2), 1–8.

–Rodseth, et al. (2012), Developments toward the unmanned ship, Proceedings of International Symposium Information on Ships – ISIS 2012, Hamburg, Germany, August 30-31, 2012.

–Tokyo MoU. (2017). Annual Report on Port State Control in the Asia-Pacific Region 2017. Tokyo Retrieved from http://www.tokyomou.org/publications/annual