Maritime Industry Revival Through Systems Digitalization

F.Terpsidi
Dept. of Industrial Design and Production Engineering
University of West Attica
Athens, Greece

N. Nikitakos
Dept. of Shipping Trade and Transport,
University of Aegean
Greece
mipapou@uniwa.gr

D. Papachristos
Dept. of Industrial Design and Production Engineering
University of West Attica
Athens, Greece

***Abstract*— The new business environment requires the shipping industry to move from the traditional business model of selling capacity to one that will provide more value to users. The purpose of this paper is to study and analyze the transition of shipping to the digital age. The 2016 amendments to the revised Annexes (International Convention for the Prevention of Pollution from Ships - MARPOL) to the Convention on Facilitation of International Maritime Traffic (FAL) include new requirements for the digital exchange of maritime transport information. From 8 April 2019, the FAL Convention now requires States Parties to establish a protocol for the electronic exchange of information between ships and ports, necessitating the digitization of shipping by all countries.**

Keywords*— *Maritime; Systems; Transport; Electronic; Digitalization; Security; E-Navigation; Technology; Big Data

I. Introduction

The purpose of this paper is to study and analyze the transition of shipping to the digital age, as well as to admire her greatness and her necessity.

The transport sector by sub-region is based on four fundamental sectors, Road, Air, Rail and Maritime Industry. In recent years, shipping adapted to market and to dynamic changes.

These changes create an environment where those who survive over time make decisions on three key pillars, asset financing, asset operation and loader selection. All these are a function of a cost-based strategies implemented by dominators in the maritime world. Existing business models rely heavily on the success of these strategies, which contribute to the profitability of companies.

The new business environment requires the shipping industry to provide more value to users and since smooth global supply chains are needed, digital business is a key factor for shipping companies. Spare parts management, etc. and demand for real-time systems, which are depended on structure and quality, will enable users to make data-driven decisions.

In addition, training and skill development to accommodate human-machine cooperation is valuable to the fulfillment of such systems success.

Market reports and announcements show that maritime companies are working with IT providers to meet the challenges of the new technological environment.

II. NAVIGATION SYSTEMS FROM ANCIENT TIMES UNITL 1920

Overview

In ancient times, land discovery and migration were the result of navigating the oceans and various techniques were used to determine a ship's position, such as understanding winds, currents of the sea, observing the position of the Sun and other stars (North Pole Star determined position on the horizon.

Western civilization countries used celestial navigation, as they used architectural features aligned with the rising sun and sailors used the positions of particular stars, as they did not disappear from the horizon, to orient their navigational means.

From the 3rd century BC and on seafarers, began to create the first navigation instruments as per below.

A. Compass

The compass has unknown roots, it is thought though to be discovered in China and a century later the Arabs discovered its usefulness and spread it throughout Western Europe (first compass was a magnetic needle on a piece of cork floating in a box of water). This instrument became an indispensable tool for all ships as it had the ability to detect the true North Pole.

B. Astrolabe

Apollo Pergaios was the inventor of the astrolabe, originally spherical shaped, but in the 8th century, the Persian mathematician Fazari created the first level astrolabe (round disk and a movable arm indicating the angle of the celestial bodies). From the 3rd century BC until the 18th century AD, sailors and astronomers used the astrolabe to observe other planets and stars and with known latitude and longitude they could understand the time and vice versa.

C. Sunstone

The sunstone was a polarized crystal invented by the Vikings where depending on its position towards the Sun it is either bright or dark. This is scientifically justified since sunlight has electromagnetic waves that oscillate perpendicular to the direction of a luminous ray and because in the atmosphere there are gas molecules that polarize the light and thus cause all the electromagnetic waves to oscillate in the same way.

This calcite crystal is polarized, and it allows only light that oscillates in a certain direction to penetrate it.

D. Sextant

Sextant is the most important instrument of navigation, since it determines the position of ship. It's essentially a development of astrolabe. Its operation rests on the laws of optics where the angle of incidence of light on a plane is equal to the angle of reflection.

Two mirrors are applied, one of which is small and immovable while the other is large and mobile. Therefore, observations were made from the positioning of the binoculars carried by the instrument.

Although nowadays is not used because of the technological advancements, bridge officers are required to know how to use it.

E. Telegraph

The first wireless communication was achieved on December 12, 1901 by Guglielmo Marconi and was the beginning of the evolution of electronic science. A test occurred between two American ships that were about thirty nautical miles away and a year later the first transatlantic message (the letter 'S'), was sent, from Cornwall, England to a United States military base. The implementation of telecommunications in shipping happened with signals that began to be transmitted every hour to ensure precise ship times. Wireless communication minimized the divergence of a vessel's positioning with an error of less than one second.

F. Radiometer

This is a directional radar detector, which determines the direction of a coastal radio broadcasting station observation. The first radio direction finder (RDF) experiments were made in 1888, with an open-loop wire used as an antenna. Its use on the ships has helped to identify the position and alert in case of danger. So, by having two or more measurements from different positions, the position of an unknown transmitter can be determined. While having two or more measurements from known transmitters we can determine the position of a vessel.

G. Gyroscope

A gyroscope is a device for measuring and controlling the angular movement of a body. In shipping it first appeared after the introduction of metal shipbuilding due to the magnetic field. It consists of a base, the gyroscope frame, the rigid member, the axis of rotation and the impeller. It's based on maintaining the angular momentum, ie keeping the external torque equal to zero. Even if the ship is tilted, the flywheel of the gyroscope will continue at the same speed of rotation and at the same time remain oriented in the same direction.

H. (Automatic) Rudder

This is an advanced system of electromechanical and electronic devices. It is connected to the ship's gyroscopic compass transmission system, which alerts the ship of deflections from its steady course and alters the rudder to return the ship to its course. There are also automatic rudders that operate attached to a standalone magnetic compass to allow for automatic monitoring even if the ship's gyroscopic compartment is damaged. To limit the stresses on the ship, it is equipped with special adjustments that regulate the rotation of the rudder depending on the sea conditions. Today there are automatic rails equipped with an electronic module that can be programmed to carry out the entire journey automatically and adjust the required route changes.

III. NAVIGATION SYSTEMS FROM THE 1ST WORLD WAR UNTIL THE BEGINNING OF THE 2ND WORLD WAR

At the end of World War I in America, the first documented scientific studies of the creation of radio wave transmitting, processing and receiving machines began. Initially, radars with the capability of measuring distances by transmitting radio waves to shipping appeared. Subsequently, the period of excessive shipping was based on the reception and processing of radio waves from coastal stations which resulted in the identification of the ship (stigma).

A. Radio Detection and Ranging (RADAR)

This is an Electromagnetic Wave Detection and Distance Measurement device. The name was given in 1939 by the American Corps of Engineers as it was developed for the Navy since there was a military need to identify enemy ships and aircrafts.

The basic idea was rooted in experiments related to electromagnetic radiation. Both light and radio waves are examples of electromagnetic waves that are governed by the same fundamental laws but have different frequencies. Radio waves can be reflected by metallic objects and refracted by a dielectric medium like light waves, and by the beginning of the 20th century a ship detection device was created to prevent ships from colliding in the fog.

B. GEE

Gee was a radio navigation system used by the Royal Air Force during World War II. It was designed as a short-range blind landing system, to improve safety during night operations. Its range though was far better than expected and thus developed into a full-scale long-range navigation system, providing enough precision without any additional help. These systems were developed to support military and civil aviation throughout Europe. Gee's operating principle was as follows:

- In the first stage, two known timing pulses were sent from ground stations and the aircraft receives and diagnoses them through an oscilloscope. The time between transmissions was not constant (variation from station to station). However, the aircraft's equipment had a system that allowed it to be adjusted.

- In the second stage the receiver has an oscillator, and when the receiver is first powered on, the pulses from the ground station move on to the screen. The operator then adjusts the oscillator until the pulses stop, which means that the local oscillator was at exactly the same pulse frequency as that of the ground station. The receiver thus has two integrated systems of this type, allowing the operator to receive signals from two stations, to easily compare and simultaneous measurements (Haigh, 1960).

C. Loran

Loran was a navigational system operating at low frequencies and thus offered a range of up to 2400km. It was first used on ships and later on long range aircraft. Post war, Loran A was created, which had a frequency of 1700-2000 KHz with a range of 540 nm. The Loran-C evolution had a frequency of 100 KHz with a range of 1080 nm.

IV. NAVIGATION SYSTEMS POST 2ND WORLD WAR

After the text edit has been completed, the paper is ready for the template. Duplicate the template file by using the Save As command, and use the naming convention prescribed by your conference for the name of your paper. In this newly created file, highlight all of the contents and import your prepared text file. You are now ready to style your paper; use the scroll down window on the left of the MS Word Formatting toolbar.

A. Extra Shipping

Determination of the position of a ship by means of overboard shipping was illustrated by the intersection of two overboard lines of position. The most important navigational aids to overseas shipping developed during World War II are:

- SONNE

The SONNE system was a radio navigation system developed by an older system called ELEKTRA and is also known as Elektra Sonnen. When the British came to know the system, they called it CONSOL which means sun.

- DECCA

The DECCA systems allowed ships and aircraft to determine their position by receiving radio signals from fixed navigators. Post war, Decca Navigation Systems developed the system for commercial use. The system used two-phase low-frequency comparison between 70 and 129 kHz, in contrast to pulse timing systems such as LORAN.

- LORAN-C

The Loran-C was a radio navigation system, introduced in 1957, that allowed a receiver to determine its position by listening to low frequency radio signals transmitted by fixed radios. It provides a signal that is both high-bandwidth and high-precision. The disadvantage was the expense of the equipment needed to interpret the signals hence was mainly used in the military.

- In the 1970s, the cost, weight and size of electronic devices for Loran-C dropped due to the introduction of solid-state electronic systems. Low-cost and easy-to-use Loran-C units became common and their use spread widely for large areas of North America, Europe, Japan and the entire Atlantic and Pacific. The Soviet Union had a nearly identical system, CHAYKA (Divis, 2015).

- The introduction of satellite navigation in the 1990s led to a very rapid rejection of the use of Loran-C (Martin, 2017).

B. Electronic Numerical Integrator and Computer (ENIAC) – Transistor - Microprocessor

- ENIAC was created in 1943 it was regarded as the first universal digital computer as it was needed for the US military, since it calculated ballistic tables (tables used by the artillery staff to calculate the range of particular cannon). ENIAC contained 70,000 resistors, 10,000 capacitors, 18,000 tubes, 1500 relays, 6000 manual switches and consumed 140kW. In volume it occupied a whole room and manual solutions were used to solve various equations for ballistic trajectories, in contrast to modern base 2 and automated procedure.

- A Transistor is a semiconductor device used to amplify or switch electronic signals and electricity., usually with at least three terminals for connection to an external circuit. The voltage or current applied to a pair of transistor terminals, controls the current through another pair of terminals. The most common transistor is the MOSFET (field-effect-field-metal-silicon-oxide transistors). The transistors revolutionized the field of electronics and most are made from pure silicone. The MOS transistor is the fundamental building block of modern electronic devices and is ubiquitous in modern electronic systems.

V. NAVIGATION SYSTEMS DURING THE 4TH INDUSTRIAL REVOLUTION UNTIL TODAY

Maritime industry has made great strides in using technology and in the daily life of the ship, making significant changes in the 80s and 90s. A period of cosmogenic change in the maritime industry is expected to be the twelve-year period by 2030.

The so-called 4th Industrial Revolution, which already significantly affects people's daily routine on earth, is taking the first but dynamic steps in shipping. This period is more important than the "steam revolution". It's a development that has boosted shipping, increased speeds, increased number of vessels, increased security and changed crew data.

Nowadays, people are turning to green technologies, to reduce global pollution, while communications and automation are slowly but steadily reducing the number of seafarers. Unmanned terminals in ports are steadily increasing, while in shipyards the demand for workers is decreasing, due to the dynamic introduction of automation, robotics and communications into the industry (Psaraftis, 2006).

A. Cybersecurity

The "entry" of high-tech shipping also raises new security issues, so monitoring of any infrastructure critical to detecting a real-time threat is required. Developments have also become widely adopted by all major organizations that either maintain a 24-hour Internal Security and Event Management (SIEM) department or outsource this work to other companies. Ensuring security, means protecting both IT devices and services from unauthorized access and focus is given to three key issues: data confidentiality, privacy and trust.

Data confidentiality is a fundamental problem in Internet devices and services (Miorandi et al., 2012). This requires addressing important aspects: the access control and authorization mechanism and the authentication and Identity Management (IdM) mechanism. Authorization helps determine if a person or device is allowed to receive a service at recognition. Access control involves controlling access to resources by granting or denying resources using a wide range of criteria. The problem is to find a solution to safely handle the identity of the user, objects / objects and devices.

Privacy is a major, open research, issue in Internet devices and services due to the ubiquitous nature of the Internet environment. Trust plays an important role in establishing secure communication when many things communicate in an uncertain IT environment: trust in interactions between entities and trust in the system from the user side. In order to gain user / service trust, there must be an effective trust-setting mechanism in a dynamic and collaborative IoT environment.

B. Maritime fuel

According to the authorities, the International Maritime Organization's (IMO) study of the European Union on the rigorous and immediate implementation of Sulfur Cap 2020 raises a number of serious issues that appear to have a significant impact on the maritime industry and the economy around it. In the near future, fuels and technologies will partially replace the use of petroleum fuel, which has been dominant for a whole time.

C. Digitilisation

Some of the major changes that have already taken place or will occur in the next one or two decades and what they entail are the following (Steenberg & Forget, 2007):

a) Electronic map and Informaion Imaging Systems (ECDIS): It is a revolutionary change that has improved the safety of navigation and its full benefits will be realized as electronic navigation strategies evolve.

b) Electronic Motors: Controlled through advanced computer systems and with the dominance of only two brands in the market, this has not led to being treated in a similar way as ECDIS.

c) Global Positioning System (GPS): This system, has led to a breakthrough in navigation. Overconfidence in GPS capabilities is a constant debate between old navy bridge officers and their newest that have never seen the system fail. The debate over the concept of ship "verification" is taking a whole new turn with the advent of GPS / GLONASS sharing, in conjunction with other satellite positioning systems on the horizon.

d) Environmental Regulations: Environmental regulations are evolving and developing rapidly, as are the regulations on the measurement of harmful gases signed. The maritime industry is under pressure and efforts to train seafarers in their role in this important field are urgent and important.

e) E-Navigations: E-Navigation, as the IMO envisions it, is a very dynamic goal and the development brings with it various challenges in data collection, integration and analysis. The way seafarers interact with electronic navigation presents a number of challenges and the risk is present as new equipment and systems are designed and developed.

f) Technology Evolution: The introduction of cheaper communication systems has led to an increase in the volume of data sharing on board ships. The internet has gone into the good of the seafaring but the increased use of electronics is accompanied by the problem of frequent hardware-related malfunctions. There are several cases of damages and there is a need for standardization and rigorous monitoring of the quality of equipment at the construction and installation stages, so that they can withstand exceptional sea conditions. Note that there is a gap in this area for people who can repair damage to the boat's electronic systems. There are too many examples of failures in which no crew member has the knowledge to repair.

g) Maritime Labor Convention (est. 2006): This pillar of international maritime law safeguards the rights of seafarers and has focused the attention of companies and seafarers on the resting hours. However, companies have not yet focused their attention on safe navigation regulations. As a result, *seafarers are often the "scapegoats" of regulatory decisions when things go wrong.*

h) Hierarchy: Reporting malfunctions, contract redress procedures and transparent systems have brought about a change in the way captains and companies manage crews. The whole system though tends to become dysfunctional because of increased disloyalty and disrespect for officers.

i) Merging: Merging ship systems with offshore systems is inevitable and an integral part of online navigation but it poses new challenges in the field of cyber security.

j) Big Data: The shipping industry is a traditional industry and is not usually the pioneer in adopting the latest technologies. The range of regional equipment products around shipping is increasing due to the much greater demands that shipowners have. This is now a key criterion for the purchase of a ship, as it costs a lot to relocate. There are incentives for the design and, more generally, for the existence of green ships. This distinction is valid for 3 years and holds a decisive role in the name of the shipping company that owns this ship. A prime example of an incentive is the port of Long Beach, which gives a cash prize to any green ship parked there. Another example is the South Korean government, which not only lends at low interest rates, but in certain cases finances the construction of new green ships. This initiative must also be made by other governments, in order to attract individuals so that there is an incentive to build new green ships.

k) GPS & GLObal NAvigation Satellite System (GLONASS): In parallel with the improvement of satellite navigation systems and navigation equipment, great attention has been paid to enhancing the accuracy of specifying and predicting the parameters of the satellite navigation paths. In 2008 the GLONASS system replaced the Cicada and Cicada-M systems. because low track systems were unable to meet the demands of a large number of users. The successful operation of low-orbit satellite navigation systems by sea users has attracted widespread attention to satellite navigation. Flight tests of the Russian, high-speed navigation satellite system, called GLONASS, began in October 1982 with the launch of the satellite Kosmos-1413. There are two currently operating global satellite navigation systems: GPS and GLONASS

l) RADAR & Automatic Radar Plotting Aid (ARPA): After manually or automatically receiving radar targets, ARPA will calculate and present a variety of information useful to the navigator in avoiding collisions and navigational decisions. All ARPA models display basic collision avoidance data: CPA, TCPA, range and carrier to target interest and route and speed targeting. Most advanced models will allow a nautical chart of the area to be electronically overlaid on the radar screen. By doing so, while viewing a screen the navigator can indentify his position with respect to the mapped channel, as well as seeing stable and moving targets that can jeopardize its scheduled navigation.

m) LORAN: It is still used by many naval vessels, but the accuracy of satellite navigation aids, such as the Global Positioning System, is increasingly downgrading ground-based backup navigation systems. A secondary station, 200-300 miles away, automatically transmits its own signals, maintaining a pulse frequency and duration consistent with those of the primary station.The secondary station maintains a constant time difference between receiving the primary signal pulse and sending its own.

n) ECDIS: An ECDIS system displays information from electronic navigation charts or digital nautical charts and incorporates information from position, direction and speed through water reference systems and other optional navigation sensors.

o) European Geographic Navigation Service (EGNOS): This satellite augmentation system was developed by the European Space Agency and EUROCONTROL, on behalf of the European Commission. Ground stations determine the precision data of satellite navigation systems and transmit them to geostationary satellites. Since July 2005, EGNOS has been transmitting a continuous signal and at the end of July 2005 the system was put to use to track bicycles at the Tour de France race. In 2009, the European Commission announced that it had entered into a contract with European Satellite Services Provider to carry out EGNOS. Initial work to extend its coverage EGNOS in the South African region are being implemented as part of a project extending the ESESA - EGNOS service in South Africa.

p) Wide Area Augmentation System (WAAS): WAAS is an aeronautical aid developed by the Federal Aviation Administration to enhance the Global Positioning System , with the aim of improving its accuracy, integrity and availability.

- Accuracy: The WAAS specification requires position accuracy of at least 7.6 meters or less at least 95% of the time.The WAAS specification requires the system to detect errors on the GPS or WAAS network and notify users within 6.2 seconds.

- Integrity of a navigation system includes the ability to provide early warnings when its signal provides misleading data that could potentially be hazardous. The WAAS specification requires the system to detect errors in the GPS or WAAS network and inform users within 6.2 seconds.

- Availability: Availability is the probability that a navigation system can meet the requirements of accuracy and integrity. An accuracy approach includes, altitude information and provides guidance, distance from the treadmill, and elevation information at all points of the approach, usually below lower altitudes and minimum weather effects from inaccurate approaches.

Before WAAS, the US National Airspace System was unable to provide lateral and vertical navigation for precision approaches for all users across all sites.

q) Multifunctional Satellite Enhancement System (MSAS): This Japanese Satellite Enhancement System is a satellite navigation system that supports Dual GPS to supplement the GPS system by reporting reliability and the accuracy of these signals.

r) GPS Aided Geo Augmented Navigation (GAGAN): The project has set up 15 Indian reference stations, 3 uplink stations in India, 3 Indian mission control centers and installed all relevant software and communication links. A national plan for satellite navigation, including the implementation of the Technology Demonstration System (TDS) in the Indian Airspace as a proof of concept, was jointly prepared by the Airport Authority of India and Indian Space Research Organisation (ISRO). TDS was successfully completed during 2007 by installing eight Indian Reference Stations at eight Indian airports and connecting to the Central Control Center near Bangalore. As part of the program, a network of 18 Total Electron Content monitoring stations was installed at various locations in India to study and analyze the behavior of the ionosphere in the Indian region.

s) Bei Dou Satellite Navigation System (BEIDOU 1): The first Chinese satellite navigation system, Bei Dou (also known as Bei Dou-1) consists of three satellites that have been providing limited coverage and navigation services since 2000, mainly to users in China and neighboring areas. The second generation of the system, known as COMPASS or Bei Dou-2, began operating in China in December 2011, with a partial array of 10 orbiting satellites.

In 2015, China launched the deployment of the third generation Bei Dou system to conquer global coverage. When fully completed, Bei Dou will provide an alternative global satellite navigation system to the global GPS positioning system Russian GLASS or European GLASS systems. It was claimed in 2016 that the Bei Dou-3 would an accuracy of some millimeters.

According to China Daily, in 2015, fifteen years after the satellite system was launched, it reported turnover of $ 31.5 billion annually for large companies such as China Aerospace Science and Industry Corp., Auto Navi Holdings Ltd and China North Industries Group Corp.

On December 27, 2018, the Bei Dou Satellite Navigation System started providing global services. The official English name of the system is the Bei Dou Satellite Navigation System.

t) GALILEO: Galileo is the global satellite navigation system launched in 2016. It was created by the European Union through the European GNSS (Global Navigation Satellite System) Agency, based in Prague (Czech Republic) with two ground centers, the Oberpfaffenhofen (Germany) and Fucino (Italy).

Galilegnsso can provide an independent high-precision location tracking system, so that European nations do not have to rely on US GPS or Russian GLONASS systems, which could be suspended or downgraded. It is designed to provide horizontal and vertical position measurements at an accuracy of 1 meter and better positioning services at higher latitudes than other positioning systems.

Galileo is also set to provide a new global search and rescue feature as part of the Medium Earth Orbiting Search and Rescue (MEOSAR). The first test satellite, Galileo In-Orbit Validation Element (GIOVE-A), was launched on December 28, 2005, and the first one that was part of the operating system was launched on October 21, 2011. Its full 30-satellite system is expected by 2020 and the next generation of satellites will be operational by 2025 to replace the older ones.

u) Global Navigation Satellite System (GNSS): As of October 2018, the United States Global Positioning System and Russias GLONASS have been fully operational. GNSS, with the Bei Dou Navigation System and the European Unions Galileo scheduled to be fully operational by 2020.

Systems that provide enhanced accuracy and integrity monitoring, for civil aviation use, are classified as follows:

- GNSS-1 (first generation) is a combination of existing satellite navigation systems, with satellite or terrestrial extension systems. In the United States, the satellite element is the Wide Area Enhancement System, in Europe the European Geostationary Navigation Service , while in Japan is the Multifunctional Satellite Enhancement System.
- GNSS-2 (second generation) independently provides a complete civilian satellite navigation system, such as Galileos European Positioning System.

v) Global Maritime Safety and Security System (GMDSS): This is an internationally agreed set of security procedures, types of equipment and communication protocols used to increase security and facilitate the rescue of troubled vessels, vessels and aircraft. The specific radio navigation requirements depend on the vessels operating area and not on its capacity.

The basic types of equipment used in GMDSS are (Johnson, 1994):

a) Emergency Radio Emission Indicator (EPIRB)

b) NAVTEX

c) Satellite

d) High Frequency

e) Search and Rescue Locator

f) Digital Selective Call (DSC)

g) *Power supply requirements*

w) Automatic Identification System (AIS): This is an automated tracking system that uses transceivers on ships and is used by ship traffic services.

This requires an AIS very high frequency (VHF) transceiver, which allows viewing in the local traffic chartplotter or computer monitor capable of AIS, and transmits information about the ship to other AIS receivers. This data can be shared over a local area network or a wide area network via TCP (Transmission Control Protocol) or UDP (User Datagram Protocol) protocols, but will still be limited to the collective array of radio receivers used in the network.

Standard data includes boat name and details, location, speed and map header, search capability, potentially unlimited global reach, and historical archiving. Most of this data is free but satellite data and special services such as file searching are usually provided at a cost. The original purpose of the AIS was solely to avoid conflicts, but since then many other applications have been developed and are still in development. AIS is currently in use for:

a) *Avoiding Conflicts*

b) *Monitoring and Control of the fishing fleet*

c) *Nautical Safety*

d) *Help with Navigation*

e) *Search and Rescue (SAR)*

f) *Accident Investigation*

g) *Ocean Current Estimates*

h) *Infrastructure Protection*

i) *Tracking fleet and cargo*

x) Speedometer: A speedometer is called an instrument, which measures the speed of the ship. The speed unit used is the node, which corresponds to one nautical mile per hour. The common tachometer included parts, made of wood and an arrangement of ropes to to hold it perpendicular to seawater. When the user would deploy the instrument into the sea they could measure the nodes in 30 or 60 seconds intervals, giving them the speed of the ship at nautical miles per hour. As a note, sand was used as a timer to measure the time of 30 or 60 seconds.

Onwards mechanical rotometers were developed consisting of a freely rotating propeller towed by the ship. The seawater's dynamic pressure, due to the movement of the ship, caused the propeller to rotate, leading to more precise and faster readings.

j) Depth meter: This instrument was previously used mainly in oceanographic studies. Jacob Perkins (1766-1849) proposed a sonar arrangement based on the compressibility of water. The movement of a plunger compressed a body of water enclosed in its cylinder depended on the pressure of the water outside the cylinder and hence its depth. The amount that the piston moved was measured when returned to the surface (Traill, 1821).

In 1876 William Siemens, driven by the needs of the telegraph industry created an instrument consisting of a mercury tube and worked similar to a barometer (Munro, 1884). The pressure of the mercury acting under the force of gravity pushed it down and distorted a thin sheet of steel. The height of the mercury in the column was therefore proportional to the force of the Earth's gravitational field. The greater the depth of the water beneath the ship, the lower the gravitational force (Kieve, 1973).

VI. CONCLUSIONS

The International Maritime Organization Convention on Facilitating International Maritime Traffic was adopted in 1965, with the aim of implementing a more streamlined logistics process for the carriage of passengers, ships and cargo in international trade.

The FAL Convention was adopted in part by maritime contracting states, in response to the increasing local demands of maritime states that created a burden on the maritime industry.

The stated objective of the International Maritime Organization, underpinning the FAL Convention, was to avoid delays in maritime traffic, to stimulate intergovernmental cooperation and to increase uniformity in the international maritime industry as far as possible. The Convention included standards and recommended practices to build efficiency in ship documentation requirements.

The 2016 amendments to the revised Annex to the FAL Convention entered into force on 1 January 2019. The new requirement of the FAL Convention for all public authorities to set up electronic maritime information exchange systems marks a significant move for the maritime industry and ports towards a digital maritime world, reducing administrative burdens and increasing the efficiency of maritime trade and transfer. The grace period for governments to comply with digital transaction requirements is at least 12 months.

ACKNOWLEDGMENT

All authors would like to thank the University of West Attica and specifically the Post Graduate Program of Studies (MSc) "New Technologies in Shipping and Transportations", for the financial support provided to them to undertake this research project.

REFERENCES

[1] Blanchard, W., The Journal of Navigation, "Chapter 4", Vol.44, April 1991.

[2] Divis, D. A., "PNT ExCom Backs eLoran as a Step to Full GPS Backup System", Inside GNSS, 10 December 2015.

[3] Duru, O.,"Motivations behind irrationality in the shipping asset management: Review of fundamental theories and practical challenges", Maritime Business Review, Vol. 1, No. 2, pp.163-184, 30 June 2016.

[4] Haigh, J.D., "Gee-H - AMES 100", The Services Textbook of Radio, Volume 7, Radiolocation Techniques, 1960.

[5] Psaraftis N. Harilaos,'EU Ports: Quo Vadis?', ECONOMIST Shipping and Ports Forum, http://www.maritime.deslab.naval.ntua.gr , 20 December 2006.

[6] Jin, X., Wah, B.W., Cheng, X., and Wang, Y. , "Significance and Challenges of Big Data Research", Big Data Research, Vol. 2, pp. 59-64,2015

[7] Nguyen, T., Zhou, L., Spiegler, V., Ieromonachou, P. and Lin, Y., "Big data analytics in supply chain management: A state-of-the-art literature review", Computers and Operations Research, In Press, on line July,2017.

[8] Nicolini, L. & Caporali, A., "Investigation on Reference Frames and Time Systems in Multi-GNSS". Remote Sensing, 2018

[9] Stopford, M., Maritime Economics, Routledge, London, 1997.