**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



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# The importance of science and scientific Research

The importance of science and scientific research and their role in development and progress is an old concept, but at the same time a renewed concept across time and place to the extent that it has become an axiom, and it's well known that the status of any civilized country is measured by the degree of its development in this field. Where the sophistication and progress that economically developed countries have reached through scientific research is not only a result of providing material liquidity and natural raw materials, but rather a result of the interest of universities and educational & research institutions to provide the qualified manpower needed by Developmental Institutions that need human resources as much as their need for financial and natural resources.

Scientific research is the real and correct approach to the development of societies, as it is not valid to talk about development far from its effective role as an important base from which all development projects and all its various sectors start to give a natural and necessary product, which is the achievement of social luxury, and accordingly the role of science and scientific research at all levels is the reason to achieve this purpose.

Hence, universities have an important role in the life of nations at different stages of their cultural, economic and social development. They are no longer limited to traditional goals by teaching scientific material to students. Rather, their mission extends to include various aspects of scientific, technical and technological life, which made it one of the most important duties of contemporary universities is to interact with the community to discuss its needs and meet its requirements. Not only that, but it must go hand in hand with the requirements of the industry by conducting questionnaires to learn about the current and future needs and analyzing them to determine the most appropriate methods of university education, which is the main pillar of scientific research in universities of various specializations. In order to achieve this, countries must place in their budgets a share for spending on scientific research and provide a suitable environment for the researcher so that his scientific outcome is at the level of qualification. Scientific research is the gate to knowledge that has no limits, as it is a field of experimentation and addition to human life and well-being and ensuring better conditions for his life according to the standards.

**Editorial Board**

# The dynamics of the Mediterranean container terminals' market

Prepared by

Dr. Khaled Salem; Dr. Ahmed Ismail; Capt. Ahmed Al-Bishi

Mr. Mohamed Gamil

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

**Abstract:**

The aim of this paper is to illustrate the level concentration in Mediterranean to determine the type of market structure, in order to measure market behavior concentration by using the Concentration Ratio (CR) and Herfindahl Hirschman Index (HHI). By studying the competition and market concentration of the Mediterranean container terminals, the researchers found that the container terminal in this region is going to be low concentrated during the period of study. The research will be limited to the selected container terminals located in the Mediterranean, during the period of the study from 2009 to 2018.

Key words: Container Ports, Concentration Ratio and Herfindahl Hirschman Index.

## 1.Introduction

Since the development of containers and inter-modalism in the late 1960's, containerization is constantly growing and penetrating almost all seaborne trade sectors, as by 2016 nearly1.7 billion tons were transported by container, while about 90% of the world trade goes through seaports, and more than 50,000 vessels are sailing all over the world (UNCTAD, 2017). The port market structure have witness a changes due to containerization era which relay on to many aspect, this research focus on the rapid increase of container use, while a clear difference concerning the competitors, the bigger ports are compete for the biggest share, and left the fractions for the smaller ports that compete with each other also to attract more container traffic .

The market structuring is a way to classify markets based on the level of competition among dealers in the market. Market structure can be defined as the number of competing firms and their market share. Measurement of market structure that is most widely used in the United Kingdom, United States and Canada is an assessment of concentration. The most commonly used concentration tool is the percentage of output, or any other indicator of industry size such as employment (Obrębalski and Walesiak, 2015), rail freight (Crozet, 2017), throughput and etc. (Ismail, 2019.(

There are many tools used to measure the market concentration such as: Hall-Tideman index "HTI" index, Entropy index (E)", The Comprehensive Industrial Concentration Index (CCI), The Hannah and Kay Index (HKI), Gini coefficient (GC), The U Index (U), Hachman Index and The Hause Indices (H). The reasons why the researcher used only these two indexes; the N-Firm Concentration Ratio (CRN) and Hirschman-Herfindahl Index (HHI) index to analyze the dynamics of container terminals' market because they are the most common and simple measures that are used in earlier studies such as (Pehlivanoğlu and Tiftikçigil 2013; Akomea and Adusei, 2013; Krivka, 2016; Yaşar and Kiracı, 2017) to determine market concentration.

This paper aims to investigate the current trends in port competitiveness in the Mediterranean basin by analyzing the dynamics of the carriers' market. This will be carried out by presenting the concepts, definitions and thorough analyses of the market conditions using CR and HHI indexes. This research is containing all container ports which have a design capacity more than one million TEU per year.

Regarding geographical asymmetries, we can easily find the differences between three maritime entrances: the Gibraltar, Suez and Bosporus straits. Gibraltar is the natural and main gate to world from the Mediterranean Sea, and so far new logistical technologies cannot avoid this evidence. Algeciras, on the Spanish side, and Tangier, on the Moroccan side, are competing to capture maritime transport and are investing to enlarge their transport facilities. Finally, Bosporus is the path to Black sea countries that unfortunately suffer from the weakness and instability of the Caucasian area, but the opportunity to communicate, through Turkey, to high potential growing areas. The Mediterranean container volume based on UNCTAD statistics indicates that all container volume needs to enhance competitiveness to increase or maintain their market share out of the 78 million TEU in 2018. Figure (1) shows main Mediterranean container ports.


Figure 1: Mediterranean main container ports
Source: Monteiro (2013) adopted by author.

## 2. Literature Review

Market concentration refers to the number of firms that account for the total production within a given industry at a point in the time. Industrial concentration is necessary for investors, consumers and regulators (Akomea and Michael, 2013). The main idea is to identify

how many firms account for the majority of the product that is produced within a given market. In this research, market structure will be assessed by using concentration indices. The next section illustrates the features and limitations of concentration indices used in this research .

Al-Muharrami (2008) examined changes in concentrations that occurred during 1993-2002 within Arab GCC countries' of banking industries used the Herfindahl-Hirschman index and the k bank concentration ratio to measure concentration changes over ten years. The results showed that concentration does not appear to have increased in Golf countries' banking industry.

Notteboom, (2010), provide a detailed container traffic analysis for 78 container ports at the period 1985–2008, identified of multi-port gateway regions, changes in the hinterland orientation of ports and port regionalization processes. Depend on assumption that containerization would lead to further port concentration is not a confirmed fact in Europe: the European port system and most of its multi-port gateway regions witness a gradual cargo de-concentration process. Find the container handling market remains far more concentrated than other cargo handling segments in the European port system, as there are strong market-related factors supporting a relatively high cargo concentration level in the container sector .

Varan and Cerit, (2014) analyzed the industry concentration and competition in the specific context of container ports in turkey to measure the outcome of Turkey's recent privatization process by using HHI, Shift share analysis, and concentration ratio. The statistical findings of this study suggest that the recent port privatizations have been successful in stimulating private investments and competition, also the improvement in the port policy and regulatory are very important to build the competitive advantage to attract new customers (shipping lines) and to have future advantage to compete globally.

Elsayeh (2015) analyzed the impact of ports' technical efficiencies on the improvement of Mediterranean container ports' competitiveness by using of K-Firm Concentration Ratio (CRk), HHI, GC, and SSA. The researcher found the Mediterranean container port market tends to de-concentration the existence of inefficiency pertaining to the management of container ports in the region, his contributes to assist port managers to optimize their resources and set operational plans that enable them to satisfy their customers' needs and requirements.

Elbayoumi & Dawood, (2016) provides a satisfactory understanding of the market share and competition of selected container terminals in the Middle Eastern region by using HHI to analyze 24 container terminals from 12 countries in the region. Based on analysis the 24 terminals in the region only 5 terminals (Dubai included Jebel Ali, Suez Canal C. terminal, Ambarli, Salalah and Jeddah) are growing constantly; the rest of the terminals are inefficient. Aden terminal shows the lowest level of Market share with a score of 0.201.

More recently, El-Haddad et al., (2017) analyzed the East–Mediterranean region market behavior concentration during the period from 1995 to 2014 by using the Concentration Ratio (CR3 and CR5), HHI and SSA. The researchers found that the container port/terminal in the stated region is going to be concentrated in 2014 along with the continued growth rate and the market share of the port of Piraeus and Ambarli or the market tends monopoly.

## 3. Methodology

This paper provides market structure analysis for Mediterranean container terminals market using CR and (HHI) analysis. However, this research is limited to 30 container terminals for 10 years period from 2009 to 2018.

(The K-Firm Concentration Ratio (K-CR 3.1

Concentration ratios are widely used for characterizing industrial structures. Concentration Ratio (CR) is one of the early indicators that takes market concentration into account. CR is defined as the sum of market shares of the largest markets in the industry as shown in the equation 3-1. Concentration ratio is

used basically for two purposes first, to measure the market coverage ratios of several largest companies which manufacture a special product in a private sector and second, to measure the degree of oligopoly of the largest companies (Çalmaşur and Daştan, 2015).

N-Firm concentration ratio is the oldest and commonly used index known among the concentration criterions. But, the Four-Firm Concentration Ratio (CR4) is the most relevant index to measure concentration before the advent of the HHI (Naldi and Flamini, 2014). It is given by the sum of the market shares of the largest four, eight or twenty firms in the market; according to (Ismail, 2019) CRN can be explained as:

$$CR_N = \sum_{i=1}^{N} P_i$$

The range of the concentration ratio is from almost zero for perfect competition to 100 percent for monopoly. A low ratio indicates a CR high degree of competition and its relation with competitiveness. On the other hand, a high concentration ratio indicates an absence of competition and the closer to an oligopolistic or monopolistic type of market structure (Pehlivanoğlu and Tiftikçigil, 2013).

### 3.2Herfindahl–Hirschman Index (HHI)

Hirschman-Herfindahl Index is a commonly accepted measure of market/trade concentration (Crozet, 2017). It is the most well-known measure of specialization and concentration constructed on the basis of structural data in economics. HHI index was postulated by both Hirschman (1945&1964) and Herfindahl (1950) as a measure of trade and industry concentration (Hossain et al., 2017). It plays a significant in the enforcement process of antitrust law in banking sector of the United States (Ismail, 2019).

Herfindahl-Hirschman Index is defined as the sum of the squared market shares (Crozet, 2017). According to this research, HHI index is the sum of the squared values of each port's market share that is obtained by comparing the throughput of each port against the total throughput of the defined ports in the market, as shown in the equation 3-2. Therefore it is sensitive to inequality in the distribution of the market shares (Maksimović and Kostić, 2012). The higher the HHI value, the more concentrated the industry and the greater the potential for market power (Yaşar and Kiracı, 2017). It is believed that the Herfindahl-Hirschman Index is more precise measure because it takes into account all companies.

It is calculated by squaring the market share of each firm competing in a market, and then summing the resulting numbers, and can range from close to zero to 10,000. The value of the index increases when the number of companies decreases (Crozet, 2017). These values range from 0 to 10000, and as the number gets smaller, the market can be said to be more competitive. As impossible as it is, if the value is 0, a full competitive market is observed, even though this is very difficult to come by today. If the HHI value is 10000, the market is a monopoly (Yaşar and Kiracı, 2017). HHI index can be explained as:

$$HHI_{1...n} = \sum_{n} S_n^2$$

According to this research, S is the throughput of port n on the Egyptian market and n is the total number of the defined ports in the market.

Classifications made for HHI values are as follows: $0 \leq HHI < 1500 \rightarrow$ Low Concentration, $1500 \leq HHI < 2500 \rightarrow$ Medium Concentration and $HHI \leq 2500 \rightarrow$ High Concentration (Ismail, 2018).

## 4. Empirical analysis and results

### 4.1Mediterranean container ports market concentration using K-Firm

According to K- firm theory Concentration ratios only provide an indication of the oligopolistic nature of an industry and suggest the degree of competition. The four-firm and ten – firm concentration ratio is calculated based on the market shares of the largest firms in the industry. Using the K-Firm concentration ratio (K-CR), the table 1.1 and figure 1.2 shows the result of the degree of the Mediterranean

container port market concentration between 2009 and 2018 for the top 4 and top 10 container ports in Mediterranean. Researcher uses the calculated market share in appendix 3 to calculate K-Firm C-4 and C-10 Concentration ratio .

The calculation shows that continuous decrease in the market share regarding concentration ratio for the period of ten years under study. Also, found that the highest market share for the top four container port in year 2009 was 36 %, while the top ten was 66.4 % in 2013, as shown in table (1).

Following the top container port in Mediterranean found Valencia was 10% in 2009 and 10.6% in 2010, then Port Said was 11.9% in 2011 and 10.2% in 2012, followed by Algeciras was 9.2% in 2013, 9.1% in 2014, Valencia 9.6% in 2015 and Algeciras 8.7% in 2016, Valencia back again to the first again in year 2017 with market share 8.5%, finally Piraeus was 8.7% in 2018. For year 2009 the top four container port was 36%, the top ten was 63.7% while the rest 20 container ports have 36.3%. In the last two years 2017 and 2018, the top four container port was 29.6% and 31.7%, the top ten was 62.1% and 63.9% while the rest 20 container ports have 37.9% and 36.1% respectively .

That concludes that Mediterranean container ports enhanced its competitive position. The above analysis reveals the intense competition among study ports in the Mediterranean container market. The market share of the top four ports decreased from 36.4% in 2009 to 34.6% in 2010, but increased to 35.5% in 2011, and it makes a continuous decrease during the rest of the years under study, from 34.9% in 2012, 34% in 2013, 33.2% in 2014 and 2015, 31.7% in 2016, 29.6% in 2017 and finally 31.7% in 2018. This reveals that there are a tendency towards de-concentration and increased competition between ports in the market.

The market share of the top ten ports also increased from 63.7% % in 2009 to 65.3% in 2010, but decreased to 63.1% in 2011 and started to increase to and in 2012 and 2013 to 64.6%, 66.4% respectively, but started decreased from 66.2% in 2014, 65% in 2015, 63.8% in 2016, 62.1 in 2017 and 63.9% in 2018. Port Said saved one of the top four container ports for six years consecutive from 2009 to 2014. Also, from 2015 to 2018 saved one of the top ten container ports from thirteen container ports under study; as shown in table (1).

In 2018, Piraeus is the 1st rank has market share for has 8.7%, followed by Valencia with a market share of 8.5% and Algeciras has market share 8.4% remain the top 3 in 2017 and 2018, but the 4th rank was for Barcelona with has market share 6%, Tangier ranked 5 th with a market share 5.9%. Table (1) also shows that Valencia container port is the only container port that was one of the top three container ports ranked during all the period of the study.

Table (1) Mediterranean container ports market concentration using K-Firm.

| 2009 | | 2010 | | 2011 | | 2012 | | 2013 | | 2014 | | 2015 | | 2016 | | 2017 | | 2018 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Valencia | 10.0% | Valencia | 10.6% | Port Said | 11.9% | Algeciras | 10.2% | Algeciras | 9.2% | Algeciras | 9.1% | Valencia | 9.6% | Algeciras | 8.7% | Valencia | 8.5% | Piraeus | 8.7% |
| Port Said | 9.8% | Port Said | 9.7% | Valencia | 9.7% | Valencia | 9.5% | Valencia | 9.2% | Valencia | 8.9% | Algeciras | 9.3% | Valencia | 8.7% | Piraeus | 7.7% | Valencia | 8.5% |
| Algeciras | 8.3% | GioiaTauro | 7.2% | Algeciras | 8.0% | Algeciras | 8.7% | Port Said | 8.7% | Port Said | 8.2% | Piraeus | 6.9% | Piraeus | 7.4% | Algeciras | 7.2% | Algeciras | 8.4% |
| GioiaTauro | 7.8% | Algeciras | 7.1% | Ambarli | 6.0% | Piraeus | 7.0% | Ambarli | 7.0% | Piraeus | 7.0% | Ambarli | 6.4% | Port Said | 6.9% | Tangier | 6.3% | Barcelona | 6.0% |
| **Top Four** | **36.0%** | **Top Four** | **34.6%** | **Top Four** | **35.5%** | **Top Four** | **34.9%** | **Top Four** | **34.0%** | **Top Four** | **33.2%** | **Top Four** | **32.2%** | **Top Four** | **31.7%** | **Top Four** | **29.6%** | **Top Four** | **31.7%** |
| Marsaxlokk | 6.2% | Ambarli | 6.4% | Marsaxlokk | 5.2% | Piraeus | 5.8% | GioiaTauro | 6.5% | Ambarli | 6.9% | Marsaxlokk | 6.4% | Marsaxlokk | 6.1% | Ambarli | 6.0% | Tangier | 5.9% |
| Ambarli | 5.0% | Marsaxlokk | 6.0% | GioiaTauro | 5.1% | GioiaTauro | 5.8% | Tangier | 6.2% | Port Said | 6.3% | Tangier | 5.9% | Ambarli | 5.6% | Marsaxlokk | 6.0% | Marsaxlokk | 5.9% |
| Barcelona | 4.9% | Tangier | 5.2% | Tangier | 4.9% | Marsaxlokk | 5.4% | Marsaxlokk | 5.8% | GioiaTauro | 5.8% | GioiaTauro | 5.3% | GioiaTauro | 5.6% | Barcelona | 5.2% | Genoa | 5.6% |
| Genoa | 4.2% | Barcelona | 4.9% | Barcelona | 4.5% | Tangier | 4.7% | Tangier | 5.4% | Marsaxlokk | 5.8% | Barcelona | 5.2% | Barcelona | 5.6% | Genoa | 5.0% | Port Said | 5.6% |
| Alexandria | 4.0% | Genoa | 4.4% | Genoa | 4.1% | Genoa | 4.4% | Genoa | 4.2% | Genoa | 4.4% | Genoa | 4.6% | Genoa | 4.6% | GioiaTauro | 4.7% | Genoa | 5.3% |
| Tangier | 3.4% | Alexandria | 3.8% | Piraeus | 3.7% | Barcelona | 3.7% | Barcelona | 3.6% | Barcelona | 3.8% | Barcelona | 4.1% | Barcelona | 4.5% | Port Said | 4.7% | GioiaTauro | 4.1% |
| **Top Ten** | **63.7%** | **Top Ten** | **65.3%** | **Top Ten** | **63.0%** | **Top Ten** | **64.6%** | **Top Ten** | **66.4%** | **Top Ten** | **66.2%** | **Top Ten** | **65.0%** | **Top Ten** | **63.8%** | **Top Ten** | **62.1%** | **Top Ten** | **63.9%** |
| Damietta | 3.3% | La Spezia | 3.3% | Livorno | 3.4% | Alexandria | 3.4% | Alexandria | 3.2% | Alexandria | 3.4% | Alexandria | 3.5% | Alexandria | 3.3% | Alexandria | 3.3% | Alexandria | 3.0% |
| Haifa | 3.1% | Haifa | 3.2% | Alexandria | 3.3% | Mersin | 3.2% | Mersin | 2.9% | Mersin | 3.0% | Mersin | 3.0% | Sines | 3.0% | Sines | 3.2% | Sines | 3.0% |
| La Spezia | 2.9% | Damietta | 2.8% | La Spezia | 3.0% | Haifa | 2.9% | La Spezia | 2.6% | Ashdod | 2.5% | Ashdod | 2.7% | Ashdod | 2.7% | Mersin | 3.0% | Mersin | 2.9% |
| Beirut | 2.7% | Mersin | 2.6% | Haifa | 2.7% | Mersin | 2.7% | La Spezia | 2.6% | Ashdod | 2.5% | Sines | 2.5% | La Spezia | 2.7% | Ashdod | 2.7% | Izmir | 2.8% |
| Ashdod | 2.5% | Ashdod | 2.6% | Damietta | 2.7% | La Spezia | 2.6% | Ashdod | 2.5% | Sines | 2.4% | Beirut | 2.5% | Marseilles | 2.5% | Izmir | 2.6% | La Spezia | 2.6% |
| Marseilles | 2.4% | Marseilles | 2.4% | Ashdod | 2.6% | Ashdod | 2.5% | Beirut | 2.4% | Beirut | 2.4% | Haifa | 2.5% | Haifa | 2.5% | Marseilles | 2.6% | Ashdod | 2.6% |
| Mersin | 2.3% | Beirut | 2.4% | Mersin | 2.5% | Marseilles | 2.2% | Marseilles | 2.3% | Haifa | 2.4% | Marseilles | 2.3% | Beirut | 2.3% | La Spezia | 2.5% | Marseilles | 2.5% |
| Izmir | 2.3% | Izmir | 1.8% | Beirut | 2.3% | Beirut | 2.2% | Sines | 2.0% | Marseilles | 2.4% | Beirut | 2.3% | Marseilles | 2.5% | Haifa | 2.5% | Haifa | 2.6% |
| Cagliari | 2.1% | Livorno | 1.6% | Marseilles | 2.1% | Damietta | 1.6% | Izmir | 1.7% | Izmir | 1.6% | Koper | 1.6% | Beirut | 2.3% | Beirut | 2.5% | Beirut | 2.3% |
| Taranto | 2.0% | Cagliari | 1.6% | Izmir | 1.5% | Izmir | 1.5% | Damietta | 1.6% | Damietta | 1.6% | Livorno | 1.6% | Koper | 1.7% | Damietta | 2.2% | Damietta | 2.1% |
| Piraeus | 1.8% | Taranto | 1.5% | Novorossiysk | 1.4% | Novorossiysk | 1.4% | Cagliari | 1.4% | Cagliari | 1.4% | Damietta | 1.5% | Cagliari | 1.6% | Koper | 1.7% | Koper | 1.8% |
| Livorno | 1.6% | Constantza | 1.4% | Cagliari | 1.4% | Cagliari | 1.3% | Cagliari | 1.4% | Koper | 1.4% | Constantza | 1.4% | Livorno | 1.6% | Cagliari | 1.6% | Odessa | 1.5% |
| Constantza | 1.5% | Naples | 1.3% | Taranto | 1.3% | Constantza | 1.3% | Constantza | 1.4% | Constantza | 1.3% | Cagliari | 1.4% | Constantza | 1.4% | Novorossiysk | 1.4% | Novorossiysk | 1.4% |
| Naples | 1.4% | Piraeus | 1.3% | Koper | 1.3% | Livorno | 1.2% | Livorno | 1.1% | Constantza | 1.3% | Izmir | 1.4% | Odessa | 1.2% | Livorno | 1.4% | Constantza | 1.3% |
| Koper | 1.0% | Koper | 1.2% | Constantza | 1.2% | Odessa | 1.1% | Odessa | 1.1% | Livorno | 1.2% | Novorossiysk | 1.2% | Novorossiysk | 1.2% | Constantza | 1.3% | Naples | 1.0% |
| Novorossiysk | 0.9% | Novorossiysk | 0.9% | Odessa | 1.0% | Naples | 1.0% | Naples | 1.0% | Naples | 0.9% | Odessa | 0.9% | Naples | 1.0% | Odessa | 1.2% | Livorno | 0.7% |
| Limassol | 0.8% | Odessa | 0.9% | Naples | 1.0% | Limassol | 0.8% | Limassol | 0.6% | Odessa | 0.8% | Naples | 0.8% | Limassol | 0.5% | Naples | 1.0% | Limassol | 0.7% |
| Odessa | 0.7% | Limassol | 0.8% | Sines | 1.0% | Odessa | 1.0% | Taranto | 0.6% | Limassol | 0.6% | Limassol | 0.3% | Ilichevsk | 0.3% | Limassol | 0.7% | Cagliari | 0.5% |
| Sines | 0.7% | Sines | 0.7% | Limassol | 0.8% | Taranto | 0.7% | Koper | 0.5% | Ilichevsk | 0.3% | Taranto | 0.3% | Taranto | 0.0% | Ilichevsk | 0.3% | Ilichevsk | 0.3% |
| Ilichevsk | 0.3% | Ilichevsk | 0.3% | Ilichevsk | 0.3% | Ilichevsk | 0.2% | Ilichevsk | 0.1% | Taranto | 0.3% | Ilichevsk | 0.3% | Limassol | 0.5% | Taranto | 0.0% | Taranto | 0.0% |
| **SUM** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

Source: by the authors.

The next figure (2) shows the Concentration Ratio of the selected container ports using CR4 and CR10 during the period of the study from 2009 to 2018.

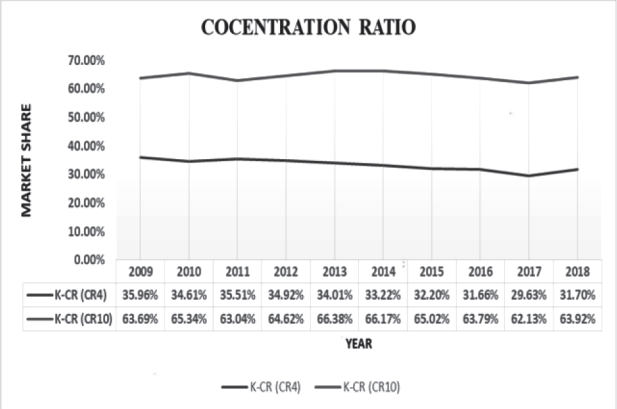


Figure (2) K-firm top 4 &10 concentration ratio between 2008 and 2018.
Source: (Authors own calculations).

In the next section, the Hirshman-Herfindahl Index (HHI) is used to provide further elaboration of the changes in the ports' market shares in relation to the total market throughput. However, using the concentration ratio has disadvantages, as the selection of the number of Mediterranean container ports to be included is for container port whom has a design capacity over 750000 TEU and neglect the small ports less than 750000 TEU. However, research will overcome this disadvantage using an alternative measure of market concentration such as the Herfindahl-Hirschman index (HIR), entropy, Lorenz curve, Hall-Tideman index.

## 4.2Analyzing Mediterranean container port market using HHI

Hirshman-Herfindahl Index (HHI) is an indicator of the degree of competition between firms in the market. The HHI is used to provide further elaboration of the changes in the ports' market shares in relation to the total market throughput. The assumption behind the HHI is that a low level of concentration is expected to be accompanied by a high level of competition and vice versa. This assumption is particularly true for inter-port competition in the container port market. Table (3) show that the overall level of competition in the Mediterranean container port market as measured by HHI reveals increasing trend overtime, decreasing value of the HHI over time indicates that the level of competition is intensifying .

Reference to the Justice Department uses the Hirshman-Herfindahl Index (HHI) decide whether a merger is good for competition in the marketplace. A market with an HHI under 1,000 is considered competitive. The Justice Department is likely to scrutinize a merger in an industry with a post-merger HHI of between 1,000 and 1,800, and it is almost certain to outright reject approval for mergers that result in a post-merger HHI exceeding 1,800.

Table (3) Analyzing Mediterranean container port market using HHI (2009-2018).

| Port | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|
| Marsaxlokk | 0.38% | 0.36% | 0.27% | 0.29% | 0.34% | 0.34% | 0.40% | 0.37% | 0.36% | 0.34% |
| Alexandria | 0.16% | 0.14% | 0.11% | 0.10% | 0.10% | 0.11% | 0.12% | 0.11% | 0.11% | 0.09% |
| Damietta | 0.11% | 0.08% | 0.07% | 0.03% | 0.02% | 0.02% | 0.02% | 0.03% | 0.05% | 0.04% |
| Port Said | 0.95% | 0.94% | 1.42% | 1.04% | 0.75% | 0.67% | 0.40% | 0.47% | 0.33% | 0.28% |
| Tangier | 0.11% | 0.27% | 0.23% | 0.22% | 0.29% | 0.38% | 0.39% | 0.35% | 0.40% | 0.34% |
| GioiaTauro | 0.61% | 0.52% | 0.26% | 0.33% | 0.43% | 0.35% | 0.28% | 0.31% | 0.22% | 0.17% |
| Genoa | 0.18% | 0.20% | 0.17% | 0.19% | 0.18% | 0.19% | 0.22% | 0.21% | 0.25% | 0.31% |
| La Spezia | 0.08% | 0.11% | 0.09% | 0.07% | 0.08% | 0.07% | 0.07% | 0.06% | 0.06% | 0.07% |
| Livorno | 0.03% | 0.03% | 0.12% | 0.11% | 0.01% | 0.01% | 0.03% | 0.03% | 0.02% | 0.02% |
| Taranto | 0.04% | 0.02% | 0.02% | 0.01% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Cagliari | 0.04% | 0.03% | 0.02% | 0.02% | 0.02% | 0.02% | 0.02% | 0.02% | 0.02% | 0.00% |
| Naples | 0.02% | 0.02% | 0.01% | 0.01% | 0.01% | 0.01% | 0.01% | 0.01% | 0.01% | 0.01% |
| Limassol | 0.01% | 0.01% | 0.01% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Novorossiysk | 0.01% | 0.01% | 0.02% | 0.02% | 0.02% | 0.02% | 0.01% | 0.01% | 0.02% | 0.02% |
| Algeciras | 0.70% | 0.50% | 0.64% | 0.76% | 0.84% | 0.83% | 0.87% | 0.76% | 0.52% | 0.71% |
| Barcelona | 0.24% | 0.24% | 0.20% | 0.14% | 0.13% | 0.14% | 0.16% | 0.20% | 0.27% | 0.37% |
| Valencia | 1.00% | 1.13% | 0.93% | 0.89% | 0.84% | 0.79% | 0.91% | 0.75% | 0.71% | 0.73% |
| Ashdod | 0.06% | 0.07% | 0.07% | 0.06% | 0.06% | 0.06% | 0.07% | 0.07% | 0.07% | 0.07% |
| Haifa | 0.10% | 0.10% | 0.08% | 0.08% | 0.08% | 0.06% | 0.06% | 0.06% | 0.06% | 0.07% |
| Odessa | 0.00% | 0.01% | 0.01% | 0.01% | 0.01% | 0.01% | 0.01% | 0.01% | 0.02% | 0.02% |
| Ilchevsk | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% | 0.00% |
| Marseilles | 0.06% | 0.06% | 0.04% | 0.05% | 0.05% | 0.06% | 0.06% | 0.06% | 0.07% | 0.06% |
| Piraeus | 0.03% | 0.02% | 0.14% | 0.34% | 0.46% | 0.49% | 0.48% | 0.55% | 0.59% | 0.75% |
| Mersin | 0.05% | 0.07% | 0.06% | 0.07% | 0.09% | 0.09% | 0.09% | 0.08% | 0.09% | 0.09% |
| Izmir | 0.05% | 0.03% | 0.02% | 0.02% | 0.03% | 0.03% | 0.02% | 0.07% | 0.07% | 0.08% |
| Ambarli | 0.25% | 0.41% | 0.35% | 0.43% | 0.49% | 0.48% | 0.41% | 0.31% | 0.36% | 0.31% |
| Koper | 0.01% | 0.01% | 0.02% | 0.01% | 0.00% | 0.02% | 0.03% | 0.03% | 0.03% | 0.03% |
| Beirut | 0.07% | 0.06% | 0.05% | 0.05% | 0.06% | 0.06% | 0.05% | 0.05% | 0.06% | 0.05% |
| Constantza | 0.02% | 0.02% | 0.01% | 0.02% | 0.02% | 0.02% | 0.02% | 0.02% | 0.02% | 0.01% |
| Sines | 0.00% | 0.01% | 0.01% | 0.01% | 0.04% | 0.06% | 0.08% | 0.09% | 0.10% | 0.09% |
| **HHI** | **541** | **545** | **547** | **540** | **547** | **540** | **530** | **510** | **489** | **514** |

Source: By the authors.

Table (3) shows that in 2009 the HHI was about 541 which indicated that the market was low-concentrated. By 2013 the HHI had decreased from 547 for six consecutive years during the period of the study from 2013 to 2018, which indicating an increase in competition between the market players which reveals that the inter-port competition among ports under study is intensified.

The following table (4) collect the Mediterranean container port market using CR4, CR10 and HHI indices.

Table (4) Mediterranean container port market using CR4, CR10 and HHI (2009-2018).

| Year | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|---|
| K-CR (CR4) | 35.96% | 34.61% | 35.51% | 34.92% | 34.01% | 33.22% | 32.20% | 31.66% | 29.63% | 31.70% |
| K-CR (CR10) | 63.69% | 65.34% | 63.04% | 64.62% | 66.38% | 66.17% | 65.02% | 63.79% | 62.13% | 63.92% |
| HHI | 541 | 545 | 547 | 540 | 547 | 540 | 530 | 510 | 489 | 514 |

Source: By the authors.

The result accords with the widely accepted view of the general trend in the container port market over recent years, as reviewed in the important literature of inter-port competition that have included among others, Heaver et al. (2001); Notteboom (2010) and Elsayeh (2015). Figure 3 illustrates the HHI result from year 2009 to year 2018.

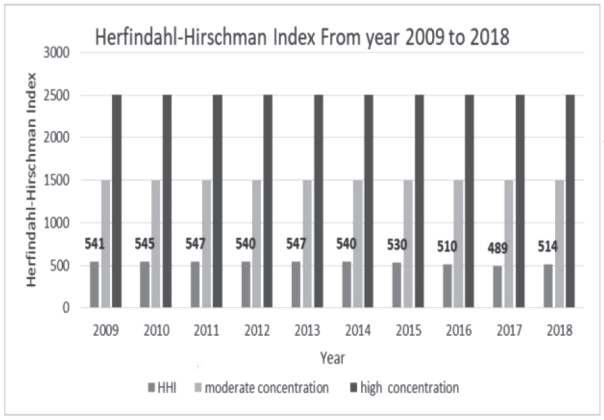


Figure (3) HHI from year 2009 to year 2018.
Source: By the authors.

## 5. Conclusion

The above analysis of market structure using the K-CR and HHI demonstrates that the Mediterranean container terminals market is going to increased number of market players and the distribution of container traffic among the ports under study. The K-CR analysis revealed that the market is moving toward low concentrated and high competition. Similarly, the value of the HHI has indicates that the market moves towards de-concentration which leading to intense competition among selected ports during the period of the study from 2009 to 2018. For further research it could be applied the Boston Consulting Group BCG; it evaluates the growth share matrix was evolved in the early 1970s by Bruce Henderson, to help corporations make investment or disinvestment decisions related to their business units or product portfolios, also will be part of choosing port for proposed integration, while the BCG matrix categorizes business units are depending on whether they deserve cash infusions or need to be closed down. Applying BCG Growth Share Matrix to put each port of research in its appropriate business strategies. BCG consisting of four category "Stars" the first is when business units that have a high market share but consume a high amount of cash as they are situated in a high-growth market, second category is cash cow that appear when the firm can maintain their market share, third is Cash cows when firm can generate funds for other business units under the corporation, to turn "question marks" into "stars," to repay corporate debt, finally dogs, have a low market share in a low-growth market.

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# A Review of Egypt's Transition to LNG; Challenges and Recommendations

Prepared by

Capt. Yasser B. A. Farag  capt. Mohamed S. Rowihil

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

**Abstract:**

The recent natural gas (NG) discoveries in the Mediterranean have lately shifted Egypt from a net importer of Liquified Natural Gas (LNG) to a net exporter. With its at-hand infrastructure, Egypt may well be on its way to becoming a major LNG hub in the region. Yet, in order to achieve this, several issues have to be considered.

This paper reviews Egypt's position with regards to its energy mix with focus on LNG and investigates the factors affecting the employment of this fuel for marine uses in light of the increasing international requirements for controlling air pollution. The paper, then, calls attention to the proposed Emission Control Area (ECA) in the Mediterranean and discusses the need for Egypt to preempt this.

Finally, the paper presents the Norwegian NOx Fund as a successful tool that may be tailored to aid the Egyptian transformation towards the use of LNG as a marine fuel and towards becoming a regional LNG hub .

Keywords: Egypt, Emissions, Energy, LNG, Marine fuel, Mediterranean ECA, NOx Fund

# 1.Introduction

## 1.1 Background

The Arab Republic of Egypt which is located in North Africa has always been considered as the main gateway to international trade through the Suez Canal. Egypt has an extended coastline on the Red and the Mediterranean Seas of 2,450 km (Central Agency for Public Mobilization and Statistics, 2017). Egypt's population hit a new record of 102 million in 2020 (Worldmeters, 2020) with a current annual population growth of 2%, one of the highest if compared with global rates as illustrated Figure 1 1 (World-Bank, 2020). This rapid increase in population, no doubt, has been accompanied by an accelerating demand in development and energy needs. Consequently, the Aswan High Dam which once provided Egypt with approximately 60% of its energy needs, currently generates less than 8% of Egypt's total energy production.

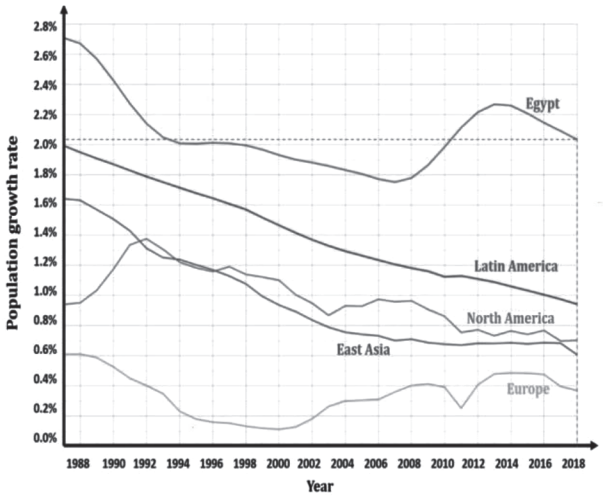



Figure 1-1 Egypt's population growth pattern compared to other regions,
Source:World-Bank data

Over the years, Egypt obtained its energy production demand from different sources. In 1960 the government recognised the importance of developing alternative energy sources for preserving the national energy security. As a result, the Aswan High Dam which was built from 1960 to1970 covered more than 60% of the country electricity needs with a new hydroelectric source. However, the continuous population growth combined with the country's accelerated development demand has driven the government to start using natural gas from 1979 .

In response, the government in 1979 started considering the use of Natural Gas (NG). The New and Renewable Energy Authority (NREA) was established in 1986 to sponsor the use of renewable energy sources and promote energy efficiency (NREA, 2020). However, more than twenty years later, the share of renewable sources (excluding hydroelectric) remains no more than 1%. According to the latest official data published by (World-Bank, 2020), in 2015, Egypt's energy production is still highly dominated by fossil fuels with 21% from oil and 71% from natural gas as Figure 1 2 illustrates.

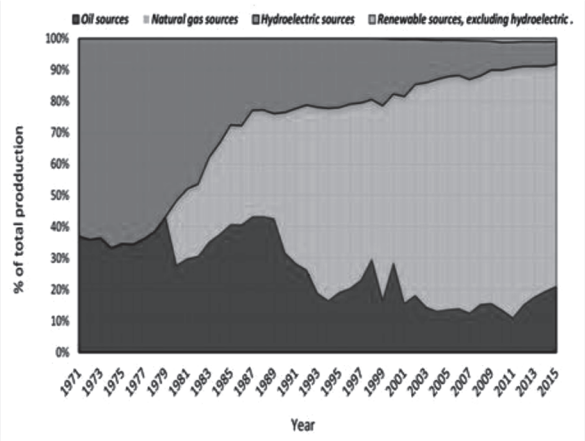



Figure 1-2 Egypt's electricity production, analysed by authors from (World-Bank, 2020)-data

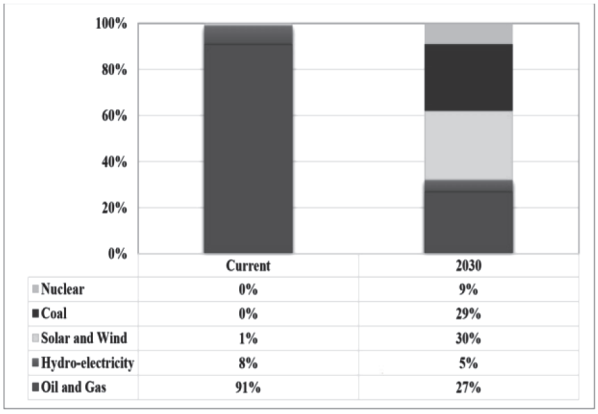
This single-dimensional energy mix dominated by fossil fuels had earlier triggered the government to announce a new energy policy in 2008. The policy mainly aims to extract 20% of the country's electricity consumption from renewable sources by 2020 (Sustainable Development Strategy; Egypt vision 2030, 2014). Nevertheless, demand-side management has been lacking in Egypt's earlier plans. Subsequently, the government has recently set strategic objectives of maximising utilisation of domestic energy resources, enhancing rational and sustainable management of the energy sector, reducing the intensity of energy consumption by rationalisation of energy consumption rates for all sectors and limit the environmental impact of the energy sector's emission.

## 1.2 Egypt's Energy Vision 2030

As a part of Egypt's plan to cope with the UN adopted sustainable development goals and to address the energy deficit, the government

announced in 2014 it's "Sustainable Development Strategy; Egypt vision 2030". The strategy dedicates thirteen indicators to the energy sector. The ambitious plan targets to fade out the government subsidy by 90% by 2019 while increasing the wind and solar share from 1% to 30% by 2030 in an effort to diversify the energy production mix (Sustainable Development Strategy; Egypt vision 2030, 2014). A comparison between current and targeted energy mix for electricity production is summerized in Figure1-3.

The strategy is composed of three main pillars; energy security by diversification and improvement of the country energy efficiency; sustainability by introducing alternative and renewable energy sources; and governance by modernising infrastructure and encouraging the private sector involvement in the energy sector (Hegazy, 2015). However, the ambitious plan was slowed down by the political unrest in the country of 2011. The political instability combined with the heavy burden of fuel subsidies amounting to 126 billion pounds annually (IEA, 2019) has led to a severe economic crisis in the country. These challenges have also led to a sharp drop in foreign investments in natural gas exploration.




| | Current | 2030 |
|---|---|---|
| Nuclear | 0% | 9% |
| Coal | 0% | 29% |
| Solar and Wind | 1% | 30% |
| Hydro-electricity | 8% | 5% |
| Oil and Gas | 91% | 27% |

Figure 1- 3 Current and future energy mix for electricity production, summerized by authors from (Sustainable Development Strategy; Egypt vision 2030, 2014) and (EIA, 2018).

**1.3Egypt's Natural Gas:**

Since 1990, Egypt's Natural Gas production has been steadily increasing except for the period from 2009 to 2016 which may be attributed to the political instability during the same period. This period witnessed a sharp drop of 30% as shown in Figure 1-4. According to the latest published data by (BP, 2020), Egypt's production has substantially increased by 61% during the following three years. This increase may be attributed to several factors, most importantly the recent economic reforms and political stability which paved the way to more exploitation activities, especially in the Mediterranean Sea.

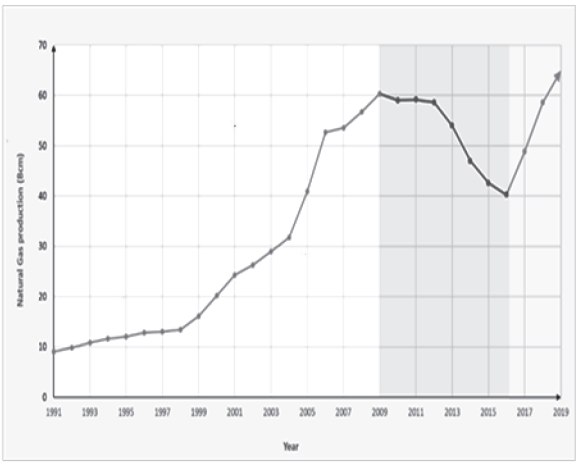



Figure 1 4 Egypt's Natural Gas production, analysed by authors from (BP, 2020) report data

The recent discovery of the Zohr field may be considered one of Egypt's most significant natural gas findings in the Midetranean Sea. The field is considered to be the largest natural gas reservoir ever found in the region as it has an estimated 30 trillion cubic feet (Tcf) of gas with almost triple Egypt's gas reserves (BP, 2020). According to a recent governmental announcement (Feb-2020), the Zohr field production has increased to a current 3 billion cubic feet per day. Egypt, currently, has two natural gas liquefaction sites on its Mediterranean coast in Dumyata and Idko. Additionally, a third site is located in Ain Sukhna in the Gulf of Suez area. The combined LNG export capacity is close to 600 Bcf/y with plans to expand soon, pending export policy changes and legislation (EIA, 2018). Though most of Egypt's LNG supply is directed to the Arab states in the region, it is expected to play an important role as a reliable natural gas supplier to Europe and the Mediterranean region within the upcoming years (Abbas N.S, Assfour H.M, Abdel wahhab M.Z., Ashour E.A, 2020).

With the natural gas boom in the eastern Mediterranean, compared to neighbouring states, Egypt seems to be best prepared for the natural gas uprising in the region. It is, therefore, imperative that the Egyptian government take the opportunity at hand. Egypt, through modernization and expansion of its available infrastructure, may well be on its way to becoming a regional energy hub. Finally, more important than modernising the infrastructure is the transfer of know-how and technology, especially from developed countries and similar developing countries with previous experience and conditions (Hegazy, 2015).

## 2- LNG and the Maritime Sector

### 2-1 IMO emission control measures and the potential role of LNG

In response to the environmental concern of air emissions from international shipping, the IMO has developed a regulatory regime to control air emissions as detailed in MARPOL Annex VI. The regulations include, among others, measures to control SOx, NOx, particulate matters $PM_{10}$and GHG emissions (International Maritime Organization). All these requirements in addition to the 2020 Sulphur cap have driven ship designers, engine manufacturers, operators and technology experts to comply with the requirements either by introducing innovative methods, optimizing the ship's operation or the use of alternative/renewable fuels.

Though, not the only option to reduce emmissions from shipping, the use of LNG as an alternative fuel seems quite promissing. DNVGL (2015) claims that with LNG, a reduction of 85% of NOx emissions has been achieved in low-pressure gas spark engines, thus fulfilling NOx Tier-III requirements. While, in dual high-pressure engines, only a 40% reduction of NOx has been achieved, thus requiring further treatment for Tier-III compliance. On the other hand, both LNG engine configurations achieved a $CO_2$ reduction of 25-30% compared with conventional diesel engines (DNV-GL, 2015).

Long before the entrance into force of the global 0.5% Sulpher cap, discussions had already begun concerning an Emissions Control Area (ECA) in the Mediterranean Sea. With nations like France, Spain and Italy in favour, these discussions envision a limitation of sulphur emissions in the region to 0.1% (UNEP, 2019). Consensus on such an ECA has yet to be achieved especially due to availability of LNG in the region and associated financial concerns. However, with the latest discoveries of natural gas in the east Mediterranean, it seems that the suggested ECA seems slightly more feasible. As natural gas discoveries in the region boom, more and more Mediterranean nations may be willing to accept the propsed ECA. Hence, Mediterranean nations, including Egypt, should plan ahead for a seemingly eventual ECA. Similar to existing ECAs in the Baltic and the North Sea, the proposed ECA when implemented will have a great effect on shipping in the Mediterranean. Without going into unnecessary specifics, many shipping companies will certainly need to re-address their policies on the choice of marine fuels; with LNG becoming a strong option, if not the foremost solution.

### 2-2 Emissions during a typical LNG life cycle

The life cycle of LNG includes two stages; an upstream stage including extraction and processing; and a downstream stage constituting all onboard operations as shown in Figure 2 1. For a more precise estimation of the LNG emissions during its full life cycle, both upstream and downstream emissions have to be taken into account. According to the study conducted by H. Thomson (2015), $CO_2$ emissions were less with the use of natural gas, while $CH_4$ emissions were higher. The study found that natural gas $CH_4$ emissions are highly affected by two factors; the way the natural gas is obtained i.e. pipeline length and time of transfer; and downstream vessel operations i.e. engine efficiency. The study concluded that LNG can substantially reduce net GHGs only with better upstream infrastructure designs while minimizing engine combustion methane slip in the downstream stage (Heather Thomson, James J. Corbett, James J. Winebrake, 2015).

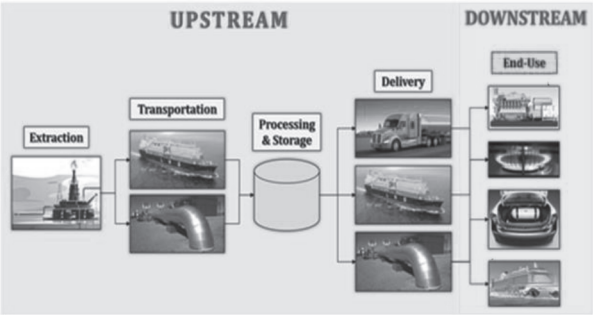



Figure 2- 1 Total fuel-cycle processes of LNG from feedstocks to end-use, by authors.

## 2-1-Considerations for the successful adoption of LNG in the maritime sector

The successful adoption of LNG in maritime transportation depends primarily on the following considerations. Firstly, the nature of the environmental requirements that may favour the use of LNG; e.g. the reduction of air emissions in ECAs and the newly adopted global Sulphur cap in 2020. Secondly, the availability of the needed infrastructure (during the upstream stage) without which the introduction of LNG on a national scale is impractical. Thirdly, technology solutions to reduce the risk associated with methane slip (in the downstream stage) and storage limitations (also, as part of the upstream stage). Fourthly, the financial funds required to cover the relatively high capital cost despite its relatively short payback time compared to other fuel types (Heather Thomson, James J. Corbett, James J. Winebrake, 2015) (O. Schinas, M.Butler, 2016) (Marlene Calderón, Diana Illing, Jaime Veiga, 2016). The last, though not least, consideration affecting the successful adoption of LNG in maritime transportation is the existence/inexistence of the much needed political will. A good example of this last consideration may be found within the European Union which has taken a number of measures to enforce its policy to promote LNG as a marine fuel in European ports as per Directive 2014/94/EU which necessitates among others that LNG bunkering infrastructure be available by 2025 in all EU ports (European Commission, Directive 2014/94/EU). As such, the European continent and especially the Baltic and North Sea regions currently possess the highest density of operational and planned LNG infrastrucuture, as can be seen in Figure 2-2.

Figure 2-2 Global distribution of LNG infrastructure, Source: (DNVGL, 2019)

According to DNVGL, the total number of LNG fueled ships in 2019 has reached 164 vessels with Passenger and Tanker vessels accounting for more than 50% of vessels in operation (DNVGL, 2019). Where Cruise and Container ships have the highest demand on-order as shown in Table 2-1. The key reason behind a greater interest in LNG has been ascribed to the development of the infrastructure to support its uptake, especially in the Baltic region as shown in Figure 2 2.

Table 2-1 Number of LNG fuelled ships by type, summerized by authors from (DNVGL, 2019).

| Ship type | LNG fuelled ships | | Demand growth % |
|---|---|---|---|
| | In operation | On order | |
| Passenger ferries | 43 | 9 | 21% |
| Supply ships | 22 | 15 | 68% |
| Tankers | 43 | 25 | 58% |
| Tugs | 14 | 2 | 14% |
| RoPax | 8 | 13 | 163% |
| Container | 7 | 31 | 443% |
| Bulk carriers | 5 | 3 | 60% |
| General cargo | 5 | 3 | 60% |
| RO-RO / Car carriers | 5 | 10 | 200% |
| Cruise ships | 2 | 31 | 1550% |
| Fishing vessels | 1 | 3 | 300% |
| Other activities | 10 | 10 | 100% |
| Total | 164 | 155 | 95% |

## 3- The Norwegian Model

### 3.1- Norway as an LNG pioneer

Norway is Europe's largest petroleum liquids producer, the world's third-largest natural gas exporter, and an important supplier of both petroleum liquids and natural gas to other European countries (IEA, 2019). Norway was the first nation to embrace the LNG shift within the maritime sector. Norway has 40 LNG terminals distributed along their coast and more than 50 LNG fueled vessels as Figure 3 shows.

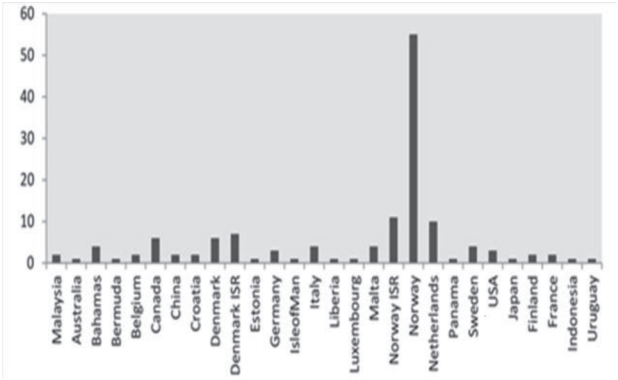



Figure 3 World LNG Fueled fleet
(IHS Maritime database 2015)

Norway has been leading with small-scale LNG industry in the Nordic countries with three small-scale liquefaction plants that produce 0.44 Mt/year of LNG. LNG is distributed to neighbour countries by small tanker ships and tanker trucks. Aside from being used as a marine fuel, LNG in Norway is also being used for industrial purposes (EIA, 2018). It is for these considerations that Norway may be considered as the foremost pioneer of LNG not only in the maritime sector, but in the world. Many economies worldwide looking to make the transition to LNG have for this reason looked to the Norwegian model for insight. One very successful innovative idea lies in the so-called "NOx Fund".

### 3.2-The Norwegian NOx Fund

In an effort to motivate their short-sea vessels to convert to LNG, Norwegian authorities in cooperation with maritime stakeholders have put together the Norwegian NOx Fund. Driven by the environmental requirements mandated by MARPOL, the Baltic/North Sea limitations, as well as the national legislations on nitrogen oxide emissions, the NOx Fund which was started in 2008, was intended to incentivize the reduction of NOx emissions (Cathrine Hagem, Michael Hoel, Thomas Sterner, 2020). Through its implementation, the NOx Fund has led many state and private-owned companies to shift to LNG as a primary fuel onboard their vessels. Moreover, the government in parallel adopted a maritime strategy emphasizing and promoting green shipping through a strong incentives scheme .
As a result, the Norwegian government was able to successfully facilitate a rapid change to clean short-sea shipping within a brief period of time. Furthermore, these incentive schemes have been very effective in encouraging the maritime industry to invest in Nox reducing technology (EIA, 2018). The success of the Norwegian model may be credited to the presence of a clear vision, pioneering policies, strong government commitment, effective stakeholders involvement, and a clear bias toward the environment. Additionally, availability of financial support through the NOx Fund, and taking advantage of the already-in-place infrastructure was crucial to securing required support for the high-cost capital investments. Finally, the exploitation of favourable environmental regulations and developing of national standards have also acted as a calyst to the transition process. The impressive success of the NOx Fund has led some European nations such as the UK and others to consider adopting a similar NOx model. Meanwhile, discussions on a comparable CO2 fund have been ongoing in Norway for some time now (Daniel Ruben Pinchasik, Inger Beate Hovi, 2017).

## 4- RECOMMENDATIONS AND CONCLUSION

### 4.1- Egypt in the wake of Norway

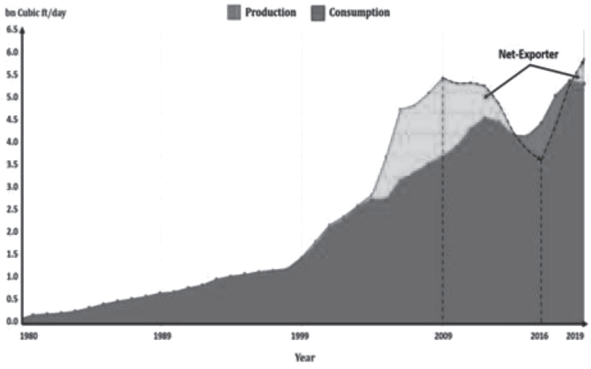



Figure 4-1 Egypt's NG production vs consumption, analysed by authors from (BP, 2020) report data

Following the 2011 unrest, Egypt has been subject to wild economical and political fluctuations. Egypt has moved from being the world's eighth-largest LNG exporter in 2009 to the world's eighth-largest LNG importer in 2016 (Aliyu, Modu, & Tan, 2018). Following a set of economic reforms accompanied by restoring political stability and the massive natural gas discoveries in the Mediterranean, Egypt in late 2018 has become a net exporter of LNG. With the at-hand liquefication capabilities and expanding natural gas infrastructure, the opportunity for Egypt to become a regional LNG hub has presented itself. Nevertheless, a number of challenges need to be considered when discussing Egypt's LNG potential, namely:

- Maintaining political and economic stability .
- Developing a resilient and sustainable environmental/energy policy.
- Coping with the continually rising energy demand as a means to maintain net exporter status.
- Fulfilment of the energy subsidy phasing-out while dealing with expected socio-economic complications.
- Maintaining, upgrading and expanding the national LNG infrastructure.

**4.2 Recommendations**

The following recommendations are proposed to enable a swift and effective transition to LNG in the Egyptian maritime sector:

- Adopting a clear environmental policy backed up by effective implementation mechanisms.
- Adopting an Egyptian-tailored incentives scheme to motivate involvement and compliance.
- Collaboration with stakeholders in order do develop suitable emissions reduction mechanisms possibly modelled on the Norwegian NOx Fund .
- Providing the financial support needed by national shipowners to convert to LNG which may be partly provided through the proposed fund.
- Ensuring the availability of detailed and well-updated data for the country energy sector to encourage research activities.
- Encouraging Suez canal transient vessels by offering a discount on Suez canal's passage Tarif for LNG fuelled ships (El-Bawab, 2020).
- The government should plan to convert tugs and offshore supply vessels owned by Suez Canal, as well as those operating in Egyptian ports, to be retrofitted with LNG fuelled engines.
- Build LNG bunkering facilities near to the existing natural gas infrastructure especially with the unique Suez Canal exit to the Mediterranean Sea and the rising demand on LNG as a marine fuel in Europe.

**4.3-CONCLUSION**

Boosted by the discovery of the Mediterranean's largest field, the rapid growth in Egypt's Natural Gas (NG) supplies turned it from a net importer to an exporter in late 2018. With the natural gas boom in the eastern Mediterranean, compared to neighbouring states, Egypt seems to be best prepared for the natural gas uprising in the region. Egypt, through in-hand NG liquefaction capabilities accompanied by its unique location, modernization and expansion of its available infrastructure, may well be on its way to becoming a regional energy hub. But all of this is conditional on the country taking correct and considered steps in the right direction, especially with the continuous rise in domestic energy demand due to relatively high population growth rates. The Norweigian model will surely need to be tailored to better suit to Egyptian needs and circumstances. Undoubtedly, deeper investigation of the Norwegian model will be required once the political will is presented.

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# Overweight Containers accidents, problem and solutions

Prepared by

Capt. Essam El-Din Youssef  Capt. Hesham Elsayad Aly

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

## Abstract:

The false declaration of container weights in the maritime industry is the cause of many ship accidents over the years. The risk of excess weight containers has been the main concern of the system, the insurance, the government, and even the importers, as more and more marine accidents occur where the excess weight of containers on board is a major factor for their occurrence .

Despite the issuance of multiple international legislations to control the containers excess weight so as to reduce the number of injuries and losses that result from them in the container transport system which is considered the future of maritime transport through the forthcoming years. However, containers losses due to extra weight still occur, that's why, more international efforts must be combined to reduce this problem.

Through this research paper; we tried to shed light on the risk resulting from the extra weight of containers and its impact on the safety of lives, property and environment in the maritime transport system. The paper highlighted some accidents that resulted from the excess weight containers and tried to suggest solutions to reduce this problem and raise the level of safety of maritime transportation.

**Keywords**: IMO, container over weights, CSC, SOLAS. Containerization system, Container losses, container accidents.

## 1.Introduction

The global economic system witnessed many changes boosted by the emergence of what is known as globalization. The modern information technology revolution was one of the most important changes. In light of the changes that took place in the international scene in the past century and the accompanying emergence of the phenomenon of globalization, it had the greatest impact on the development of the transport system in general and the maritime transport industry in particular. Maritime transport plays an important role in promoting internal and external trade and supporting economic and social integration between countries. Seaports play a fundamental role in the process of economic development in many countries of the world. Through seaports; foreign trade operations are carried out, providing countries with different needed commodities in addition to exporting their products to foreign markets. Industrial or commercial development in any country cannot develop without a modern and efficient maritime transport. A successful maritime activity cannot be achieved without the presence of giant commercial industrial activities. Seaports are one of the main elements of maritime transport development. Among the most important features of maritime transport in the Twenty-First century are the following:

First: The containerization system: Containers have a major role in bringing about important economic changes and fundamental development in maritime transport due to the trend towards building giant container ships and running fixed shipping routes with specific schedules which increases customer confidence and dependence on maritime transport.

The market forecast report for 2017, issued by Europe Shipyards' and Maritime Equipment Association (SEA) indicated an increase in the share of container ships not only due to globalization and the growth of global trade but also compared to other shipping sectors. Given that the cost of freight in the container is not related to the distance as is the case in general cargo ships, but related to many other factors, including the availability of supply and demand. Compared to the Ro-Ro ships, we find that container ships are more flexible and more cost-effective.

The report also referred that during the period 1982-2005, the share of container transportation grew 3.5 times the speed of global GDP and 40% faster than international trade in general. Recently, nearly 90% of bulk cargo is transported around the world by containers stacked on ships. Share of China of the total container trade volume in the world increased from 16% in 2000 to 31% in 2015. Slow economic growth in 2015 reduced the rate of expansion in container trade. Trading volumes increased 2.4% to 175 million TEUs (Twenty feet equivalent unit) in 2015. [14]

Due to the rapid and successive development of the container transport system is continued and the consequent annual increase as a result of the confidence of customers, the speed of transportation, the preservation of the safety of goods, the reduction of damage to them, the reduction of pollution and energy. A rapid growth in the volume of container ships, which reached a capacity of 23,756 TEUs was clear.

Second: modern and developed ports: With the emergence of giant containers and companies, modern and developed ports have emerged, and ports have turned into part of the logistics supply chains. The big shipping companies no longer choose the hub port in the region according to the strategic geographical location of the port only, but also on a number of other factors such as; cost and time taken in operations inside the station, the logistics services provided by the station and their efficiency, the availability of an electronic network for information exchange, and the provision of an industrial area supportive to the port and container storage yards that are sufficient to accommodate giant modern ship containers, and the availability of internal transport networks.

Third: multimodal and logistics transport: where the logistic services, including information and communication systems, work to achieve tight synchronization services for commercial exchanges, which reduces inventory and its costs.

The flows of containerized goods along the main trade routes around the world are constantly increasing, especially in the routes to East Asian countries, as shown in the following figure:

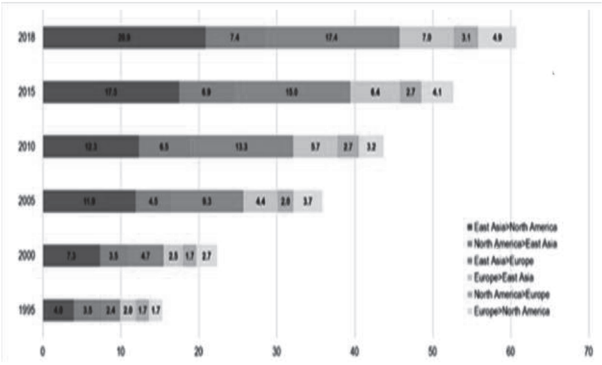


FIG. (1): Containerized Cargo Flows along Major Trade Routes, 1995-2018 (in million TEUs)
Source: (UNCTAD, 2018)

Container shipping is a service of transporting goods by high-capacity ships in seas and oceans that pass through regular roads on specific schedules (World Shipping Council, 8, 2012). The global sizes of freight containers allow easy transportation between trains, trucks and ships. Over the past few decades, container shipping has become a more important aspect of trade, with increased outsourcing due to globalization. Today, about 90% of bulk cargo worldwide is transported by containers stacked on transport vessels. [17]

Maritime transport methods are numerous and have passed through various stages, ranging from the traditional methods of transporting goods on water areas to innovating the method of container transportation that led to a revolution in the field of transport industry. As a result of the new and successive developments in maritime trade patterns, containerized transport represents the largest share in freight forwarding in the world due to the service it provides to the transportation system, namely, the transportation from door to door, which allows the maritime carrier to fully control the goods through all phases of their transportation between geographical locations and different modes of transport. Thus, containers have become the ideal means of international transportation with multiple modes of transport, and the container ship has become the main means of transportation for cruises.

However, for the containers to perform their job effectively, it is necessary to ensure their safety from being lost, damaged or any other losses during their movement and handling, which leads to the safety of the goods that is packed in, as well as the safety of maritime transport. That's why it is necessary to ask about the correct principles and bases that must be followed in manufacturing containers and freight forwarding operations and handling operations to ensure their safety.

.2Container transportation:

The Container Safety Agreement,1972, defines: "A container is a unit of cargo transporting equipment valid for frequent use with sufficient strength for handling in ports and on board ships specifically designed to transport goods in one or more means of transportation and without an intermediate reloading process and in order to be quickly stowed and / or handled, It shall be provided with corner fittings for these purposes, and the size of the space confined to the four external lower corners should be either 14 square meters (150 square feet) or 7 square meters (75 square feet) [2].

Container transportation organizes the transportation of manufactured goods trade, which is the largest percentage of the world trade. As a result, a change in transportation patterns and practices has emerged as door-to-door freight transport has increased and multimodal transportation has gained great importance, and this is due to the advantages of containerized transport.

On the freight side, using containers has resulted in saving a lot of money for the shipper, as the container ship can load or unload its cargo in a part of the time it takes for the traditional cargo ship to complete either of these operations, thus the costs of loading and unloading decrease, this also helps to make the handling of cargo faster and more flexible, and thus delivered faster. [1]

On the other hand, the container provided the optimum solution for the transportation system, as it facilitated transportation from one medium to another while packed without unloading or reclassifying its contents, and it also enabled the marine carrier to reduce the lost areas inside the ship without being worried that the goods inside it could be damaged, which led to the best exploitation of the ship. In addition to that, ships carrying containers stay in ports from 20% to

30% of the duration of the trip, contrary to traditional ships that stay 60% of the time of their trip, which in turn is reflected on the transportation cost. [1]

**3. Advantages of container transport:**

Container transport has many advantages that have made it the safest means of transporting goods across seas and oceans, which has resulted in an increase in the share of container transport, other than other means. Among the most important advantages of container transport are the following:

**a. Operational speed:**

There are modern container ships that have 3 to 6 times more operational capacity than traditional cargo ships. Mainly, this is due to saving reloading time as container shipping equipment can operate with more than 30 movements (loading or unloading) per hour. Consequently, port delivery times have been reduced from an average of 3 weeks in the 1960s to less than 24 hours, as it takes an average of 10 and 20 hours to unload a 1,000 TEUs container compared to 70 to 100 hours for a similar amount of bulk cargo. More cranes can be assigned for reloading. Whereas 3 to 4 cranes can serve a 5,000 TEU container, while vessels of 10,000 TEU can be served by 5 to 6 cranes. The latest generation of containers with tonnage greater than 23,000 TEUs requires that more than 9 cranes operate effectively. This means that larger ship sizes do not have much difference in loading or unloading time, but this requires more loading and unloading equipment on the dock, and that's why containers are considered more profitable. Moreover, containers are on average 35% faster than regular cargo ships (19 knots versus 14 knots). It is estimated that containers have reduced travel time of shipping by 80%. [10].

**b. Storage and safety:**

Stowing and packaging cargo in containers is less expensive and can occupy a smaller volume which reduces insurance costs because goods become less likely to be damaged during transportation. Besides, the containers fit together allowing stacking on ships, trains as well as double stowage in addition to stacking on the floor. Container stacking height is confined to the allowed weight which is 192 tons with 30 tons per container, this equates to a stack of 6 containers in height. However, due to the operational complexity of the high piles, the stake usually doubles from three to four loaded containers and six empty containers on the floor. To secure goods transported in containers, the contents of the container are kept unknown to strangers, as it can only be opened in origin, customs, and the final destination. Thus, thefts, especially in case of precious commodities, are reduced to a great extent thus reducing insurance claims. [10].

**c. Site restrictions:**

The container consumes a big space in the stowing yards in terminals where the loading or unloading of a 5,000 TEU container requires a minimum of 12 hectares of stowage space inside the station. Also, many container ships require a draft of at least 14 meters (45 feet) and the last generation requires of bigger ships require more than 18 meters. So, it needs providing facilities in railway stations to transport containers, that's why, many of them are transported to urban areas. Nowadays, the main container handling facilities have new site standards whereas suitable sites are located only outside the high population centers. [10].

**d. Infrastructure and stowage costs**

Container transportation is an intensive capital challenge, as container handling infrastructures, such as gantry cranes, yard equipment, road and rail equipment, are important investments for port authorities and terminal operators. For example, the cost of a modern container crane (portainer) ranges from 4 to 10 million dollars depending on its size which is considered a burden on many developing economies, as well as on small ports, where obtaining capital for these infrastructure investments become a great challenge.

Stacking containers, whether in terminals or on the means of transportation (container ships and dual stowage trains) is a complex problem. During loading time, it is necessary to make sure that the containers that must be removed first are not stowed below others, and containers must be loaded in a way to avoid any subsequent

reloading during the voyage. Thus, once the infrastructure of the container terminals is completed, the return from that equipment will be profitable for the station as a whole. [10].

e. Limiting thefts and losses

There are many problems of theft due to not disclosing the identity of the container, it remains a problem with regard to movements outside the container terminals where the contents of the container can be evaluated based on its final destination. The World Shipping Council has estimated that on average 1382 containers are lost at sea each year under normal operating conditions. This number rises to 1679 containers if events such as ship collision and drowning are included. Stormy weather is considered the main cause of container losses, however, improper container stowing also plays a major role in these accidents.

Also, as the container is insulating, solid, and unbreakable, it is by far the safest packaging method, as it protects goods and reduces the risk of their loss and damage. Transporting goods in refrigerated containers preserves perishable foodstuffs from heat, cold, humidity and from all possible weather fluctuations, in addition to reducing theft as the container is closed tightly. [10].

**4. International legislation organizing container transportation**

The International Maritime Organization has developed and adopted a number of requirements to ensure the safe transport of containers, it has also set specific guidelines for the packaging and securing of containers, the most important of which are:

The International Convention for the Safety of Life at Sea (SOLAS) set by the International Maritime Organization, includes in its sixth Chapter concerned with the transport of goods, a number of requirements for the storage and safety of goods or freight units (such as containers).

Whereas, the International Convention for Safe Containers (CSC) provides test procedures and related force requirements for containers.

The IMO together with the ILO and the United Nations Economic Commission for Europe (UNECE), worked on developing an international code of practice for handling and packing cargo units transported by sea and land by ECE through the Code of Conduct on Packaging for Goods Transport Units (CTU Law) along with other related articles.

Upon the request of the International Maritime Organization, the International Organization for Standardization (ISO) has revised the relevant ISO standards (ISO 1161) and (ISO 3874: 2017) which are related to the specifications, insurance and handling of freight containers and the integration of the latest developments in container handling equipment and insurance, taking into consideration the latest generation of container ships with high design capacity, including design characteristics and power against automatic torsion.

The International Maritime Organization also adopted the Safe Practice for Cargo Stowage and Securing (CSS CODE).

In July 2016, the special requirements for ensuring the total mass of the filled container entered into force under the International Convention for the Safety of Life at Sea (SOLAS). Knowing the exact total mass of the filled container is crucial to ensure proper stowing and stacking and avoid collapsing or losing containers at sea. This is an important safety measure that aim at saving lives, preventing injury and property destruction. [3]

There has always been a condition in SOLAS to declare the total mass of goods and containers, but the so-called Verified Gross Mass (VGM) has added an additional level that requires the verification of the mass to ensure that the declared mass is a true reflection of the total mass of the packed container in order to avoid injury, goods damage, container loss, etc.

Declaring the verified gross mass is a requirement to load a packed container on board a ship. A packed container, which did not declare its accurate total verified mass, with sufficient time to be used in the stowage plan of the ship, will not be loaded on board a ship to which SOLAS regulations are applied and on top is the safety of life. [3]

Geneva Convention of 1972; is an agreement related to container safety concluded on 02/12/1972, and entered into force on 06/09/1977 at the level of the Customs

Cooperation Council. This agreement aims to facilitate international transport by containers. For this purpose, it sets the standards for manufacturing containers and specifies the accreditation system. It also facilities temporary acceptance and containers' repair. Accordingly, containers that meet the conditions specified in the agreement benefit from allowance as well as approval to transport goods under the customs seal.

Despite these agreements and legislations issued to reduce the risk of excess weight and the safe transportation of containers, accidents due to the extra weight of the container are frequent, and therefore need a deterrent action to reduce this risk.

5. Accidents of lost and damaged containers:

With the emergence of container ships, namely; vessels designed for transporting containers, it has been taken into account in their design to carry between 25% to 40% of their cargo on the deck, also, their structure is designed to reduce the water pressure on the hull and cargo of the ship, in addition to providing them with tanks to reduce the ship's sway, as well as provide their surfaces with grabs so as to keep the containers fixed and stable on its surface so that the containers become part of the hull, which reduces the possibility of the containers falling into the sea, however, he could not prevent this risk completely.

The issue of increasing the weight of containers has been a worrying issue for the maritime transport industry, insurance companies and governments over the years. Also, after the accidents that took place in the recent years and involved overweight, this issue became from time to time a concern for cargo owners. With regard to the noticeable increase in container transport, there is no accurate data available to indicate the number of excess weight containers, however, the problem is massive, and accidents resulting from it are frequent, and arise in almost every trade to some extent. Some transport companies reported that it is not normal that the total gross weight of goods on board the ship to be 3-7% greater than the declared weight as it results in many problems, among them are:

- The risk of personal injury or death of seafarers and freight workers.
- Incorrect stowage decisions of vessels that adversely affect the safety of vessels, lives and property.
- Re-stocking containers (and the resulting delays and costs).
- Containers and goods are damaged due to the accumulation of excess weight and may lead to their loss at sea.
- Liability claims for goods.
- Risks of vessels' instability.
- Poor service schedule integration
- Supply chain service delays for properly declared container shippers.
- Loss of revenue and profits.
- Operating costs, road safety problems .

The World Shipping Council states that, on average, 64% of containers lost during this period could lead to a disaster, and the problem of excess weight of containers has affected the maritime transport system in general and resulted in numerous losses, an estimate of 130 million dollars annually, a problem that worries many of those concerned with the shipping industry. So the World Shipping Council (WSC) and the International Shipping Chamber (ICS) started to change the regulations to make shipping containers a safer way to export and import. [5]

Accidents of lost containers in the maritime transport system are old and still occur until the current time despite the efforts exerted by international bodies to reduce them. Here are some examples of accidents that resulted from the excess weight of containers:

In January 2006 the excess weight containers shipped on board the P&O Nedlloyd Genoa container ship were damaged and broken due to excess weight of the containers causing the stowed containers to collapse.

In January 2007 the MSC Napoli ship lost a number of containers after mooring equipment was destroyed due to excess weight, where the excess weight of a total of 137 containers was 312 tons heavier than the manifest.

In February 2007, containers collapsed aboard the Limary Container Ship in Damietta berth in

Egypt. Where the loading equipment and the cranes at the port showed that the actual weight exceeded the declared weighs in at least four containers. They were overweight by 407%, 393%, 362% and 209%, respectively.

In June 2010 at Port of Longoni, Brazil, a severely damaged container was lifted as the actual weight of the container was 30,220 kg which far exceeds the declared total weight of 16,890 kg.

In January 2011 in the port of Beira, Mozambique, onboard ship generators malfunctioned while the crane was operating, causing the container to fall. The investigation revealed that the declared container weight was 25,000 kg while the actual weight was 46,000 kg.

In February 2011 a container crashed on an Australian berth, where the declared container weight was 4,000 kg, while according to union sources, it was actually 28,000 kg which was over the capacity of the crane and lead to breaking it.

In May 2011, an overweight container caused the forklift to drop forward in the West Port of Melbourne, Australia.

In June 2011, the container ship Dniepe was destroyed in the Green Island (Spain) as it capsized while on the berth. During the investigation, it was evident that one of every ten containers was overweight in a total of a factor of 1.9 to 6.7 times more than the declared weight.

In December 2011, a container ship grounded (identity and location kept secret) and was refloated by ballast water after the captain realized that the containers were overweight and caused his ship to have more immersion than calculated.

Among the famous accidents was the MOL Comfort ship, which capsized in June 2013, and suffered cracks in the middle of the ship due to the increased weight of the containers according to the investigations conducted. [13]

By reviewing the WSC 2020 report on the number of actual containers lost at sea where the WSC carried out its first survey on its member companies since 2011, with updates published in 2014, 2017, and 2020. When reviewing the results of the surveyed twelve-year period (2008-2019), WSC estimates that there was an average total of 1382 containers lost at sea every year.

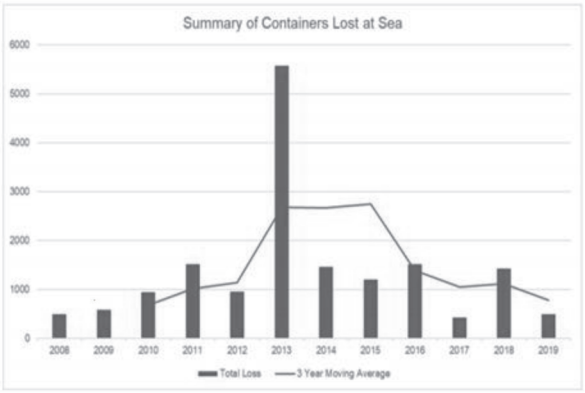


FIG. (2): Summary of container lost at sea
Source: Graph courtesy World Shipping Council.

According to the World Shipping Council report, after twelve years, more than half of the total number of containers lost at sea can be attributed to a limited number of major accidents, such as the losses of the MOL Comfort container ship (4,293 lost containers), and the MV Rena container ship (~ 900 lost containers) and SS El Faro container ship (517 lost containers). [17]

The report also showed that during the three-year period ending in 2019, the average number of lost containers per year decreased to 779, which is not a small number mainly due to a smaller number of major accidents, According to the WSC, the number of containers lost at sea represents less than 1 % of about 226 million containers carrying $ 4 trillion worth of cargo transported by sea in 2019. However, the industry still realizes that all lost containers at sea represent safety and environmental risks regardless of how and when those containers were lost, In each of the surveys conducted in 2011, 2014, 2017 and 2020, WSC member companies were required to report the number of containers lost at sea for the previous three years. For the 2020 report, all WSC member companies responded and accounted for 80% of the total global container capacity published at the time of the survey. [17]

The WSC stated that "global maritime trade using containers will need to comply with the new international regulations that require that each container should have a fixed weight as a condition for loading the ship." For shippers,

this means sole responsibility for the documented weight of the containers. The documented weight must be verified by someone authorized by the shipper and the weight of all items of individual goods must be checked as well.

**6.International standards for container weight in accordance with the CSC:**

There are two main measures of the most common container size, namely, 40 feet and 20 feet, through which the shipment can be transported easily and quickly at the best prices. ISO containers have been standardized in terms of their quality and measurements. Because of this, FEU (40ft unit) is especially useful for all concerned parties, as transportation of these containers can be easily planned and executed. Processing, loading and unloading can be done quickly, which reduces transportation time. Moreover, ISO 40ft containers can be stacked perfectly because of their measurements and stability.

The measurements, weight, size and space of the container are important for shipping the cargo as well as the customer. Below is the most important information about 40 feet ISO containers:

40feet empty container weights 3,740 kg and can be transported with a maximum weight of 30,480 kg. This means that another 26,740 kg can be loaded.

High Cube: The total weight of 30,480 kg may not be exceeded either. This means that 26,330 kg can be loaded in 40 feet. An empty high cube container weights 4,150 kg, which is a little less than the 40 standard ISO

The second measure is for 20 feet ISO containers. This type is very popular, it is also called TEU (twenty feet equivalent unit). ISO rules describe the properties of a container, for example measurements or transport capacity. The ISO container simplifies domestic and international transportation. A container weighting 2.250 kg can be shipped for a maximum weight of 30.480 kg, which means that 28.230 kg can be loaded in a container

Figure. (3): Container approval sheet
Source: CSC 1972.

Figure (3) shows that it cannot be loaded this container more than the allowable weight which in this case is 32500 kg including the empty weight of the container otherwise it will be considered an overweight container. Therefore, it is necessary for the shipper or packing yards to check this CSC plate when the container arrives and ensure that it does not exceed the maximum total weight indicated on the plate .

There are two approved methods for obtaining the total weight of a container:

**The first method:** weighting the packed container as a whole, which is done one time after the container is loaded with goods and prepared to be shipped, and includes the weight of the empty container, goods, internal mooring equipment, etc.

**The second method:** weighting each piece of cargo to be packed in the container (for example: pallets, cartons, packing materials, support, etc.) and adding these weights to the empty weight of the container. This method is not used in bulk cargo (such as: bulk grains, metal scrap, etc.). [2]

**7. Procedures for handling excess weight containers?**

The basic principle is that it is prohibited to load an overweight container to reduce the major risks that may arise in the future, but if it is discovered that a container contains excess weight at any stage of the transportation, it must be dealt with strictly to ensure the reduction of the risk that results from it. Those procedures are being applied by many shipping companies, which have proven effective to reduce excess weight and are represented in several points as follows:

**a.** Container terminals should be provided with means distributed over separate points inside the terminal to ensure serious handling and limit the excess weight of the container.

**b.** In case that the transportation company knows at any time that the container exceeds the maximum gross weight as indicated on each container, the shipping company has the right to refuse to ship the container on board or unload it from it or refuse to release the container out of the container terminal except after dealing with the extra weight.

**c.** Instead, the transportation company may, upon its choice and at the expense and responsibility of the shipper, the consignee and the shipment owner, remove the excess weight from the container, put it in another container and send it as a separate shipment at the shipper's expense.

**d.** When the containers are loaded by the shipper or his authorized representative, the shipper is responsible for making sure that any container to be transported must not exceed the maximum capacity of the total weight mentioned on the container.

**e.** It is the shipper's responsibility to ensure that any container to be transported comply with all laws and regulations of each country it will pass through.

**f.** When containers are supplied, stored, or filled by the shipper, the consignee or the shipping owner, or supplied, stored, or packaged on their behalf, the shipper, the consignee, and the shipment owner are fully responsible for any personal injury or death, or any damage or loss of goods or other property resulting from their failure to comply with any into force laws, regulations or decrees related to safety specifications and standards and taking into account the maximum permissible limit for each container.

**g.** Both the shipper, the consignee and the shipment owner agree that his act or negligence (or the act of his agent) is a direct cause of any loss, damage, penalty, fine, or cost (including attorney's fees), bonds, interest, or other, to compensate and detain the carrier from any loss, damage, penalty, fine, or cost (including attorney's fees), bonds, interest, or other penalties, and from the cost of defending claims, suits, or assessments against Carrier or its agents or participating car companies, including for example reasonable attorney fees.

**h**. Any expenses that involve the refusal of the carrier or during loading or unloading these containers (including for example fines for delay, detention, storage, handling, internal transportation, unloading, stuffing, container refilling and additional equipment costs) will be divided between shipper and the consignee and shipment owner. Excess cargo must be evaluated and additional charges is to be paid for re-handling. These charges should be big to be deterrent so as to reduce the problem of excess weight of containers.

**i.** The carrier has the right not to release any container to the consignee until all fines, penalties and costs are paid or the carrier is compensated to pay them.

**j.** Keeping a record of the shippers that have previously shipped overloaded containers and can share this information with other container lines that connect in the same port. [15]

**8. Conclusion and recommendations:**

The problem of excess containers still presents many risks to the safety of lives, the environment, ships, and the maritime transport industry in general. International measures and legislation regulating these cases alone did not succeed in reducing the risk of excess weight of cargo containers. However, the number of countries that strictly apply international legislation are considered few.

Amending the SOLAS terms was the most reasonable solution to the issue of excess weight containers. WSC and ICS stated that the number of international accidents involving excess weight containers and capsized ships has slightly decreased. These incidents provided evidence of the need for a regulation to declare container weights, and the necessity of declaring the containers' weight and implementing international legislation and agreements by governments and port authorities with maximum precision and firmness.

To conclude, the container transport system is the future of a safe, growing and faster maritime transport. In order to ensure its effectiveness and ensure the safety of the system, all efforts must

be combined to reduce the risks that may be among the causes of accidents that affect the system in general as following:

- Efforts should be exerted to closely monitor containers that might not be suitable for transport. Also, any container with excess weight must not be loaded until its load is adjusted and examined by a certified and neutral surveyor.
- Container inspection must include a Container Safety Agreement (CSC) plate, which must demonstrate if approved inspections are out of date or expired.
- Developing the supervision of container weight inside container terminals, and not to be limited to inspecting containers at the exit / entry points of the station to avoid taking responsibility for pre-existing container damage and setting several separate points inside the station during the container cycle, starting from receiving it then shipping it until it leaves the container terminal at the port of arrival.
- Ship crews must by all means make sure of the actual weight of the containers in order to have good stowage on board.
- To conclude, the container transport system is the future of a safe, growing and faster maritime transport. In order to ensure its effectiveness and ensure the safety of the system, all efforts must be combined to reduce the risks that may be among the causes of accidents that affect the system in general

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# The effect of applying the new technology of Personal Locator Beacon in enhancing search and rescue of person overboard passenger ships.

Prepared by

Capt. Sherif Aly Mohamed Aly Abdelrahman

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

## Abstract:

The International Convention on Maritime Search and Rescue (SAR) 1979 as amended was aimed to develop a SAR plan, no matter where accident occurred. The rescue of persons in distress at sea is coordinated by a SAR organization and Management. The objective of this research paper is to gain more attention from the International Maritime Organization and Member States that a new technology should be in place to ensure the achievement of the international requirements concerning the quick activation of the search and rescue operations and concerning the reduction in the time needed for rendering the immediate assistance to survivors.

In addition, the recommended response time for SAR operation range between five minutes to two hours. As a result, the new technology should also enhance the effectiveness and efficiency of the search and rescue alert phase and concurrently should increase the detection ability for any person overboard.

The author assumptions were based on the statistics for the number of fatalities to persons overboard within three consecutive years. However, an approach to an individual technique for the search and rescue operation has been identified instead of using the mass techniques for search and rescue as the only method. But the solutions introduced was without any effect in reducing the effectiveness of the mass search operations. This technique has been supported by the use of an equipment presented in the market and already in use within the oil and gas offshore fields which is the Personal Locator Beacon (PLB). The PLB with many advantages in locating the person over board using both systems the Global Positioning System (GPS) and the Automatic Identification System (AIS). In other words, the range and distance of the survivors will be determined on the AIS with the survivors GPS position.

Undoubtedly, the use of the PLB should save a lot of time and effort to locate the person over board, besides the benefit of saving lives which leads to a recommendation to have the PLB attached to the personal life jacket for rendering immediate assistance to any person over board from the passenger ships especially for mass rescue operations.

## 1- Introduction

The development of the Search and rescue techniques started when the IMO have adopted the international convention on Maritime search and rescue (SAR) at a conference in Hamburg 1979, The conference was aimed on developing a SAR Plan which meant that no matter where the location of the accident is, an action for search and rescue should be in place in order to rescue all survivors . Moreover, a cooperation should occur between different parties within the SAR organization and if necessary, between the SAR neighbouring organizations. (IMO,2020 a).

However, it's an obligatory to all ships to go and assist other ships in distress as required by the International Convention for the Safety of Life at Sea Convention (IMO, 2014 a). But the IMO was more ambitious to increase the performance of the SAR operation by cooperating with the International Civil Aviation Organization (ICAO) to gain the advantage of using the aircrafts in the SAR operations. (IMO, 2020 a).

Accordingly, the International Aeronautical Search and Rescue Manual (IAMSAR) was the fruitful achievement for the cooperation between the IMO and the ICAO. It has been published concurrently with the new revision of the SAR Convention in January 2000, the IAMSAR Manual was published in three volumes, the first volume covered the organization and management, the second volume covered the mission co-ordination procedures, and the third volume covered the mobile facilities procedures. (IMO, 2020 a).

The IAMSAR manual defined reducing the response time , as the most important element in improving the effectiveness of SAR services and defined as the reduction in the elapsed time between the initial time for an incident and when the persons in distress were rescued and it was numerically identified as five minutes to be the recommended start period for the initial notification of the distress incident and within two hours as an average required period for the rescue of the person in distress in order to survive. (IMO/ICAO, 2019 a).

Besides, the IAMSAR manual identified the importance for the proper use of the Alert Phase Activities with a continuous reviewing for the technologies that might improve the effectiveness and efficiency of the alert phase. And to maximize the ability to locate and provide assistance for distressed crafts, the probability of detection should be improved using sensors.

Additionally, the IAMSAR explained the importance of Putting into consideration the Mass Rescue Operations (MRO) with the necessity for instant response to huge numbers of persons in distress specially when the available resources for the SAR authorities were not enough. (IMO/ICAO, 2019 a). For example, the MRO for the passenger ships crises that involves the need to have an immediate assistance for a large number of persons in distress.

As mentioned in the SAR convention "Search and rescue operations shall continue, when practicable until all reasonable hope of securing survivors has passed " which indicates absolutely no recommendations for any specific period to stop search and rescue after this period but in the mean time we need to have a decision supporting methods to measure the end of hope time.

## 2- Types of vessel alert phase activities.

According to the IAMSAR manual there are two methods of alert, the distress alert from a vessel and the distress alert from an air craft. The distress alert from a vessel should be triggered by any of the Global Maritime Distress Signals System (GMDSS) equipment such as:

- The Inmarsat distress calls on Very High Frequency (VHF) channel 16.
- Digital Selective Call (DSC) on (VHF/Medium Frequency (MF), or High Frequency (HF)).
- Emergency Position Indicating Radio Beacon (EPIRB).
- Any distress transmissions on the frequency VHF channel 16, which could be after a DSC.

Additionally, in the remote oceans areas, the distress call should also be transmitted on a ship-to-shore HF circuit to a Coast Radio Station (CRS), especially when distress calls on channel 16 are not replied by other stations.

In the event of failure of the ship's radio station, the message should be transmitted using portable equipment to be reachable to the vessels in the vicinity and the equipment provided in the survival crafts should be used such as:

- The Search and Rescue Radar Transponder (SART).
- Emergency position Indicating Radio Beacon (EPIRB).
- (AIS- SART).

However, it is important to have an individual alert phase activity for each person over board (POB) surviving in the water who might be unconscious or non-visual but it is not a mandated as an international carriage requirement by any of the IMO instruments. (IMO/ICAO, 2019 b).

## 3- The importance of using the Automatic Identification System (AIS) as one of the alert phase activities.

Some of the advantages of the AIS are its propagation which is better than that of radar, because of the longer wavelength. As a result, the sea rooms around bends and behind islands should be covered if the height of the land masses did not restrict that to happen. In addition, the range of coverage of the AIS is around 20 nautical miles in the open sea, (USCGNC, April 2020). Which maximized the ability to locate any POB using an individual alert phase activity and rendering immediate assistance for the POB if the ability of detection has been improved via using an individual alert phase activity linked to the AIS.

### 3.1Automatic Identification System types.

As per International Telecommunication Union (ITU) recommendations and the International Electrotechnical Commission (IEC) Standards, AIS was classified into two classes.

- Class A stations report their position autonomously every 2-10 seconds dependent on the vessel's speed and/or course changes (every three minutes or less when at anchor or moored); and, the vessel's static and voyage related information every 6 minutes.
- Class B Shipborne mobile equipment which is interoperable with all other AIS stations, but, does not meet all the performance standards adopted by IMO. "ITU, 2008."

### 3.2 Features of the AIS Search and Rescue Transmitter

The AIS search and rescue transmitter (AIS-SART) is a Mobile equipment used to assist in locating any of the survival crafts. An AIS SART transmits a text broadcast of either 'SART TEST' or 'ACTIVE SART'. During the activation of the unit it transmits a position message. An AIS-SART, after being switched on manually or automatically sends updated position reports using a standard AIS class A/B position report. An AIS–SART has a built in Global Navigation Satellite System (GNSS) receiver, AIS-SART also display on any X band radar as a series of 12 dots for identification.

Vessels or aircraft should respond to the location of the AIS-SART signal, if it is safe to do so. In order to assist the Rescue Coordination Center (RCC) in investigating the cause of the transmission.

Hence, the AIS-SART signals are likely to be transmitted over relativity short distances, e.g. up to 10 nautical miles (NM), a vessel should not be significantly delayed to proceed to the location. (Aeromarine SRT, 2020).

### 3.3 Features and operation of the AIS locating beacons on 406 MHz EPIRBs.

The AIS locating beacons on 406 MHz (AIS-EPIRB) which means an EPIRB transmits its distress signal to the COSPAS SARSAT satellite system for search and rescue and in the meantime its signal transmitted to the vicinity vessel's AIS and consequently the targets were displayed on the AIS with their Maritime Mobile Service Identities (MMSI) number begins with "974". ( DGRM, August 2019).

When the AIS was operated it determines the surrounding targets, then the operator might face the problem of having a delay to view the names of the targets on the display screen at an early stage which could be due to the long range between the receiver and the targets. accordingly, the (MMSI) numbers should be initially displayed instead of the ship's name and used as a reference in order to differentiate between different transmitters from being a distress transmitter or not. this should be possible because the first three digits in the **MMSI number should explain that difference as Shown in the table 1.**

Table 1 (Difference between Transmitters using the MMSI numbers)

| S/N | Type of MMSI number | Structure of the number |
|---|---|---|
| 1. | Individual vessel | $M_1I_2D_3X_4X_5X_6X_7X_8X_9$ |
| 2. | Group of vessels | $0_1M_2I_3D_4X_5X_6X_7X_8X_9$ |
| 3. | Shore station or group of shore stations | $0_10_2M_3I_4D_5X_6X_7X_8X_9$ |
| 4. | SAR aircrafts | $1_11_21_3M_4I_5D_6X_7X_8X_9$ |
| 5. | Navigation aids | $9_19_2M_3I_4D_5X_6X_7X_8X_9$ |
| 6. | AIS-SART | $9_17_20_3\ X_4\ X_5Y_6\ Y_7\ Y_8\ Y_9$ |
| 7. | EPIRB-AIS | $9_17_24_3\ X_4\ X_5Y_6\ Y_7\ Y_8\ Y_9$ |
| 8. | PLB | $9_17_22_3\ X_4\ X_5Y_6\ Y_7\ Y_8\ Y_9$ |

Reference. ((Telecom ABC, 2005). (DGRM, August 2019)).

The MMSI number started with a few digits which gave a kind of identification for what the number was used for. A MMSI number of an individual vessel started with three digits represented the Maritime Identification Digits (MID), followed by 6 digits to identify a particular vessel. A MMSI number for a group of vessels had a leading zero before the MID, followed by 5 digits to identify a particular group of vessels. A MMSI number of a shore station or a group of shore stations had two leading zeros before the MID followed by 4 digits to identify a particular station or group of stations. (Telecom ABC, 2005)

SAR aircrafts, used to assist in search and rescue operations, use MMSI's with the block 111 as the leading three digits, followed by the country MID and then three digits to indicate the individual aircraft. Marine navigation aids, like light ships and beacons had a MMSI with 99 as the leading digits, followed by the country MID and then 4 digits. (Telecom ABC, 2005).

AIS-SART have a MMSI with 990 as the leading digits and for the EPIRB-AIS have a MMSI with 994 as the leading digits and the PLB have the MMSI with 992 as a leading digit then followed by the two digits manufacture ID and the four digits sequence number. (DGRM, August 2014).

In addition to that, user can introduce audible alarms and color coding to differentiate between different distressed transmitters.

## 4- Features of the Emergency Locator Beacon (ELB):

The ELBs improved the probability of detecting distress messages. They are tracking transmitters aided in detecting and locating boats, aircrafts, and people in distress.

ELBs are radio beacons that could interface with Search and Rescue (SAR) satellite systems and in the meantime a built-in radio direction finder was installed in the receivers and used as a homing device. The radio direction finder receivers were installed as new equipment in the industry on board the SAR vessels and in the aircrafts with the basic purpose of ensuring that survivors were rescued as quick as possible in order to achieve the required response time. (OGUK, 2011).

### 4.1 The Operation of The Emergency Locator Beacon.

After the activation of the ELB, the beacon sent out a distress signal. Some signals could be detected by the satellites on 406 MHz, but all other signals should be detected by the radio direction finders locally on 121.5 MHz frequency which is essential for homing at short ranges.

The signals transmitted as a digital signal, and the transmitter could be instantly and uniquely identified by the satellite. Furthermore, Global positioning system (GPS) should identify the device of the person in distress from the received message in addition to his location. Then the SAR air craft and the surface search units should perform an accurate homing to the activated device. (OGUK 2011).

### 4.2 Types of Emergency Locator Beacons

As per (OGUK ,2011) The ELB covered different types of beacons with an assortment of names depending on the environment of their operation. Commonly used beacons are named as Emergency Beacons, Emergency Location Transmitters (ELTs), Automatically Deployed Emergency Location Transmitters (ADELTs), Crash Position Indicators (CPIs), Emergency Position Indicating Radio Beacons (EPIRBs) and Personal Locator Beacons (PLBs). However, there are three main types of distress

radio beacons in the following three categories:

- EPIRBs which signal maritime distress.
- ELTs which signal aircraft distress (Including ADELTs and CPIs).
- PLBs which indicate a person in distress

Hence, all beacons are of greater assistance to the rescue crew in darkness, restricted visibility and adverse weather.

### 4.3 Features of the Personal Locator Beacon

In accordance with (IMO/ICAO, 2019 b). EPIRBs and ELTs operate on the 406 MHz frequency and are required to be carried on board certain vessels and aircrafts, respectively. The 406 MHz frequency PLB is not required to be carried on board any vessel or an aircraft internationally but can be carried on a person. However, it offered some coded identities and other advantages which should reduce the SAR response time by up to several hours. Moreover, an aircraft should receive a distress signal aurally from some types of PLBs.

## 5.Statistics for fatalities in Cruise and Ferry Passengers with Crew Overboard.

Table (2): statistics for fatalities in cruise and ferry passengers

| Vessel/year | 2016 | 2017 | 2018 | Vessel/year | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|
| Carnival Cruise Lines | 2 | 4 | 5 | **MSC Cruises** | 1 | 3 | 2 |
| Aida | | 1 | 2 | **NCL** | 2 | 2 | 4 |
| Costa | 1 | 1 | | Celebrity | | | 1 |
| Cunard | 1 | | | RCI | 2 | 2 | 3 |
| Holland America | | | 2 | Silversea | | | 1 |
| P&O Australia | | | 1 | **Star** | 1 | | |
| Princess | 2 | 2 | 1 | European Ferry | 2 | 1 | 2 |
| **Disney** | | 1 | | Other Cruise | 2 | | 2 |
| Total Average | | | | | | | |
| 2016 | | 2017 | | 2018 | | | |
| 16 | | 17 | | 26 | | | |

Reference "Saeed A, 2019"

Table (2) shows that the numbers of person fell overboard had increased from 16 fatalities in 2016 to 17 fatalities in 2017, then a dramatic increase to 26 fatalities in 2018, almost equal to 65.3% which reflects the need to implement new regulations and requirements to reduce the percentage of fatalities. As a result, a new devise should be adopted to perform more effective and precise search and rescue technique, this device could be the PLB.

## 6-Individual Search for Rescue Technique.

In accordance with the IAMSAR requirements before conducting the search and rescue patterns, the first fundamental step should be planning the search area and allocating the datum. Considering many other factors such as; the weather conditions, ship's speed, number of vessels engaged in the operation, those factors are very important and should facilitate the best choice to have the suitable search patterns to be used. (IMO/ICAO, 2019 b).

The search and rescue pattern should be identified by the Rescue coordinate center in an early stage or by the On-Scene coordinator (OSC) in a developed stage. On both stages the probabilities to find survivors are based on the searched area and a visual search via personal lockouts on board the search and rescue units. (IMO/ICAO, 2019 b).

The author recommended to have an individual search technique to be used instead of the group searched area technique. the individual search and rescue technique should be characterized by an accurate range and distance to identify the accurate location of the survivor and in order to achieve that an engineering solution should be in place and could be by using the PLB and to amend this solution globally .

### 1. latest properties of Personal Locator Beacon

In accordance with SOLAS requirements chapter IV it is required to carry either SART, AIS SART or EPIRB (IMO, 2014 b), In addition, according to the Maritime Safety Committee meeting in June 2019 (IMO, June 2019), the IMO Adopted new performance standards for float-free emergency position-

indicating radio beacons (EPIRBs) provided with an AIS locating signal an (AIS EPIRB),On the other hand it is not existed in any international requirements to have a PLB mandatory on board any vessel, despite this benefits associated with the use of the this equipment. (IMO/ICAO, 2019 a)

Some new types of PLB is a dual operating, alerting first on the aeroplanes and homing receivers used emergency frequency, while simultaneously transmitting the GPS coordinates on AIS. Automatic activation will alert any surrounding vessel for any POB within 2 – 5 seconds. With an updated GPS position in the AIS, then all vessel becomes an instant SAR asset able to track multiple casualties up to 75 miles away, it activates automatically on immersion in water or manually alerts via traditional 121.5 MHz frequency, it Indicates GPS position in less than 45 seconds updating GPS position via AIS every minute. (MRT, 2020)

Multiple targets can be tracked simultaneously with an Individual MMSI identification, the PLB had a built in flashing light at which enhances visual detection, Utilises existing homing devices operating on the frequencies of 121.5 MHz receivers/SAR finders could be located either in the vessel or in the Rescue craft or the Fast Rescue Craft, however there are some factors might affect the Coverage like weather quality and Altitude of the SAR finder. (MRT. 2020)

finally, the author questioning if the Maritime industry proceeding in the right track regarding reducing the percentage of fatalities happened within the (POB) incidents, or the maritime industry need to proceed with extra solutions to achieve a better search and rescue results.

## 2- Conclusion

Since the required period to reach to any POB is too short , therefore to reduce the response time which is the time between the occurrence of the accident till the person in distress will be rescued, and from the fact that five minutes is the recommended time to start the initial notification of distress incident and two hours is the average critical time within which POB's should be rescued in order to survive. (IMO/ICAO, 2019 b).

It is the time to change the search and rescue technique from group searching for POBs in an expected search area to find the survivors, to another method to search directly and individually with an identified position, range and distance to the POBs in the identified search area.

The paper proved that using the PLB should achieve its objective ,because it had dual benefits for both the EPIRB and the AIS to every POB and following the track of The IMO to Implement AIS EPIRB device in the near future according to the IMO (2019b), probably the IMO should consider about implementing the new type of PLB in the passenger ships in the future and to have it attached to the personal life saving appliance life Jacket to reduce the response time , help in the MRO and support in deciding when the end of hope time should be.

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# Measuring the dynamics of the Egyptian container terminals' market

Prepared by

Dr. Ahmed Ismail, Capt. Ahmed Osman, Capt. Mohamed Elhussieny,

Capt. Walid Abd Sattar.

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

**Abstract:**

This paper aims to analyze the concentration level in the Egyptian container terminals market to determine the type of market structure, by using Herfindahl Hirschman Index (HHI). They found that the container terminal market in Egypt indicates an absence of competition during the period of study. The research will be limited to the selected container terminals located in Egypt, during the period of the study from 2015 to 2019 .

**Key words**: Container terminals, Market structure, Herfindahl Hirschman Index (HHI).

## 1.Introduction

Since the development of containers and intermodalism in the late 1960's, containerization is constantly growing and penetrating almost all seaborne trade sectors, as by 2016 nearly 1.7 billion tons were transported by container, while about 90% of the world trade goes through seaports, and more than 50,000 vessels are sailing all over the world (UNCTAD, 2017).

The market structure is a way to classify markets based on the level of competition among participants in the market. Market structure can be defined as the number of competing firms and their market share. Thus, understanding the concentration or de-concentration trends can identify the future development of these container terminals. Measurement of market structure is most widely used as an assessment of concentration. The most commonly used concentration tool is the percentage of output, or any other indicator of industry size, such as employment, rail freight, throughput, etc.

Market concentration refers to the number of firms that count for the total production within a given industry at a point in the time. Generally, the concentration ratio is the measure of the percentage market share in an industry held by the largest firms within that industry. The researcher measures the concentration of the Egyptian container terminals market by using their throughput (TEUs). There are many tools used to measure the market concentration such as: Hall-Tideman index "HTI" index, Entropy index (E)", The Comprehensive Industrial Concentration Index (CCI), The Hannah and Kay Index (HKI), Gini coefficient (GC), The U Index (U), Hachman Index and The Hause Indices (H). The reasons why the researcher used only Hirschman-Herfindahl Index (HHI) index because it is the most common and simple measures that are used in earlier studies such as (Crozet, 2017; Yaşar and Kiracı, 2017; Salem et al., 2020) to determine market concentration.

This research is limited to the six main container terminals in the Egyptian container terminals market. These ports are Alexandria port, El-Dekheila port, Damietta Port, Port Said port, East Port Said port and El-Sokhna port. These ports represent the Egyptian main container terminals within the period of the study. Egypt has a pivot role in the world supply chain due to its geographic position, being at the intersection of the main maritime flows between East and West of the northern hemisphere. Furthermore, it features some of the major African ports such as Alexandria, Damietta and Port Said. Egypt bordered by the Mediterranean Sea to the north, which remained a minor market in the global transportation system. Egypt identified as one of the busiest parts of the continent for maritime trade .

## 2. Literature Review

Market concentration refers to the number of firms that account for the total production within a given industry at a point in the time. The main idea is to identify how many firms account for the majority of the product that produced within a given market. In this research. The next section illustrates the features and limitations of concentration indices used in this research. Al-Muharrami (2008) examined changes in concentrations that occurred during 1993-2002 within Arab GCC countries' of banking industries used the Herfindahl-Hirschman index and the k bank concentration ratio to measure concentration changes over ten years. The results showed that concentration does not appear to have increased in Golf countries' banking industry.

Notteboom, (2010), provide a detailed container traffic analysis for 78 container ports at the period 1985–2008, identified of multi-port gateway regions, changes in the hinterland orientation of ports and port regionalization processes. Depend on assumption that containerization would lead to further port concentration is not a confirmed fact in Europe: the European port system and most of its multi-port gateway regions witness a gradual cargo de-concentration process. Find the container handling market remains far more concentrated than other cargo handling segments in the European port system, as there are strong market-related factors supporting a relatively high cargo concentration level in the container sector .

Elsayeh (2015) analyzed the impact of ports' technical efficiencies on the improvement of Mediterranean container ports' competitiveness by using of K-Firm Concentration Ratio (CRk), HHI, GC, and SSA. The researcher found the Mediterranean container port market tends to de-concentration the existence of inefficiency pertaining to the management of container ports in the region, his contributes to assist port managers to optimize their resources and set operational plans that enable them to satisfy their customers' needs and requirements.

Elbayoumi & Dawood (2016) provides a satisfactory understanding of the market share and competition of selected container terminals in the Middle Eastern region by using HHI to analyze 24 container terminals from 12 countries in the region. Based on analysis the 24 terminals in the region only five terminals (Dubai included Jebel Ali, Suez Canal C. terminal, Ambarli, Salalah and Jeddah) are growing constantly; the rest of the terminal is inefficient. Aden terminal shows the lowest level of Market share with a score of 0.201.

Hanafy et al. (2017) analyzed the East–Mediterranean region market behavior, concentration during the period from 1995 to 2014 by using the Concentration Ratio (CR3 and CR5), HHI and SSA. The researchers found that the container port/terminal in the stated region is going to be concentrated in 2014 along with the continued growth rate and the market share of the port of Piraeus and Ambarli or the market tends monopoly. Finally, Salem et al., (2020) illustrates the level concentration in Mediterranean to determine the type of market structure, by using the Concentration Ratio (CR) and Herfindahl Hirschman Index (HHI). They found that the container terminal in this region is going to be low concentrated during the period of study from 2009 to 2018.

From previous research we found that too limited research has tried to evaluate the Egyptian container terminals market as a whole such as (Ismail, 2019), he assess the market structure of the Egyptian container terminals through measuring and analyzing market concentration by using two different methods; these methods are: Concentration Ratio (CRN) and Hirshman-Herfindahl Index (HHI). The main findings of the market structure by using the N-Firm Concentration Ratio (CRN) and Hirshman-Herfindahl Index (HHI) are that it is non-competitive market and moves towards high concentration.

## 3. Methodology

According to this research, HHI index is the sum of the squared values of each port's market share that obtained by comparing the throughput of each port against the total throughput of the defined ports in the market. The higher the HHI value, the more concentrated the industry and the greater the potential for market power. As mentioned in chapter three, the main advantage of the HHI index is its computational simplicity (Elsayeh, 2015).

According to this research, S is the throughput of port n on the Egyptian market and n is the total number of the defined ports in the market. Classifications made for HHI values are as follows: $0 \leq HHI < 1500 \rightarrow$ Low Concentration, $1500 \leq HHI < 2500 \rightarrow$ Medium Concentration and $HHI \leq 2500 \rightarrow$ High Concentration (Pavic, et al., 2016.(

## 4. Container Terminal

The next definitions are important to understand the meaning of Container terminal.

*Containerization

Containerization, the movement of cargo in containers, is a System. It has an ocean component and a land component. The players (carriers, terminal operators, stevedores, labor, port authorities, shippers, railroads, truckers, government, and others) all interact within a dynamic System. Each exerts influence over productivity and at one time or another may be the primary determinant or constraint on control of productivity at a specific terminal or within the entire System (Elsayeh, 2015).

***Container Terminal station**

A container terminal is a facility that provides a package of activities/services to handle and control container flows from vessel to railroad,

or road, and vice versa. The container terminal is the physical link between ocean and land modes of transport and a major component of the Containerization System.

***Productivity**

Container terminal productivity deals with the efficient use of labor, equipment, and land. / Terminal productivity measurement is a means to quantify the efficiency of the use of these three resources (Ismail, 2019).

***Dwell Time**

Container dwell time is one of the many performance indicators to assess the efficiency of terminal operation. As compared to standard indicators such as ship turnaround time or productivity indicators, it is however not yet widely used for global benchmarking purposes.

It is therefore challenging to define standard limits above which dwell time would be considered too long in any given seaport. Maritime industry sector experts tend to agree however on a 3 to 4 days representative mean value (Nyema, 2013).

***Infrastructure**

The critical role that container infrastructure plays in favoring the economic development of a country or region is well established. Infrastructure is the necessary condition for efficient cargo handling operations and adequate infrastructure needed to avoid congestion.

Container infrastructure, however, needs to be complemented by efficient hinterland transport connections if the port is to fully exploit its potential as growth catalyst and supply chain node (Suykens and van de Voorde 1998). Unfortunately, it is not uncommon for development projects to focus exclusively on enhancing the infrastructural capabilities of the port, without adequate consideration of the hinterland connections.

## 5. Container terminal operation

In both physical capacity and operational efficiencies are necessary to accommodate ever-greater volumes of containerized cargo every major port or its container terminal are under the pressure of meeting the projected increasing capacity demand.

The degree of ground space utilization that any particular terminal should achieve depends on the economic calculations of that container terminal operation. With existing technologies and equipment employed at terminals, higher ground space utilization rates require more man power and an increase in productive lifts and moves to access containers when called for.

It follows therefore, that higher ground space productivity is more suitable where labour costs are relatively inexpensive, and land costs are high, or where terminal physical expansion is essentially impossible. This situation is found in Asian ports but rarely in European and Egyptian ports automated cargo handlings technologies, reduced container dwell time, extended hours of operations on terminal gate or usage of an inland container terminal are some of strategies that offer potential for improving throughput considerably if properly used with other equipment.

The interface of automated and manual operations should be designed properly, in order to avoid delays that could significantly reduce the benefits of automation and to maintain high levels of safety.

Terminal basic operations are:

***Ship Operations.**
***Quay transfer operation.**
***Container yard operations.**
***Receive/ Delivery**
***(Gate) Operations**
***Container Freight**

**Ship operations**

It the operation of discharging and loading container ships using the terminal quay gantry cranes.

**Quay Transfer Operations**

It represents the flow of the in-bound containers received at the quay and moved to container yard to be stored, and the flow of out-bound containers that to be loaded on the ship.

**Container Yard Operations**

The yard operations includes receiving containers From: the ships at the quay area, Entered from the gates, Empty containers from CFS and the delivery of containers to the gate,

the quay for loading and the CFS for stripping of the L.C.L

**Receive/ Delivery Operations**

The gate represents a significant part of any terminal operation in that it controls the flow of containers in and out of the container yard. A typical outbound loaded container weighed and inspected for damage, and the shipping documents checked.

This process can take either a matter of minutes or more than an hour, depending on the problems encountered. Difficulties in accessing the terminal can result in delays for cargo getting inside the terminal, scheduled vessel departure time, and scheduled cargo pickup time.

The success or failure of any terminal depends to large extent on the efficiency of the gate operations. Since reducing block size decreases land utilization (because it leads to more land allocated to roads between consecutive blocks), this alternative merits consideration only if crane clashing are a frequent occurrence affecting performance. The optimum value of ship operation and the effectiveness of the operating policies can only evaluated using a comprehensive simulation package of terminal operations.

Several simulations packages for container terminal operations have developed already, these are used to analyze various operating policies storage, stacking operations have become more important, and complex they play an important role in the overall performance of container terminals. The proposed booking system provides the container terminal with pick-up time information before the arrival of the containers to the terminal and it thus becomes a useful tool for decision making at the moment when the containers move from the marshaling yard to the container yard waiting to be picked up by the consigned.

According to the results of the discriminate analysis, we can conclude that the determinant variable in the assignment of a stacking category is the type of cargo, owing to the fact that the majority of the raw materials and component parts imported in Egypt are used for scheduled production by various industries whose demand needs to be fulfilled in a short period of time to maintain uninterrupted production .

Categorized stacking, based on analytical results from historical data and the booking system, provides the necessary information to stack containers in a better position this reduces the number of container re-handles and the handling time of containers delivered to the trucks.

The booking system should be included into the management information system of a container terminal. Advance booking should be recommended to all the consignees but it should also be strongly recommended to infrequent users.

## 6. Empirical analysis and results

As illustrated in table (1) the measurement of the Egyptian main container terminal's market structure using Hirschman-Herfindahl Index (HHI), calculated as shown in table (1). Alexandria has recorded a fluctuated in its market share during the period of the study, 10.63 % in the year of 2015 to 12.06 % in 2016 but decreased to 11.77% in 2017 and increased to 12.02% in 2018 but returned to decrees to 11.86% in 2019. But, El-Dekheila has maintain a market share within 14%, and recorded market share 14.30% in 2015 and 14.07% in 2016, 14.29% in 2017, 14.07% in 2018 but decreased to 13.43 in 2019. Damietta has recorded a market share 10.67 % in 2015 and recorded a continuous increase in 2016 and 2017. Increased to 11.10% in 2016 and 18.23% in 2017, but started to decrease to 17.32% in 2018 and 14.88% in 2019.

Nevertheless, East Port Said has recorded a continuous decrease in its market share for four years from 2015 to 2018. East Port Said has recorded a market share 45.14% in 2015, 43.20% in 2016, 39.205 in 2017, 37.95% in 2018 but started to increase to 41.86% in 2019. Port Said has recorded a decrease in its market share from 10.50% in 2015 to 7.99% in 2017 and started to increase in its market share and became 8.80% in 2018, and continuous increase in 2019.

In addition, El-Sokhna has recorded a fluctuated in its market share during the period of the study, from 8.76% in 2015 to 11.58% in 2017, decreased to 9.42% in 2017 and increased to 9.85% in 2018 but decreased to 8.84% in 2019.

Table (1) Measurement of the Egyptian container terminal market structure using Hirschman-Herfindahl Index (HHI) from 2015 – 2019.

| Egyptian container terminals | TEUs 2015 | Market share 2015 | TEUs 2016 | Market share 2016 | TEUs 2017 | Market share 2017 | TEUs 2018 | Market share 2018 | TEUs 2019 | Market share 2019 |
|---|---|---|---|---|---|---|---|---|---|---|
| Alexandria | 696018 | 10.63 % | 775784 | 12.06 % | 729951 | 11.77 % | 798277 | 12.02 % | 851256 | 11.86 % |
| El-Dekheila | 936686 | 14.30 % | 905687 | 14.07 % | 886670 | 14.29 % | 934879 | 14.07 % | 963664 | 13.43 % |
| Damietta | 698493 | 10.67 % | 713966 | 11.10 % | 1131226 | 18.23 % | 1150630 | 17.32 % | 1068002 | 14.88 % |
| East Port Said | 2955890 | 45.14 % | 2780071 | 43.20 % | 2431864 | 39.20 % | 2521021 | 37.95 % | 3003840 | 41.86 % |
| Port Said | 687539 | 10.50 % | 514465 | 7.99 % | 439959 | 7.09 % | 584397 | 8.80 % | 654319 | 9.12 % |
| El-Sokhna | 573782 | 8.76 % | 744921 | 11.58 % | 584750 | 9.42 % | 654510 | 9.85 % | 634656 | 8.84 % |
| Total | 6,548,408 | 100.00 % | 6,434,894 | 100.00. % | 6,204,420 | 100.00 % | 6,643,714 | 100.00 % | 7,175,737 | 100.00 % |
| HHI | 2656 | | 2531 | | 2350 | | 2257 | | 2456 | |

Source: Authors own calculation.

In this context, there is a decrease in the HHI of the Egyptian container terminals, as shown in figure (2), in 2012 HHI was 2656, and started the decrease in 2013 to 2531, in 2017 becomes 2350 in 2018 HHI value becomes 2257 and started to increase in 2019 and became 2456. The average HHI value during the period of the study during 2015 and 2019 is 2450; which indicates medium concentration in the Egyptian market structure.

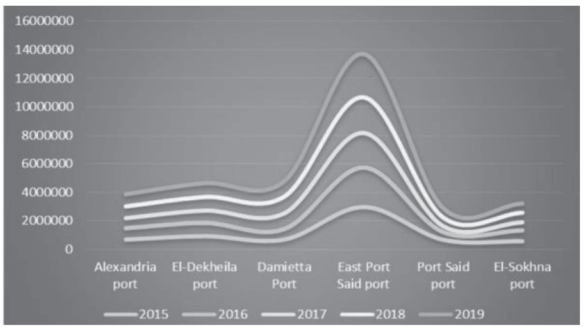


Figure (2) HHI during the period of the study from 2015 to 2019.
Source: (EMDB, 2020)

Based on the findings from the survey, the Government of Egypt needs huge investments in expanding the physical infrastructure such as adequate berthing facilities, wharves, yard capacity, quayside, railway, as well as expanding the hinterland road network .

These physical infrastructures are the main determinants of port productivity, agility and efficiency. Not only has that but also invested in the soft infrastructure especially the ICT infrastructure. The ICT infrastructure needs to be re-engineered and handle by IT specialists who will then integrate various internal systems as well as external systems. When both internal and external systems are integrated it will streamline the port operations business processes and reduce some of those barriers like long cargo dwell time delays in custom and clearance processes, long waiting time of vessels at deep seas. These barriers cause the Egypt Government to lose millions of USD every year. Egypt as a nation depends heavily on international trade due to its strategic location, by investing more in the infrastructures especially the hinterland connections to its regional borders will accelerate trade growth and significance increase in revenue growth will be realized thus making the Ports competitive.

## 7. Conclusion

Hirschman-Herfindahl Index shows that the Egyptian container terminals market represents medium concentration, HHI values are 2656 in 2015 and 2456 in 2019. For further research it could be applied the Boston Consulting Group BCG; it evaluates the growth share matrix was evolved in the early 1970s by Bruce Henderson, to help corporations make investment or disinvestment decisions related to their business units or product portfolios, also will be part of choosing port for proposed integration, while the BCG matrix categorizes business units are depending on whether they deserve cash infusions or need to be closed down. Applying BCG Growth Share Matrix to put each port of research in its appropriate business strategies.

BCG consisting of four category "Stars" the first is when business units that have a high market share but consume a high amount of cash as they are situated in a high-growth market, second category is cash cow that appear when the firm can maintain their market share, third is Cash cows when firm can generate funds for other business units under the corporation, to turn "question marks" into "stars," to repay corporate debt, finally dogs, have a low market share in a low-growth market. Based on the findings from the survey, the Government of Egypt needs huge investments in expanding the physical infrastructure such as adequate berthing facilities, wharves, yard capacity, quayside, railway, as well as expanding the hinterland road network. These physical infrastructures are the main determinants of port productivity, agility and efficiency. Not only has that but also invested in the soft infrastructure especially the ICT infrastructure.

The ICT infrastructure needs to be re-engineered and handle by IT specialists who will then integrate various internal systems as well as external systems. When both internal and external systems are integrated it will streamline the port operations business processes and reduce some of those barriers like long cargo dwell time delays in custom and clearance processes, long waiting time of vessels at deep seas. These barriers cause the Egypt Government to lose millions of USD every year.

Egypt as a nation depends heavily on international trade due to its strategic location, by investing more in the infrastructures especially the hinterland connections to its regional borders will accelerate trade growth and significance increase in revenue growth will be realized thus making the Ports competitive.

Finally, it is recommended based on the findings that the Management of Egypt Port Authority invest more on training and development of staff and employees. This will also minimize some of the human errors and duplications of business processes that normally occur on the job site. Maritime container terminals depend on substantial investments and improvements, in both physical capacity and operational efficiencies.

As the infrastructure and superstructure of a maritime container terminal are very expensive, the productivity quality managers are under pressure to choose solutions where, with limited resources, they must achieve maximum results.

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Appendix1: Previous research about concentration in ports and other sectors.

| N | Authors | Title | Concentration indicators | Research Area | Results |
|---|---|---|---|---|---|
| 1 | Krivka (2016) | On the Concept of Market Concentration, the Minimum Herfindahl-Hirschman Index and Its Practical Application. | HHI | The paper analyses the phenomenon of market concentration in the context of the most popular industrial organization approaches | The author's opinion, (HHIM) should be applied to concentrated markets. |
| 2 | Crozet (2017) | Rail freight development in Europe: how to deal with a doubly-imperfect competition? | HHI | Rail freight in Europe | The market structure is still characterized by a strong concentration, competition in rail freight can clearly be classified as imperfect competition. |
| 3 | Yaşar and Kiraci (2017) | Market Share, the Number of Competitors and Concentration: An Empirical Application on the Airline Industry | CR and HHI | They examined the market structure and competition level of the airline market in the world between 2006 and 2015. | The market structure is generally competitive, but significant changes in market structure have taken place over the years. |
| 4 | Ismail, A. (2019) | Benchmarking the Efficiency of the Egyptian Container Terminals | CR and HHI | Analyzing the Egyptian container terminals market structure. | The N-Firm Concentration Ratio (CRN) of the Egyptian container terminals market shows a very high concentration and Hirschman-Herfindahl Index shows that the Egyptian container terminals market represents medium concentration |
| 5 | Salem et al., (2020) | The dynamics of the Mediterranean container terminals' market | Concentration Ratio (CR) and Herfindahl Hirschman Index (HHI) | Illustrate the level concentration in Mediterranean to determine the type of market structure | Mediterranean container terminals. the researchers found that the container terminal in this region is going to be low concentrated during the period of study. |

# Rigorous Security and Legislation Actions for Autonomous Vessels and Ports Operations

Prepared by

Capt. Salah Farid  Dr. Sameh K Rashed

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

## Abstract:

The concepts of fully autonomous vessels, port facilities, and contractual arrangements via what's so-called "block-chain technology", are expected to be mainstream in a comparatively short time in the shipping industry. Even on traditional vessels nowadays, there is an increasing tendency to "automation functions". They are progressively utilizing systems that depending on digitization, digitalization, electronic combination, and automation. As technology continues to improve, Operational Technology (OT) actuality networked, and more regularly linked to the internet .

Modern vessels and port facilities are becoming gradually dependent upon the wide utilization of digital communication technologies during their operations. In addition, the integration of various electronic system onboard vessels and onshore facilities as well, are supporting all management processes. However, there are potential risks threatened shipping industry (vessels and ports falsities) due to redirection towards the automation even vessels and ports.

Addressing all potential hidden risks and threats became very significant, the development of any technological industry will be in parallel with the development of crime technology. Therefore, vessels and ports security require active, proactive reactions and proposed sustainable security precautions to combat risks and threats that caused by criminal misuse of sophisticated technology, this considers more significant currently than ever .

This paper is descriptive as it obtains the observed data concerning the current and expected risks and threats of automation onboard vessels and in ports. Moreover, describe the automation on vessels and ports status quo. Moreover, it reveals the practical and legal proposed mitigation phases exist for decreasing such threats.

**Key words:** Autonomous vessels – Cyber security – Cyber-risk - Cyber-attack

## 1.Introduction

Vessels and ports safety has been improving in current years, determined frequently evolving rules and the growth of a more robust safety culture. Conventionally, attacks on vessels containing piracy, boarding, theft, and/or destruction. These occurrences were frequently prosperous, as it is hard to request and get immediate assistance during a vessel sailing time across the ocean.

Vessels and ports are progressively using technological systems that depending on digitization, combination, and automation, therefore vessels and ports are reliable to cyber-risks in addition to threats onboard vessels as moving units and brings the greater risk of unauthorized access or malicious attacks to vessels and ports' systems.

Unmanned autonomous vessels and smart port facilities are considered the near future of the shipping industry. The technology of autonomous vessels does not seem to present any challenges. Obviously, a number of aspects related to the legal responsibility of using autonomous vessels and ports need to be illuminated. From a safety point of view, the contests seem to be informal to handle .

On the other hand, autonomous vessels are not revealed in the international codes and treaties that have been drawn up during the past 30 years as well as ports. It has been supposed that all vessels and ports are always manned and exactly this fact presents us with a major challenge. It may cause the legal framework covering behind the technological development, therefore excluding some of the ways in which autonomous vessels and ports are capable of operating globally. The International Maritime Organization-IMO, and the International Association of Lighthouse Authorities and Aids to Navigation-IALA are preparing for near-future work on automation .

In addition, autonomous vessels are dangerous weapon if enhanced by terrorists, specifically autonomous vessels operations controlled through working rooms ashore, as well as ports facilities, which are the most important active nations border points, as they receive incoming and departure vessels that have passed on multiple ports before reaching their final destination. Therefore, this technology must be well-known, whether onboard vessels or facilities which serving vessels in ports (port facilities) (Rashed, 2019).

This paper addresses the concepts of autonomous vessels and ports, then describes the conceptual risks to the operations security that arises as a result of the new era of automation of these types of vessels and ports. Then applying the cyber-security, and legal procedures as the mitigation ideal proposed phases to reduce such type of electronic attacks harmful when substituting the self-driving vessels "autonomous vessels" and smart ports.

## 2- Conception of Vessels Automation

Transportation of goods via ocean is now the least expensive and most characteristic method of load transport. They open up additional opportunities in the field of development, structure, and activity of the vessel (Zubowicz et al, 2019).

The IMO identifies that independence is a 'spectrum' for the purposes of examining regulatory changes, it has defined as "a vessel which, to a varying degree, can operate independent of human interaction". For current determinations the IMO provided the following four degrees of Automation levels in a regulatory context:

Degree one: Vessel with automated processes and decision support: Seafarers are on board to operate and control shipboard systems and functions. Some operations are automated and at times be unsupervised but with seafarers on board ready to take control.

Degree two: Remotely controlled vessels with seafarers on board: The vessel is controlled and operated from another location. Seafarers existing on board for receipt control and to operate the shipboard systems and functions if required.

Degree three: Remotely controlled vessel without seafarers on board: The vessel is controlled and operated from another location. There are no seafarers on board.

Degree four: Wholly autonomous vessel: The operating system of the vessel is able to make decisions and determine actions by herself.

In the year 2017 IMO finalized tactical instructions for the association, including one on the combination of new developing

advancements in the administrative structure balancing the rewards consequent from new and evolving technologies rather than safety and security concerns, the impact on the environment and on international trade facilitation, the potential costs to the industry, and their effect on personnel, both onboard vessel and shoreward (IMO, 2018).

The cargo vessels sailing on oceans autonomously "unmanned independently" may be a real matter sooner rather than later that evolve Maritime Unmanned Navigation through Intelligence in Nets (MUNIN). The autonomous vessel will navigate independently around the globe and will securely return to her destination with cargo. The simple remote control process would be unwanted due to satellite bandwidth limits and improved communication charges. On the opposite, an absolute automated control vessel would be risky in unpredicted conditions if decision systems frameworks neglect to react (Burmeister, 2014).

**1-2 Semi-Autonomous Vessels**

A semi-autonomous vessel isn't planned to be absolutely totally autonomous during the entire voyage. The vessel is working without a team just during the remote ocean cruising. a vessel close to shore will Control by a pilot in a conventional way while the crew onboard the vessel. From the quay to a certain point the vessel will manned with crew and a pilot. As soon as the vessel arrive to a specific place wherever the commencement of ocean passages, the crew and the pilot return back to the shore. At that particular place, the vessel mod change to autonomous operation mode.

In the autonomous operation mode, the vessel will be modifying to follow a pre-characterized voyage. Operation technology onboard will distinguish the encompassing conditions such as the vessel status, and the environment condition to select if pre-characterized voyage plan can be performed safely and securely. The fitting data will be sent to the shore-based control center which is in charge to screen and ensure the safe and secure operation of the vessel. Nevertheless, if a slight alteration in navigation operation are needed, the autonomous performance mode will convert to the man switch mode. As brief, if the system framework's process manage that the traffic conditions discover a slight alteration in navigation route, the autonomous control will be empowered automatically to apply the modification (Burmeister, 2014).

**2-2 The Autonomous Vessels**

The autonomous vessel will be reducing the human element interface and to show that a vessel is observing always by human element shoreward. The idea of distant control permits at any stage of remote process of vessel from the shore through a bridge model working room. If the shore-based control assesses that the autonomous controller is not sufficient skilled crew shoreward it will take over the direct control of the vessel. This mechanism allows the safe and effective control of the vessel by reducing the human element interference (Bruhn, 2014).

The previous clarification of automation vessels shows the control points of the human element on the vessel and its remote controlling, which indicates the danger of controlling the vessel while sailing by unauthorized persons which called cyber-attack. In fact, vessels will be utilizing progressively systems that depending on digitization, digitalization, combination and automation Fig (1&2).

Fig (1) Autonomous vessel

As technology keeps on improving, operational innovation onboard vessels, vessels are networked and more regularly linked to the internet. This implies that vessels are becoming composite and reliant upon the wide utilization of computerized interchanges advancement during their working life, increasing the significance of addressing all concealed dangers, the risk of cyber threats which is all-time high.

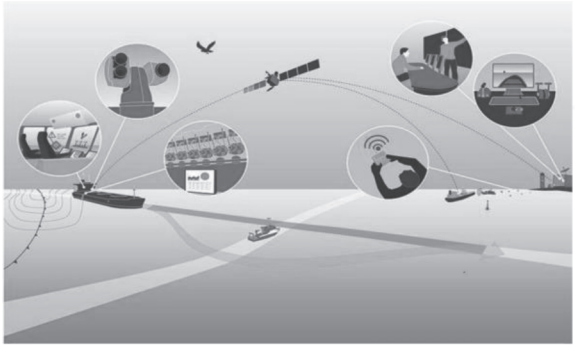

Fig (2) Operational technology of autonomous vessels

As interconnectedness growths, alongside the extensive usage of the human element to accomplish electronic data exchange, and the integration of electronic navigation, so the probability and assorted variety of cyber-attacks grows in recurrence and multifaceted nature. The development of any industry is in parallel with the development of crime technology.

The requirement for guard and security applications to mitigate the hazard is more significant these days than any time in recent memory. Guidelines to support secure cyber tasks and emergency plans of action to be followed in for a situation of the cyber incidents or digital episodes have become essential (Rashed, 2019).

### 3- Conception of Cyber-Attack Hazard

The definition of the cyber-attack is :

*"An attack threw by cyber-criminals utilizing one or more computers against a single or several computers or networks" (Rashed, 2019).*

Cyber-attack spitefully disabled computers, take information, or utilize a breached computer as a tool device to make other attacks. Moreover, cyber criminals use a diversity of techniques to introduce a cyber-attack, such as "malware, phishing, ransomware, denial of service". It is recognizable that the contacts between the vessel and the shore is crucial and significance. A vessel is an independent unit and a cyber-attack may compromise the safety of it. Furthermore, cyber-attacks severely affected the security, the continuity of shipping transportation, and the economy of countries as a result, the cyber-attack motivation on vessels and ports system, illustrated in Figure (3)


Fig (3) motivations of cyber-attack threat
Source: Mraković et al, 2019

Any of these motivation performers are equally applicable to element of vessels and port systems located remotely; (vessel or port information/data stored on external servers, and facilities transported by 3rd parties). Whatever the aim and motivation for attacking a vessel, vessels fleet, or port computers, threat performers will have an outcome that criminals are attempting to achieve (Rashed, 2019).

### 4- Port's Automation

Ports constitute an essential component of the global transportation sector providing the means for maritime transport and trade. Moreover, ports are considered critical and effective vital points in countries maritime borders security and may turn into weaknesses and breaches of border security for countries unless they are secured effectively and tightly. After the heavy reliance on new era of technology as mentioned. Therefore, a consequent awareness of modern threats are generated in parallel with vessels.

Presently, ports across the world have technology combined to some extent for comprehensive organization. Though, there has been a systematic increase in the number of smart ports.

The growth of protectionism, and the rapid adoption of digitalization, are increasing struggle and consolidation. In particular, the impact of digitalization is creating a fundamental shift of traditional model concepts such as the 'Virtual Border, the 'Smart Ports. Automation is leading the digital revolution of

ports with automated equipment handling such as cranes and self-driving trucks .

Ports are being integrated into maritime data network hubs, wherever applicable data is accessible and communications can be shared in real-time with shipping associates. Automation handling of cargo data offers container tracking transparency and efficiency, as well as supporting other port processes associated with the flow of containerised cargo. Table (1) summarize some crisis even before the impending technological transformation for shipping industry.

**Table (1) Maritime Cyber-Attacks Crisis**

| Year | Crises |
|---|---|
| 2011 | The malware was utilized to monitor each movement on control panel or keyboard press positively retrieved profound data about vessel movement, their cargo. they proficient to plot their additional activities and asking for redemption. |
| 2013 | - Antwerp Port of Belgium, attacked by hackers, committed by contemporary drug smugglers.<br>The hackers were find out the position of cargo container including narcotics.<br>- A students group indicated shortcomings and imperfections of "Global Positioning System" GPS, they hacked on GPS broadcast on a private boat (yacht) and spread untrue position coordinates data to their route pack. |
| 2014 | Electronic pirates utilized malware to stop an oil platform by totally disabled it for about 19 days continuously. |
| 2017 | - "Maersk", one of the largest shipping company in the world get hurt, by cyber-attacker. "NotPetya". Malware activated, producing the need for recovery of more than 4,000 servers and 45,000 PCs.<br>The company obliged to transport, loads, discharge containers (containers handling) without using of the Information Technology Chains for 10 days.<br>- "Svitzer" global company, was targeted and attacked from data robbery team led to over 5000 e-mails with personal informations were sent to outside addresses.<br>More than 400 of staffs are threatened.<br>The difficulty arose about 10 months before it was revealed and then secured. |
| 2018 | "COSCO" Shipping Corporation attacked by "NotPetya" malware, during this attack, all communication nets totally deactivated, first at port of "Long Beach" and then in the entire of USA area. |

Source Mraković et al, 2019

**1-4 Cyber-Attack Threats for the Smart Ports**

Digital alteration of ports security is enhancing the ability to detect the illegal movement of goods and people through innovations in surveillance technology, access controls, screening, communications and command and control integration.

Technology has shaped a vast alteration in the same way ports function today. Computerized systems, progressive navigation software, remotely operated derricks, and huge humorless cargo handlers have improved ports efficiency. As the technology grows, the character of human element suffers in comparison, as potential cyber-attacks by persons with malicious aims are a consider powerful risk.

In June 2017. The cyber-attack affected 2000 organizations through 65 countries causing approximated economic losses of $2.5 billion to $3 billion1 and exposing vulnerabilities in the marine supply chain .

Also cyber-attackers forced "Maersk" shipping company to interfere operations at several stations worldwide, causing operational confusion continued for weeks afterward the attack. Generally, the attack charge Maersk about $300 million .

By 2018, a cyber-attack against oil and gas infrastructure charge energy corporations about $1.9 billion. It was against one of the industry which the organizations suffered of monetary losses due to cyber-threats (SIMSEC, 2018).

The exertions of protecting automated ports from cyber threats lies with their complication. In unmanned ports systems, diverse system components have to successfully work self-possessed as one, increasing the time needed to figure out and repair bugs.

Eventhough, ports have to be secured from broad diversity of dangers, cyber criminals can select from a number of entry points, such as external sellers, terminal operating systems, and aware less persons that may be exposed to phishing attacks .

Working systems and information nets are not always up-to-date or correctly protected, permitting electronic criminals to gain somewhat easy access to data to control the

vessels or ports of diverse operations. Consequently, shipping industry stockholders required to have preventive security mitigation procedures counter to cyber-security threat not only onboard vessels but also onshore (ports). Likewise, they need to have Cyber-Security regulations, policies, and plans for handling breaches and attempted breaches.

## 5-Proposed Mitigations

Cybersecurity threat mitigations refer to procedures and rules put in place by organizations for avoiding security occurrences and information breaches, and minimize the level of destruction when security attacks do occur. Cyber-security threat mitigations can be done through three stages' threat identification, prevention, and remedy to reduce the influence of active security threats.

The US Navy issued Resilient Hull, Mechanical, and Electrical Security (RHIMES)", that targets to avoid the same exploit succeeding on multiple controllers. Though, these system is limited nowadays and should be limited until the next group of autonomous vessels arises (Freeman, 2015).

### 1-5Cyber Security as a Mitigation Phase

Cyber-security according to ships code of practice (CSSCP) can be defined as :

*"The collection of tools, policies, security concepts, security safeguards, guidelines, risk management approaches, actions, training, best practices, assurance and technologies that can be used to protect the cyber environment and organisation and user's asset "*

Through the previous definition, 'cyber environment' includes consistent systems of both information technology, and physical cyber systems using electronics, computer-based and wireless systems, containing the information, services, common and business functions that occur only in cyber space. Furthermore, onboard vessels, the computer systems include a range of data technology modules (personal computers (PCs), tablet, laptops, servers and interacting modules such as routers and switches.) and operative technology (Authorized Systems, Instruments, Actuators, Radar, and others.) (CSSCP, 2017).

In addition, crew connect to several devices, infrastructure, personnel facilities, and cable systems, then stored data information in the cyber location. Cyber-security struggles to attain and maintain eight common security determinations, as showed in Figure (4)

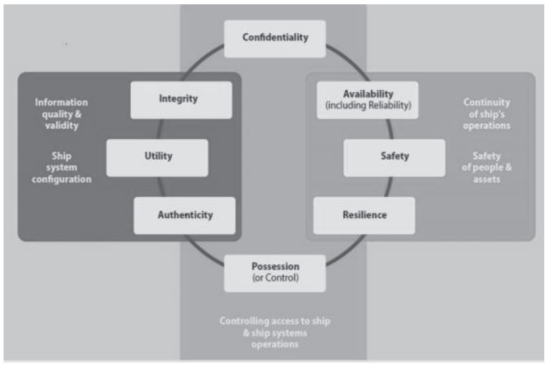


Fig (4) Cyber security purposes

On the other hand, to keep the ports from most cyber-attacks, regular operating framework system modernizes, resilient passwords, protected satellite networks, strength works out, data sharing, and employee consciousness movements should be practiced in addition to cargo surveillance systems. Moreover, the semiautonomous, autonomous and/or modern vessels tolerate the risk of dispersal viruses onto port systems simply via "Wi-Fi" or other 'data networks' can also upset the system modules of ports .

### 1-1-5Cyber-Security Regulations

Table (2) shows different international nautical cyber security regulations which developed by some nations in this field to perform a current protection of vessel fleets and what is probable in the near future from the technological transformation in the shipping industry, and the management and operation of vessels.

TABLE (2) Several global maritime cyber-security rules

| Region | Regulation(s) |
|---|---|
| Norway | Norwegian Maritime Authorities NMA reported "Digital weaknesses in the maritime division" by DNV- April 2015 |
| Netherland | *"Dutch Data Processing and Cyber-Security Notification"* Obligation Act, later of 2017 |
| France | Approvals on maritime cyber security from Sept 2016 |
| USA | - Improvement of maritime rules since Sept 2016<br>- Necessitate occurrence reporting since Jan 2017<br>- *"Draft of Navigation and Vessel Inspection" Circular-NVIC* 05-17 (hearing) |
| Japan | Improvement of Japanese recommendation for cyber-security suitable for maritime assets supported by DNV later of 2016 |
| India | Guidelines on Maritime Cyber-Safety, 2017 |
| Germany | IT-Sicherheitsgesetz since June 2015 –contains ports only "not vessels". |

Source Baskar et al, 2019

**2-1-5 The Significance of Cyber Security Awareness**

It is unmanageable to diminish all the cyber episodes. Avoidance mechanisms are very significant to decrease the whole risks to shipping industry. Cyber-risk assessment should be emphasized by top management level of any organization, rather than operations or information technology. Cyber awareness starts with planning and developing a cyber-security programs. The shipping company decide the application of a cyber-risk managing program including guidance for various personnel of the organization, many formations have followed to define how cyber-risk management should be applied onboard vessels (Baskar et al, 2019).

**2-5 Legislation as another Mitigation phase**

The Legislations supervisory close to autonomous vessels should be reflected carefully to prevent rules from becoming an interruption to technological progresses and the commercial usage of unmanned technologies in shipping. In this regard, it is of the extreme significance that the results from tests with autonomous vessels are, to the widest possible extent, published; both for achieving an acquaintance base of regulation and in order to secure wide societal sustenance for autonomous vessels by establishing the advantage society in expressions of advanced safety levels, less environmental influence and more cheap, effective autonomous shipping transport.

**1-2-5The Role of IMO**

Every innovative technological development has difficulties threatening that progress. The operation of autonomous vessels has related risks to cyber-security. The IMO is expected potentials of the risks of operating autonomous vessels, therefore discussions were held on how to proceed in determining the organizational scope of vessels in order to issue strategies on the assistance aspect to protect the shipping operation network from cyber-attacks and IMO agreements related to how to allow these vessels to sail in open and water areas .

Consequently, in the year 2016, Maritime Safety Committee MSC released the "Interim Guidelines of maritime Cyber-Risk Management", (MSC FAL.1/Circ.3, 2017) which aimed to generate effective awareness of the cyber-threat and weaknesses present in the maritime division.

The IMO established a tactical strategy plan *(International Maritime Organization, Strategic plan for the organization for the six-year period (2018 to 2023), A 30/Res.1110, 2017)* for years among 2018 and 2023 the requirement for the socializing the current and innovative technologies in controlling process is accepted, pointing to harmonizing the returns concerning security, safety, and environmental protection also the effects on human element both onboard vessels and shoreward (IMO, 2018).

**2-2-5The Role of Baltic and International Maritime Councils**

In February 2016, The Baltic and International Maritime Council (BIMCO) and other influential marine associations released "The Guidelines on Cyber Security Onboard vessels", intended the ship-owners and vessel operators. BIMCO attitudes to cyber-risk harms by the following stages :

- Recognize of threats and lack of protection,
- Assessment of risk coverage,
- Improvement of defense and recognition standards
- Creation of "contingency plans" for responding against any cyber-security events. (BIMCO, 2017).

**3-2-5The Role of American Bureau of Shipping (ABS)**

ABS as an international standard classification society; established a detailed classification of five cyber security guidance notes, in relation to cyber-security matters. of clear concern is "The Application of Cyber-Security Principles to Marine and Offshore Operation". It has the intent to supply the members of the marine operators with the references and the best performs compulsory to build and preserve cyber-security programs in five sections. In Sept. 2016, two additional volumes were available, which create measures for organizations that operate offshore units on the avoidance of cyber cases that concession the safety and security .

**4-2-5The Role of Det Norske Veritas (DNV)**

In Sept. 2016, DNV illustrated the problems and contests met by the shipping industry about the cyber-security events with the publication of "Cyber-Security Running for Vessels and Mobile Offshore Units in Operation". This suggested practice for cyber-security risk assessment offers a pure considerate of threats, weaknesses, possible significances and barriers, related to combination, digitalization and computerization of systems and procedures for the operation and verification of the shipping and offshore industry (DNV, 2016).

### 5-2-5The Role of Lloyd´s Register (LR)

In Feb. 2016, LR delivered a new guidance, "Cyber-enabled Vessel, Deploying Information and Communication Technology in Shipping" Lloyd´s register approach to assurance, for a well considerate of the associations of technological methods. The guidance offers assistance to diverse shareholders in cybersecurity problems. The guidance consists of three units, unit two defines six areas of cyber-risk which required to the safety and reliability of diverse consistent systems involved in the shipping operations schemes, human system software and communication, information assurance and cyber-security (LR, 2016, 2017).

### 6-2-5The Role of EU

"European Union General Data Protection Regulation GDPR", interred into force in May 2018. It is the most recent rule, which will have positively impacted on shipping company's role. GDPR guidance to the shipping companies to make an assessment of influence on personal privacy at any time when there is an augmented potential risk of "privacy violation". Companies are demanded to report any violation system in 72 hours in order to support the authorities to fast responding to probable cyber-attacks (Silgado, 2018).

## Conclusion

Shipping industry is backbone of countries' economies, the impact of digitalization is leading the digital revolution of vessels and ports with automated facilities creating a fundamental shift of traditional paradigms. The price of the drive towards digitalization and automation is increasing the cyber threat directions exponentially .

If the ports and vessels system enhanced by a terrorist, they will turn into dangerous weapons that can be directed to carry out terrorist acts. Cyber-security is proactive and defensive measures needed to be proportionate to the evolving risks within the new era of autonomous operations. The Cyber-security challenges relating to the evolution of maritime ports and vessel systems.

Moreover, ports and their terminals, with their complex interfaces, convergence, interconnected communications, and vessel control systems, which are much more at risk. In current years a number of high-profile cyber-attacks on vessels and ports have highlighted their vulnerability and realize that cyber incidents can occur at any point along with the operations (vessels and ports) the potentially devastating consequences include disruption of operations, financial loss, and reputational damage.

Since the autonomous vessels are vulnerable to the electronic hijacking (electronic piracy) because they operate through advanced communications technology using the internet. The paper illustrated the cyber threats that conceder barriers in ports and vessel operations nowadays and through the future expected technological transformation, also the practical and legitimate mitigation phases.

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# Evaluation of Speed Reduction of Ships

# As an Emission Control Option

Prepared by

Capt. Sherif Fathalla, capt. Aly El.Maghawry, capt. Mohamed Essallamy

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

## Abstract:

The International Maritime Organization (IMO) had done great efforts in reducing different sorts of pollution from ships into seas under the regulations of the International Convention for the Prevention of Pollution from Ships (MARPOL), inter alia. They have set under Annex VI the limit of the maximum Sulphur contents in fuel, which is used on board ships i.e. 0.1% in Emission Control Areas (ECAs). By 1st Jan. 2020, stricter rules came into force i.e. 0.5% in non-ECAs down from 3.5%. The IMO adopted different methodologies to minimize harmful emission from ships that might put some pressure on ships' operators, which might lead to instability of shipping market. Reduction of sailing speed of ships, inter alia, was considered as a measure of emission control. Discussion was held in IMO meetings and comparison was done between applying economy speed or the optimum one.

Analytical methodology was adopted in this paper to discuss the possible emission control options, and it illustrated the pressures that may lead to reduction of number of ships in shipping market. Moreover, this paper focused on consequences of applying speed reduction of ships on various aspects i.e. safety, security, and economic consequences. The paper had concluded that applying of speed reduction methodology, or optimum speed rather than economy speed, as emission control option should consider many aspects e.g. safe speed, maneuverability, and ships' handling in bad weather. Furthermore, attention should be paid to ships stability conditions and machinery and hull maintenance in addition to considerations of other security issues e.g. piracy attacks on ships with speed constrains; economic consequences should also be put into account e.g. port of call just in time arrival. Finally, this paper discussed some other future fuel alternatives .

**Key words:** Non-ECAs Sulphur contents, emission control options; safety, security, and economy of speed reduction.

## 1- Introduction

Poor air quality due to industrial exhaust particularly international shipping account for approximately 400,000 deaths per year on worldwide scope; it costs societies more than €58 billion according to recent scientific studies, (Transport & Environment, 2019). The IMO has adopted a speed reduction of ships, particularly the optimum speed rather than the economy speed, as one of the options to exhaust quality control, (IMO, 2018 a). Through applying on 1/1/2020, the amendments of Annex VI of MARPOL, ships in international trade should be requested to emit only 0.5% of Sulphur contents in Non-Emission Control Areas (Non-ECAs). Ship operators are requested to select one of the options to control emissions, all of them are considered costly, (IMO, 2018 b). Some operators may prefer to withdraw from the market leaving few numbers of ships in international trade. On the other hand, some operators have experience in using economy steaming speed during economic recessions, and feedback from the industry may be important while deciding to adopt speed reduction methodology as an option to control emission from ships. Demand and supply in addition to other related safety, security and environmental aspects were taken into account while deciding to use either the economy (ISL, 2020) or optimum speed of ships .

ECAs are marine navigational areas of the world as follows: The North American area and the Gulf of Mexico coast of the United States, the sea area is located off the coasts of the Hawaiian Islands, the United States Caribbean Sea, the Baltic Sea area, and the North Sea area, (IMO, 2019).

### 1.1 Statement of the Problem:

Recognizing that there are varieties of options to improve emission control e.g.: speed optimization, weather routing and hull maintenance, i.e. differ to a great extent depending upon ship type, cargoes, routes, and other factors. Firstly, it is needed to specify the measures for the ship to improve emissions. Adoption of speed reduction as an emission control option may result in other consequences that relate to the safety of ship e.g. poor maneuverability in bad weather. Moreover, security breaches may occur, a ship may be subject of piracy attacks for slow steaming, leaving less possibility to escape and react properly to attacks. Environmental aspects such as poor exhaust quality and quick anti-fouling release may occur for slow steaming speeds. Furthermore, demand and supply should be properly studied. A decrease in world tonnage may be witnessed as fewer ships may be able to cope with the harsh inspection for this regard. All of these subjects are to be presented in this paper.

Even if the IMO encourages using the optimum speed of ships rather than its economy speed, there would be a need to be properly defined and studied. In other words, the need to emphasize the optimum speed rather than the economy speed is really essential. During economic recessions, ship operators prefer to run their ships on economy speed for less fuel consumption and costs. Yet, this methodology showed other consequences that should be taken into consideration when adopting emission control i.e. discussed in this paper.

### 1.2. Pollution Reduction efforts:

IMO has helped to ensure a dramatic reduction in pollution from ships. As Annex I of MARPOL, for example, containing regulations for the prevention of pollution by oil that is entered into force in 2 October 1983. The Annex covers prevention of pollution by oil from operational measures as well as from accidental discharges, (IMO, 2019). In the same way, other annexes have helped to regulate the prevention of other sources of pollution to the environment i.e.: Annex II – "Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk"; Annex III – "Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form"; Annex IV – "Prevention of Pollution by Sewage from Ships"; Annex V – "Prevention of Pollution by Garbage from Ships."

Moreover, in Annex VI "the Prevention of Air Pollution from Ships", that was entered into force in 19 May 2005. The annex adjusted and set the maximum limits on Sulphur and Nitrogen oxides (SOx & NOx) emissioned from ships' exhausts and it prohibited deliberate emissions of ozone depleting substances. Moreover, assigned emission control areas were set for more stringent standards for emission matter. Furthermore, in order to cope with the

objectives of the UN, another chapter was adopted in 2011 to cover the mandatory technical and operational energy efficiency measures aimed to reduce Greenhouse Gas (GHG) emissions from ships, (IMO, 2019).

## 2. Sulphur content reduction plan:

In ECAs and Non-ECAs, Sulphur contents of fuel have been a subject of reduction plan for its effect on the environment. Acid rain is among the consequences of high Sulphur contents in exhaust, (Air Quality News, 2019). Figure (1) shows the IMO plan to reduce the Sulphur content in the exhaust in both ECAs and Non-ECAs until 2025, (UNFCCC, 2014) that ends in 2020-2025 in Non-ECAs with 0.5% and with 0.1% in ECAs in 2020.

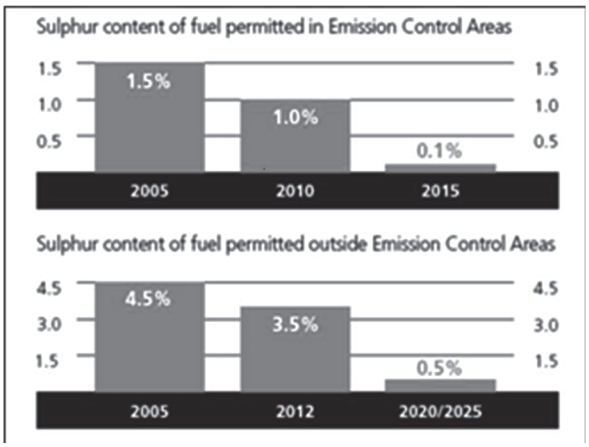


Figure 1: IMO's Sulphur emission reduction plan
Source: (UNFCCC, 2014)

### 2.1 Speed Optimization:

The Marine Environmental Protection Committee (MEPCs) has discussed the speed optimization that could produce significant promotion in exhaust quality. However, optimum speed includes many aspects of operation and environmental scopes also, including the speed at which the fuel used per-ton mile. It is not the economy speed that considers solely the economic aspects and particularly fuel consumption. In fact, sailing at less than optimum speed will consume more fuel rather than less, (PSA, 2019).

Furthermore, attention should be made to the manufacturer's engine power/consumption curve and the ship's propeller curve. 'Possible adverse consequences of slow speed operation may include increased vibration and problems with soot deposits in combustion chambers and exhaust systems', (IMO, 2016). These potential consequences should be taken into consideration when deciding that the speed reduction option as an option for emission control.

A gradual increase in speed when leaving a port or coastal waters whilst giving attention to engine load may help to reduce fuel consumption 'and on effect the exhaust'. It is recognized that under many charter parties, 'particularly the time charter party' the speed of vessel is determined by the charterer and not the ship operator. Efforts should be made when agreeing on a charter party to encourage the ship to operate at optimum speed in order to maximize energy efficiency, (IMO, 2016) and to reduce effects of emission.

## 3. Safety Aspects of Speed Reduction:

Speed reduction of ships have some consequences on the safety aspects such as, Maneuverability of ships particularly in bad weather and maintenance of hull in particular the anti-fouling release; in addition to vulnerability to security attaches for the limited speed of ships in piracy infected areas:

Speed Reduction Consequences on Maneuverability:

A ship, in unrestricted services or worldwide trade, needs certain limit of propulsion and threshold values of size and dimensions particularly in adverse conditions i.e. means sea conditions with the following parameters, as shown in Table (1):

Table 1: Mean sea conditions parameters

| Significant wave height $hs, m$ | Peak wave period $TP, s$ | Mean wind speed $Vw, m/s$ |
|---|---|---|
| 5.5 | 7.0 to 15.0 | 19.0 |

Source: (IMO, 2013).

Table (2) shows the threshold values of ship size in these adverse conditions:

Table 2: Threshold values of ship size

| Ship length, $m$ | Significant wave height $hs, m$ | Peak wave period $TP, s$ | Mean wind speed $Vw, m/s$ |
|---|---|---|---|
| Less than 200 | 4.0 | 7.0 to 15.0 | 15.7 |
| $200 \leq Lpp \leq 250$ | Parameters linearly interpolated depending on ship's length | | |

Source: (IMO, 2013).

A ship needs to fulfil one of some assessment levels to have sufficient power to maintain the maneuverability in adverse conditions as follows:

**a. Minimum power lines assessment:**

If a ship has installed power not less than the minimum power line for the specific ship type, dimensions and trading limit, the ship should be considered to have sufficient power to maintain maneuverability in adverse conditions. The minimum power lines for the different types of ships are defined as follows:

Minimum Power Line Value = a× (DWT) + b

Where: DWT is the deadweight tonnage of the ship in metric tons; and a and b are the parameters are given in table (3) for tankers, bulk carriers and combination carriers.

Table 3: Parameters a and b for determination of the minimum

| Ship type | $a$ | $b$ |
|---|---|---|
| Bulk carrier which DWT is less than 145,000 | 0.0763 | 3374.3 |
| Bulk carrier which DWT is 145,000 and over | 0.0490 | 7329.0 |
| Tanker and Combination carrier | 0.0652 | 5960.2 |

Source: (IMO, 2013; IMO, 2015)

**b. Simplified assessment:**

This is the simplified assessment i.e. mainly for ship in restricted services but, by taking consideration of all winds and waves are to be faced form all directions probabilities, alike the previous assessment. If the ship is under consideration fulfils the requirements as defined in the simplified assessment, the ship should be considered to have sufficient power to maintain maneuverability in adverse conditions. In this simplified assessment, the minimum navigational speed is set to 4.0 knots

On the other hand, the minimum course-keeping speed in the simplified assessment, Vck, is defined on the basis of the reference course-keeping speed i.e. related to ships with the rudder area AR equal to 0.9% of the submerged lateral area corrected for breadth effect, and an adjustment factor taking into account the actual rudder area:

$V_{ck} = V_{ck,ref} - 10.0 \times (AR\% - 0.9)$,

(IMO, 2013).

Where V_ck in knots, is the minimum course-keeping speed, $V_{ck}$, ref in knots, is the reference course-keeping speed, and AR% is the actual rudder area, (IMO, 2013).

Definition of required ship speed of advance:

The required ship advances speed through the water in head wind and waves (Vs), is set to the following:

- minimum navigational speed, Vnav; or
- minimum course-keeping speed, $V_{ck}$ – whichever is greater.

Moreover, the minimum navigational speed,Vnav, is to facilitate the following:

- leaving coastal area within a sufficient time before the storm escalates ,
- to reduce navigational risk and risk of excessive motions in waves due to unfavorable heading with respect to wind and waves, (IMO, 2013).

## 3.2- Optimized ship handling:

Operation at constant shaft RPM can be more efficient than continuously adjusting speed through engine power. It may be more beneficial to use automated engine management systems in order to control speed rather than relying on human intervention. Additionally, optimum trim and optimum ballast should be taken as well into considerations for less vibration and optimum fuel consumption. All in all, reduction of speed to cope with the Annex VI requirements may be harmful for optimization of ship handing, (IMO, 2016).

## 3.3-Optimum trim:

Ships are designed to carry a certain amount of cargo or passengers at a specific speed for a certain level of fuel consumption but this is

related to loaded condition as well. This implies as well the specification of set trim conditions for each loaded condition. Full load or ballast load condition requires certain trim i.e. of a significant influence on the resistance of the ship through the water and optimizing trim can deliver significant fuel savings and accordingly exhaust. For any given draft there is a trim condition that gives optimum resistance. Due to the prevailing current, it is possible to assess optimum trim conditions for fuel efficiency continuously throughout the voyage, (IMO, 2016).

### 3.4- Optimum ballast:

Ballast condition is very related to trim as well that should be adjusted taking into account the requirements to meet optimum trim and steering conditions and optimum ballast conditions achieved through out a good cargo distribution. The ship's Ballast Water Management Plans and Arrangements are to be observed while determining the optimum ballast conditions. Moreover, ballast load condition has a significant impact on steering conditions and autopilot settings and it needs to be noted 'that deviation of ship's course would lead to higher level of exhaust' which does not necessarily mean the highest efficiency. Taking into consideration that improvements may be made in propulsive efficiency and hence reduce fuel consumption, to the water inflow to under water areas, by adding or enhancing shapes of fins and/or nozzles, (IMO, 2016).

### 3.5- Optimum use of rudder and heading control systems (autopilot):

Heading control systems i.e. rudder shape and autopilots have also an effect on quantity of emitted exhaust. There have been large improvements in autopilots. Modern autopilots can achieve much more efficiency and less wastes, by reduction of track distance. These new technology systems can achieve significant fuel savings, and consequently less emitted exhaust. 'Less of track is defined as: better course control through less frequent and smaller corrections that will minimize losses due to rudder resistance'. Moreover, more efficient autopilot retrofitting to be placed in existing ships could be considered e.g. "twist-flow" rudder i.e. of improved rudder blade design added a new dimension of fuel consumption control and consequently less emission, (IMO, 2016).

### 3.6- Hull maintenance:

Hull under water maintenance provides smoothness which gives a great importance to fuel consumption and consequently for less emission. Under the enhancement systems of survey, dry docking intervals should be integrated with ship performance and ongoing assessment. Hull resistance can be optimized by new technology-coating 'or the so-called antifouling' paints. Furthermore, propeller cleaning and polishing and/or coating may significantly increase fuel efficiency, (IMO, 2016). Consequently, anti-fouling paints may be important for many reasons: less resistance of hull, more efficient fuel consumption, higher ship speed and less emission. Generally, the smoother the hull, the better the fuel efficiency and emission quantity.

### 3.7- Propulsion system:

Marine diesel engines have a limited thermal efficiency (~50%), which is only exceeded by fuel cell technology with an average thermal efficiency of 60%, (IMO, 2016) in only some modern ships. In other words, in the latest technology ships, 40% of the compositions are lost in heat and in exhaust, particularly, in the new breed of diesel electric controlled engines that can provide efficiency gains. Which means we still have a long way to go in developing such technologies and to undergo specific training for crew.

### 3.8- Propulsion system maintenance:

Normally aging ships emit more exhaust by age. Maintenance in accordance with the IMO requirements, surveying systems and as per manufacturers' instructions that are all embedded in the company's preventive maintenance systems will also maintain efficiency in emission control. The use of engine condition monitoring can be a useful tool to maintain high efficiency of propulsion and emission control. Additional means to improve engine efficiency and quality emission might include:

1. the use of fuel additives;
2. adjustment of cylinder lubrication oil consumption;
3. valve improvements;
4. torque analysis; and
5. automated engine monitoring systems, (IMO, 2016).

### 3.9. Waste heat recovery:

Waste heat recovery is now a commercially available technology, but mainly for newly build ships rather than existing ships. Waste heat recovery systems use thermal heat losses from the exhaust gas for either electricity generation or additional propulsion with a shaft motor, (IMO, 2016), these systems may be considered by shipbuilders and adopted as a compulsory requirement for emission control scope.

## 4. Security scope and piracy attacks:

By reducing speed, a ship may be subjected for attacks. In piracy high risk areas, ships may need to use its full speed for better escape capability in addition to naval speedy escorting and moving in convoys and perhaps under armed guard coverage.

### 4.1. Trade and sailing area:

The feasibility of many of the measures depends on the trade route and sailing area of the ship. Sometimes ships change their trade areas as a result of security instability, insurance and chartering requirements, (Essallamy, 2007). For example, sailing in marine high-risk areas pushes some operators to use the Cape of Good Hope rather than the Suez Canal for the political instability in Somalia and consequently high insurance premiums and low petroleum prices, (Essallamy, et al., 2019 a). Consequently, more emission is released during sailing along lengthy routes.

Ships are built either for an unrestricted service or worldwide trade or on the other hand, sometimes on an operator request, for restricted service or area of operation. Unrestricted service ships are built to face 15.5 meters of wave height for their lifetime i.e. may be considered by most of classification societies as not less than 25 years. These certain limits of sailing are aspects that should be considered as well for setting up a sailing speed limit that may not allow for the same benefit by other ships. It is also likely that some measures will have a greater or lesser effect in different sailing areas, (Essallamy, et al., 2019 b).

#### 4.1.1- Length of voyage parameters

The length of voyage may also be an important parameter for safety considerations. The most efficient combination of measures will be unique to each vessel within each shipping company, (IMO, 2016) and for certain trade route. The navigational route and the coastal state sovereignty may determine the emission measures. For example, ships that perform slow speed services at near coast areas e.g. pipe laying, seismic survey, OSVs, dredgers, may choose different methods of improving energy efficiency when compared to conventional cargo carriers.

## 5. Economic Consequences of Speed Reduction

Speed reduction of ships should be considered as a methodology of harmful emission control, economic consequences should be precisely studied. As number of ships would reduce (supply), on effect market would demand a greater number of ships otherwise an increase in merchandise would be seen. On the other hand, if number of offered ships increased to cope with the escalated demand for less streaming speed, emission would also increase.

### 5.1- Case study

The ship analyze in this study is an existing Aframax double hull tanker in operation. The main particulars of the Aframax tanker are presented in table (4). Table 4: Main particulars of the selected Aframax tanker:

| Main characteristics of the Aframax tanker | | | |
|---|---|---|---|
| Length between perpendiculars Lpp | | 238.0 m | |
| Moulded breadth B | | 43.0 m | |
| Moulded depth D | | 21.0 m | |
| Scantling draft T | | 14.3 m | |
| Deadweight DWT | | 97,000 Mt | |
| Midship Section Modulus *Z* | | 33.164 m3 | |
| Full load conditoin | | Ballast load condition | |
| Deadweight | 97,000 Mt | Deadweight | 37,728.7 Mt |
| Mean draft at Marks | 13.47 m | Mean draft at Marks | 7.17 m |

Source: (Abd El-Kader, 2012; Eldaly, 2017).

To cope with the requirements of Annex VI the operating company of the Aframax tanker had to choose among the available options:

**1.To operate the ship with Marine Gas Oil:**

This option is adding additional high cost to the daily rate fuel consumption. As extracted from table (5) the price, per different ports of the world, the Very Low Sulphur Fuel Oil (VLSFO) resembles an average of 20% less than the price of Marine Gas Oil (MGO). Moreover, the Intermediate Fuel Oil (IFO380) is cheaper in average than the MGO with 35.9% and it is cheaper than the VLSFO with 19.9%, (Ship&Bunker, 2020). Therefore, the IFO380 may be the best economical fossil fuel to use on board, if the ship is properly equipped with the approved equipment and the VLSFO comes 2nd. In the meantime, the daily hire rate for time charter parties or the freight per ton for voyage charter parties' contracts are fixed constant per a given period of time, which means reduction in profit.

**2. Ship demolition and new build order:**

This option seems the best to follow for old age vessel, of 25 years age or more, which is not applicable in our case. As the ship of the case study is operated under 2 years of time charter party, (Eldaly, 2020).

**3. Installation of Exhaust Gas Recirculating System (EGR) system on board.**

Depending on market and charterers requirements, an operator is to choose between opening loop or closed loop EGR systems. The closed loop system is more expensive but less in emission release to the environment, but may cost 2 million USD for an Aframax tanker, (Eldaly, 2020).

On the other hand, an opening loop system is seemed more economical solution, and accepted for the case study trading patterns. However, this option would cost about $750,000 and it would take about 6-7 months to assemble on board after a long time of taking measures, calculations, drawing lines and long period of implementation, but this option is seem adding to the overhead. Therefore, the company considered that is the best scenario to apply, (Eldaly, 2020).

Table 5: Latest Bunker Prices

| Bunker Price ($US/mt) | | | |
|---|---|---|---|
| **Global Average** | 349.50 | 466.50 | 295.50 |
| **Singapore** | 318.50 | 367.50 | 242.50 |
| **Rotterdam** | 281.50 | 337.50 | 245.50 |
| **Fujairah** | 321.00 | 438.50 | 232.00 |
| **Houston** | 288.00 | 351.50 | 231.00 |

Source: Based on (Ship&Bunker, 2020)

### 5.2. Improved Fleet Operation

Reduction in steaming speed for emission control may result in increase in tonnage capacity of world fleet to cope with the demand and supply markets. An increase in world tonnage may be needed for the escalation in population 'and for less steaming speed of ships. Figure (2) predicts the increase in world seaborne trade and population, which signifies that world seaborne trade would increase 3 times in 3 decades i.e. would reach almost 18 billion tons by the year 2030, (UNFCCC, 2014).

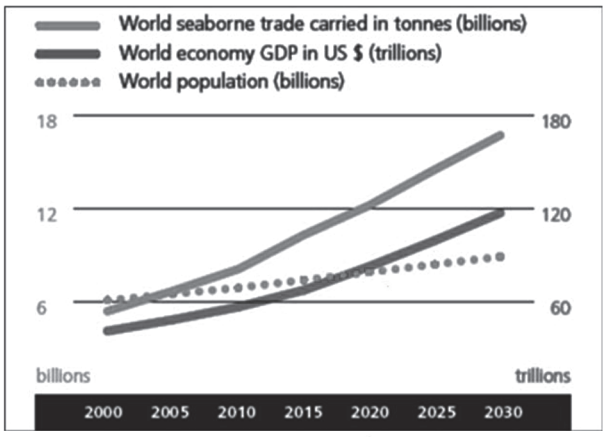


Figure 2: Predicted increase in World Sea borne trade by population
Source: (UNFCCC, 2014).

### 5.3. Port of Call Optimum Arrival Time

Better utilization of fleet capacity improvements should be also put into consideration in fleet emission control planning. For example, operators avoid or reduce long ballast voyages through better ship employment particularly in voyage charter parties, (Essallamy, 2018). This can be closely related to the concept of "just in

time" arrivals. Efficiency, reliability and maintenance-oriented data sharing within a company can be used to promote best practice among ships within a company and should be actively encouraged. Good and early communication with ports of call should be an aim to control steaming speed in order to give maximum notice of berth availability, (IMO, 2016) and to reduce wasting time at anchorage and emission release.

**5.4.Lay Can and lay time:**

As part of the speed optimization process, due account may need to be taken of the "just in time arrival" with the availability of loading/discharge berths, etc. The number of ships engaged in a particular trade route may need to be taken into account when considering speed optimization, (NeRF, 2019). Since a ship master sends a Notice of Reediness (NOR) and based on the rule of acceptance of this NOR, the lay time would count that may lead to putting a ship on demurrage or late re-delivery or loss of another new contract. The rule of NOR acceptance is normally defined as follows :

- If NOR is sent before noon, then the acceptance of NOR and lay time counts from 1300hrs,
- If NOR is sent after noon, then the acceptance of NOR and lay time counts from 0600 of the next day, or
- As a charterer and operator agreed upon, (Essallamy, 2018; GENCON, 1994; BALTIME, 1974).

## 6.Alternative Fuel Sources

Perhaps it is time to consider other sources of fuel sources and cleaner sources of power. The IMO has already adopted the International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels(IGF) code under SOLAS convention in 1/1/2017. The IMO as well is encouraged for the use of blue and clean sources of energy i.e. a probable way of emission control.

For example, Liquefied Natural Gas (LNG) produces lower CO2 emissions and could be an interim solution until a viable alternative to fossil fuels is eventually found, assumed that supply infrastructure can be developed. Moreover, renewable energy sources, such as wind and solar power, may have a place in helping to meet some ancillary requirements, such as lighting on board ships. Furthermore, fuel cells and diesel electric engines may be a possibility for new ships in the long term. Even nuclear propulsion for merchant ships is applied mainly in ice breakers until now, but safety and security implications and support infrastructure costs would require serious consideration, (UNFCCC, 2014).

## 7. Conclusion and recommendation

It is assumed that ships will continue to burn fossil fuels for the near future, i.e. the most significant means of reducing emissions from ships will be achieved by further development and improvements in efficiency across the entire discussed options not only speed optimization.

In this paper, many different aspects of emission control options are discussed in particular speed reduction effects on many scopes of the industry i.e. safety, security and economy. Only speed reduction is not a solely option to consider for emission control but other solutions have been put.

If reduction of speed is considered as a measure of reduction of harmful emission, optimum speed should be considered rather than economy speed. Taking into consideration safety of life and safe operation of ships, i.e. including safe handing in bad weather, maintenance of the hull and machinery. Security breaches vulnerability of ships in piracy-affected regions should be studied in deciding the optimum speed. Optimum speed should also consider the economic consequence i.e. effects on demand and supply market, which include number of trading ships and price of commodities, just in time arrival and berth allowances.

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