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Contents

From Editor-in-Chief

Ivica Kuzmanić

Dear Readers,

You have before you the sixth issue of the internationally reviewed scientific journal Transactions on Maritime Science, published by the Faculty of Maritime Studies of the University of Split. As always, the Journal is published in printed and electronic, open-access form. We still wish the Journal to be easily accessible to our readers at minimum cost.

In the main section, "Regular papers", in this issue we publish seven papers written by foreign and Croatian scientists. These are papers related to renewable energy sources, marine engineering, passage planning, electronic navigational devices and marine information systems, as well as extension of the existing SMCP chapter on pilotage and tug assistance.

In the section "Contributions" we publish latest news provided by Tatjana Krilić, our most precious London collaborator, related to the activities of the International Maritime Organization (IMO). All the news from the past six months has been provided. In this part of the Journal there is the section entitled "Maritime heritage" with the latest contribution by the distinguished journalist and opinion journalist Marijan Žuvić on "Heavy lifters, a closed chapter in the history of Croatian shipping". We also bring latest news from different branches of shipping.

We have also remained faithful to another area we wish to promote: the Croatian cultural heritage. Again a poem, this time written in the dialect spoken by the inhabitants of the island of Vis. And once again, this is the only contribution presented in bilingual form: in the lively language of the author Ivica Roki from his first collection of poems "Visu raju" – "To Vis, My Paradise", from 1998 and accompanied by the inspired English translation by Mirna Čudić. This versatile artist was born in Split, but has been living ever since on the island of Vis where, among other activities, he grows vines and olives. As a special treat, in the electronic version of course, we have a unique opportunity to hear the author recite his own poem.

Whenever a new issue of the Journal comes to light, we do hope that it will inspire you to cooperate in future by sending us your contributions.

Thank you.

Offshore Wind Power Plant in the Adriatic Sea: An Opportunity for the Croatian Economy

Božidar Liščić, Ivo Senjanović, Većeslav Čorić,
Hrvoje Kozmar, Marko Tomić, Neven Hadžić

The significant growth of renewable energy production in the past decades is present mainly due to the global depletion of fossil fuel reserves. One of interesting and well developed renewable energy technologies are wind turbines which are mainly built onshore. Due to more favorable wind characteristics at sea, offshore wind power plants are an interesting and challenging option for meeting future energy demands. In particular, less turbulent wind with higher average velocity enhances energy production and reduces structural fatigue of wind energy structures. In this study, benefits and drawbacks of offshore wind turbine units and power plants are pointed out. Based on the available climate data, sea depths and existing sea traffic routes, two possible wind power plants, i.e. one with fixed and another with floating turbines, are proposed for installation in the Croatian part of the Adriatic Sea. Benefits for the Croatian shipbuilding industry and its economy are pointed out.

KEY WORDS
~ Renewable energy
~ Wind turbine
~ Offshore wind power plant
~ Shipbuilding industry

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1. INTRODUCTION

Over the last couple of decades, the strong development of renewable energy technologies has been motivated by the global depletion of fossil fuel reserves. Generally, an energy resource can be considered renewable if it cannot be exhausted and its exploitation does not pollute the environment. Currently, the most frequently exploited renewable energy resources at the global level are the wind, the sun and water. Wind energy is transformed into electricity using wind turbines, as they transform the wind's kinetic energy into the rotational motion of wind turbine rotor blades.

Significant increase in the construction of wind power plants, particularly in the coastal area, can be noted in Croatia. Generally, wind turbine power plants consist of a number of wind turbines placed in an optimum arrangement ensuring favorable flow conditions, i.e. undisturbed wind flow of constant velocity and low turbulence. A relatively constant wind velocity between 5 and 25 m/s results in higher energy extraction efficiency and relatively low level of blade and column fatigue. When wind velocity is lower than 5 or higher than 25 m/s the operation is restrained, i.e. the rotor is put in the parking position preventing the rotation of the rotor blades, since its continued operation is either unprofitable or there is quite large risk of damage, respectively.

Therefore, wind turbines placed within a wind farm generally have lower operating efficiency and higher fatigue than wind turbines at the upwind edge of a wind farm. In particular, as the flow separates from the wind turbine towers and rotor blades at the leading edge of the wind farm, the wind turbines within the farm experience lower wind velocity and higher turbulence. Hence, wind turbines are usually placed at the distance of 4 to 5.5 rotor diameters between the wind-turbine towers in order to improve operating conditions for downwind turbines, (Chamorro and Porté-Angel, 2010).

Nowadays, due to the limited possibilities for wind power plant construction on land, noise problems, visual pollution, low number of available locations with desired wind properties, different commercial difficulties related to land renting or purchasing and the obtaining of necessary legal permits, the development of offshore wind power plants has intensified. Also, due to the nealy flat sea surface, offshore wind has some favorable properties, as for example nearly constant average velocity at hub height with less turbulence, increasing operating efficiency and reducing column and blade fatigue level, enabling the application of longer turbine blades for the same hub height. This trend has been driven by a strong ambition to exploit huge and relatively unused energy potentials, (Bilgili et al., 2011; O'Keeffe and Haggett, 2012).

On the other hand, some of the disadvantages are the maintenance of offshore wind turbines, particularly at high sea, requiring the development of special ships, as well as specialized engineering knowledge and skills required to design and construct such complex engineering structures operating in an aggressive meteorological and corrosive environment. A more detailed overview of the present status, resources, environmental challenges, social impacts and different technical and operational aspects of offshore wind turbines can be found in e.g. (Brennan et al., 2012; Nguyen et al., 2013; Parveen et al., 2014).

The fact that the Croatian Government prohibited the construction of onshore wind turbines on Croatian islands in general, as well as on the mainland in the region within 1000 m from the Adriatic Coast (Decision on arrangement and protection of protected sea coastal region, 2004) is yet another reason to construct offshore wind power plants in the Croatian part of the Adriatic Sea. Therefore, offshore wind power plants represent a challenging alternative capable of both generating energy and creating new workplaces in the local communities.

An important problem in the Croatian part of the Adriatic Sea is the strong and gusty Bora wind developing at rather high and steep coastal mountains like Velebit and Biokovo. Due to the transient Bora wind, offshore wind turbines are expected to be subject to higher fatigue than onshore wind turbines. Bora's average wind velocity is rarely higher than 17 m/s (Belušić et al., 2004), with wind gusts reaching up to 70 m/s (Bajić and Peroš, 2005). Another relevant wind developing in the Adriatic is Scirocco with average velocities between 10 m/s and 30 m/s. It usually develops in the southern part of the Adriatic during winter, and in the northern part of the Adriatic during spring (Penzar et al., 2001).

In addition, the numerous Croatian islands form additional obstacles, since their presence decreases wind velocity and enhances atmospheric turbulence. Currently, a comprehensive research of aerodynamics of offshore wind turbines in the vicinity on complex coastal topography is underway within the framework of the FP7-Marinet program - one of the largest offshore renewable energy research projects in history (e.g. Kozmar et al., 2014).

2. WIND PROPERTIES IN THE CROATIAN PART OF THE ADRIATIC SEA

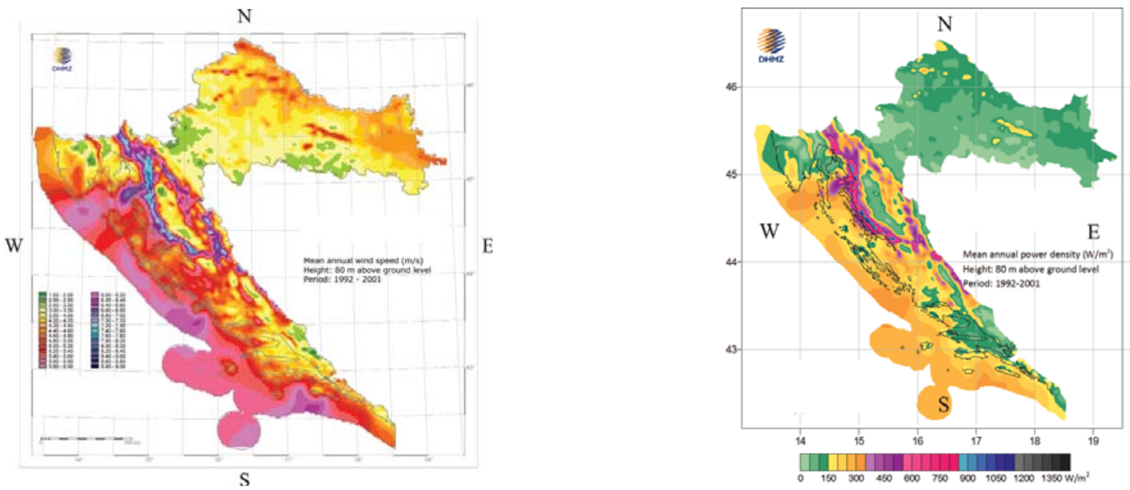
The assessment of Croatian wind energy potential based on the computational atmosphere model ALADIN (Bajić et al., 2007; Horvath et al., 2011), of the Meteorological and Hydrological Service, has already been successfully done. The available data include average wind speed and power density at altitudes of 10 and 80 m above ground level for one year as average quantities within a 2 × 2 km square, (Figure 1). Since the energy potential of wind turbines is usually determined based on the mean wind speed value at hub height, the results pertaining to the altitude of 80 m (one of the most frequently applied wind turbine hub heights) are particularly valuable.

Mean wind speed at the altitude of 80 m is the highest at open sea in front of the town of Pula and the island of Mali Lošinj, open sea in front of the town of Šibenik and the island of Mljet, with values of about 6.5 m/s. Since, to the authors' best knowledge, wind speed in the Croatian part of the Adriatic Sea has never been measured at open sea, this figure needs to be taken with caution. It is also important to emphasize that the current data does not take into consideration wind pulsation capable of significantly influencing both turbine efficiency and fatigue.

Therefore, the existing data can be applied as the first approximation for loading estimation, while other issues such as turbulence models and high resolution measurement of vertical wind profiles are planned to be resolved in the future based on the 'Wind resources and forecasting in complex terrain in Croatia' project, (Windex home page, http://www.windex.hr), as well as on experimental wind-tunnel simulations, (Kozmar et al., 2014).

3. DESIGN OF THE OFFSHORE WIND POWER PLANT

Offshore wind power plant design primarily differs from onshore wind turbine design in the complexity of subprocesses that need to be taken into account and harmonized. Wind turbine design remains in the focus of the problem, as the key factor influencing power plant field array, but all other factors influencing technical and technological implementation and economic effectiveness need to be taken into account as well. It is



a) b)

Figure 1.

a) Mean annual wind speed at the altitude of 80 m, b) Mean annual wind power density at the altitude of 80 m.

Source: Hrvatski meteorološki zavod, http://www.meteo.hr.

important to point out that the only similarity between onshore and offshore wind turbines or wind power plants can be found in their tower and rotor shape. All other components are different. The construction of onshore wind turbines is mainly based on typical solutions, which is not possible in the case of offshore turbines, since their foundations and subsea tower structure mainly depend on sea depth, sea bottom morphology and composition, and sea currents - the key components influencing the design of the turbine substructure.

Offshore wind power plants can be classified into two basic types, i.e. fixed and floating wind turbines, (Figure 2). The environmental loading of such specific offshore units consists of the wind, waves, sea current and earthquakes. Fixed wind turbines are balanced by elastic forces since they are primarily designed based on the stiffness criteria, while in the case of floating turbines, mainly designed based on the resonance criteria, the inertial forces balance the environmental loading. Fixed wind turbines are usually used in configurations where sea depth is not greater than 30 m, mainly with monopod substructure consisting of a single column. The greatest sea depth at which a fixed turbine was ever used was 45 m (E.ON, 2009). The oil and gas industry has significant experience with designing and mounting of such offshore units.

a) b)

Figure 2.

Different types of a) fixed and b) floating offshore wind turbine supporting structures.

Source: Wiser et al. 2011.

There are several key issues that need to be addressed when designing an offshore wind power plant and offshore wind turbine:

1. The geographical location of the offshore wind power plant based on the analysis of wind and wave climate, sea bottom profile (bathymetry) and properties (geotechnical testing), the analysis of the existing electrical power supply network and distance from the nearest onshore substations, existing offshore objects (gas, oil, fresh water and sewerage pipelines, telecommunication cables), environmental impact and navigation routes.

2. Wind turbine aerodynamic properties (rotor type and diameter, hub diameter, tower height and diameter) depending on the wind microclimate and the desired power output properties.

3. Wind turbine substructure (fixed or floating turbine) depending on the analyzed wave microclimate, foundation analysis and choice of anticorrosive protection.

4. Energy analysis (substation design, transfer of energy to the nearest onshore substation by underwater cables and its route, i.e. bathymetry).

5. Construction technology, transport, mounting and maintenance of wind turbines.

Based on the wind microclimate analysis, three potential locations in the Croatian part of the Adriatic Sea were selected, i.e. open sea in front of the town of Pula and the island of Mali Lošinj, open sea in front of the town of Šibenik and the island of Mljet. Taking into account the existing sea depths, (Barković, 2014), and navigation routes, (Lušić and Kos, 2006), the open sea in front of the town of Pula and the island of Mali Lošinj seems to be suitable with respect to small sea depth (under 60 m) and vicinity of the costal electrical power supply network. However, possible difficulties could emerge due to considerable sea traffic as this is the entrance to the Kvarner Bay. Due to greater sea depth, the location in front of the island of Mljet is not convenient for an offshore wind power plant, since the floating structure of wind turbines in such great depths significantly increases the necessary investment. The optimum location with respect to sea routes is the open sea in front of the town of Šibenik, i.e. between the island of Žirje and the town of Primošten. The drawback of this location is significant sea depth (up to 90 m). According to those facts and based on existing wind data it can be concluded that the optimum location for an offshore wind power plant with fixed wind turbines is the open sea in front of the town of Pula and the island of Mali Lošinj, (Figure 3). On the other hand, the open sea between the island of Žirje and the town of Primošten can be considered an optimum location for floating wind turbines.

For the purpose of this study, the potential wind power plant at open sea in front of the town of Pula and the island of Mali Lošinj is projected to consist of twenty fixed wind turbines with hub height of 80 m and rotor diameter D = 93.2 m (NWE Sales - Windmil Sales and Engineering home page, http://www.nwesales.fi). If power coefficient is taken to be approximately C_p = 0.4, air density ρ =1.2 kg/m^3 and average wind speed v=6.5 m/s, the electrical power produced by a single wind turbine is (Manwell et al., 2009),

Figure 3.
Potential location for a wind power plant with fixed wind turbines (open sea in front of Pula and Mali Lošinj) along with respective sea depths.
Source: Barković, 2014.

$$P = \frac{1}{2} C_p \rho v^3 \frac{D^2 \pi}{4} = 449.42\ kW \tag{1}$$

that gives the total amount of 78.73 GWh electrical energy annually, for the whole power plant.

The horizontal distance between wind–turbine towers placed in a staggered pattern within this power plant is taken to be 4 to 5.5 rotor diameters. Accordingly, the area that would be covered by such a plant is about 4 km^2 (2000 × 2000 m). Based on the selected offshore location and sea depth, the trusted turbine substructure is envisaged for the wind turbines. Similar existing structures for the sea depth of 45 m are illustrated in Figure 4.

4. INVESTMENT COST

The typical 2 MW offshore wind turbine erected in Europe requires an investment of 1.2 - 2 million €/MW, depending on distance from the shore, weather conditions, sea bed conditions and existing electrical power infrastructure, (Bilgili et al., 2011), which is around 50 % more expensive than onshore wind turbines.

Except investment, maintenance costs have significant contribution to the overall operational costs. In case of a fixed offshore wind turbine they range between 125 and 250 €/kW, depending on distance from the shore, weather conditions, maintenance methodology, available equipment and auxiliary units such as specialized ships, while in the case of onshore units they are between 70 and 120 €/kW (Wiser et al., 2011).

However, these considerably higher costs are partially compensated by a higher production rate due to higher offshore

a) b)

Figure 4.
Fixed wind turbine trusted substructure during a) transport and b) installation, Alpha-Ventus, Germany.
Source: E.ON, 2009.

wind velocity. Except for direct operational compensation, higher investment and maintenance can find justification in the development of other accompanying industries, e.g. shipbuilding, employment generation, as well as environmental benefits.

5. SHIPS USED FOR WIND TURBINE MOUNTING AND MAINTENANCE

The emergence of offshore wind power plant technology necessitated the development of special ships used for mounting, maintenance and decommissioning of wind turbines. Hence, new technologies were developed not only for that, but also for the purpose of rapid and safe execution of tasks. One of the specialized, unique ships developed for those purposes is a synthesis between jack-up self-elevating platform and a supply vessel. An acronym WTI (Wind Turbine Installation unit) has been widely accepted for those ships. One of the most important design parameters of a WTI ship is its operational speed, since they are designed to economically accomplish special tasks in acceptable environmental conditions. In the case of incoming storm they have to be evacuated into the protected area. In addition to their significant speed and self-elevating property, WTI ships are characterized by relatively large deadweight allowing them to transport all necessary turbine components, and are equipped with a diesel-electric power system with azimuth propellers that enable simple and accurate maneuvering in the vicinity of offshore objects. Automation, redundancy and reliability of power system requirements make WTI ships one of the state-of-the-art ship types in shipbuilding industry.

In order to be put into operation, WTI's trusted legs need to be mounted on sea bottom to raise the entire ship to the desired height (above sea level) using the self elevating device. In this way, stable working conditions are ensured for crane operations at heights above 100 m, (Figure 5).

Figure 5.
Self-elevating WTI ship.
Source: Swire Blue Ocean A/S home page, http://www. swireblueocean.com.

6. POTENTIAL BENEFITS FOR THE CROATIAN SHIPBUILDING INDUSTRY AND ECONOMY

In accordance with global trends and to ensure new business opportunities, the Croatian shipbuilding industry has started a process of production diversification. One of the possibilities along those lines is a synergy between shipbuilding and energy industries, since they have some characteristics in common. In particular, the final product dimensions in both industries are similar. They both involve mainly steel and welding, forming, bending and casting processes capable of being performed by the existing equipment in shipyards.

Croatian shipyards have the necessary production capacities (large workshops, cranes etc.) which can easily meet the technological requirements for onshore and especially offshore wind turbine unit production, in particular: towers, nacelle heavy castings, substructures for fixed turbines and floating platforms for movable ones. Also, their strategic geographical location makes them very attractive, since a significant quantity of final products is transported by sea. For the production of some wind-turbine components, Croatian shipyards could take advantage of governmental and EU renewable energy resource incentives. It needs to be mentioned that the Brodosplit shipyard already has some experience in the production of wind-turbine towers for foreign companies building onshore wind power plants in Croatia. On the other hand, the Croatia-based company Končar developed its own wind turbine with the capacity of 2.5 MW, designed for onshore application.

The possible benefits of offshore wind power plants can also reflect on other fields of economy, namely those involving the production, installation and maintenance of such a complex engineering system, placing new challenges in the sense of knowledge and skills required to plan, design and execute the entire project (general design, production planning, installation planning, logistics, engineering supervision, education of specialized staff, maintenance and safety organization). This activity could potentially employ relevant specialized offices, institutions, agencies, universities, and particularly: shipbuilding experts, civil engineering experts (foundations, soil mechanics), geophysicists (wind and wave microclimate), geologists (bathymetry), mechanical and electrical engineers (offshore substation, connection of the energy cable to an onshore substation).

Another advantage is that all required institutions and experts are available in Croatia. If adequately organized, they would be able to offer this very specialized knowledge and expertise to the world market.

The successful completion of a complex engineering project, like an offshore wind power plant, would have significant impact primarily on Croatian shipyards, giving them an opportunity to develop, design and produce specialized complex ships with high added value, e.g.: heavy-lift vessel, wind-turbine installation unit (WTI), jack-up vessel, offshore supply vessel, cable laying ship, dredger and floating crane. Some of those ships are shown in Figure 6.

a) b)

Figure 6.
a) Dredger, b) Cable laying ship.
Source: Jan De Nul Gropu home page, http://www.jandenul.com.

The construction of WTI ships, as a complement to offshore wind turbines, seems to be a privilege of developed economies. However, although none of the Croatian shipyards was able to develop such a product for the global market, some decades ago the Croatian shipbuilding industry managed to manufacture all the necessary elements of advanced WTI technology. One of the examples is the production of the self-elevating platform Labin (Čorić et al., 2004). Its hull was made in Uljanik, pads in 3. Maj, trusted legs with self-elevating device in Brodosplit, with all components assembled in Viktor Lenac. In the 1980s, one similar sophisticated project was also completed, i.e. a floating catamaran crane having the capacity of 12000 kN (Begonja, 1988; Senjanović et al., 1992). At the time it was the largest floating crane in the world. Unit value of such products exceeds standard ship price three to four times, making them very attractive from the manufacturing point of view.

7. CONCLUSION

In the past decades, wind energy has globally become a major renewable energy source. While wind energy power plants are commonly built onshore, the most recent trend is to build them offshore due to more favorable wind characteristics at sea. In particular, less turbulent offshore wind with greater average wind velocity enhances energy production and reduces the structural fatigue of offshore wind turbines.

In this study, a possible offshore wind power plant in the Croatian part of the Adriatic Sea was considered. Based on the available data on the wind microclimate, sea depth and sea traffic routes, two potential locations were selected, i.e. open sea in front of the town of Pula and the island of Mali Lošinj for fixed wind turbines, and open sea between the island of Žirje and the town of Primošten for floating wind turbines. The proposed wind energy power plant consists of twenty wind turbines, each with output power of 2.5 MW, planned to take up four square kilometers of sea surface.

The total installed power of the considered offshore wind power plant is 50 MW, with the annual energy output of 78.73 GWh. This figure was calculated for the average wind speed of 6.5 m/s, reported in the currently valid wind maps. The calculated annual energy output of this offshore wind power plant is considered not to make a significant contribution to the total energy output of all the Croatian energy sources. Nevertheless, if this project is observed from a general point of view with respect to the Croatian economy, it can easily be seen that such an offshore wind energy power plant could become a major development lever for the Croatian shipbuilding industry and other accompanying fields such as mechanical and electro-industry, civil engineering, geophysics, geodesy. In addition, planning and design offices, logistic companies, as well as individual experts would gain specialized knowledge and skills required for developing, manufacturing, exploiting and maintaining such complex engineering structures. This would make Croatian economy more competitive and capable of offering relevant services and products to the global offshore market.

The proposed offshore wind power plants would significantly contribute to the Croatian economy since they would enable the acquisition of specialized skills, enhance research and development, especially in the shipbuilding and general industry, and consequently act as a multiplicative factor in the development of new high-tech technologies in Croatia.

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Vibro-acoustic Diagnostics of Rolling Bearings in Vessels

Zbigniew Stanik

Rolling bearings for many years have formed part of many mechanisms of various machines. They are also found in vessels. Rolling bearings' failure leads to failures of entire subsystems. For this reason, it is recommended to use objective and non-invasive methods to assess the condition of key bearings having a significant impact on the reliability of operation. Tools of this type include vibro-acoustic diagnostics.

KEY WORDS
~ Bearings
~ Diagnostics
~ Vibro-acoustic
~ Statistical measures

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1. INTRODUCTION

The attempts to apply methods of vibro-acoustic diagnosis to monitor the components constituting the equipment of ships and other vehicles are generally known (Grządziela, 2007; Grządziela, 2011). One of the components widely used that make part of ships' engines are bearings. They are also applicable due to their reliability in propulsion systems. Rolling bearings are part of a very large number of basic parts of equipment in all vessels. This equipment may include fuel centrifuges (Figure 1), compressors (Figure 2) and different types of pump (Figure 3).

Bearing nodes of propulsion systems and other components are subject to unusual sea loads caused by surging sea and dynamic effects associated with various, often unconventional vessel's assignments.

Damage to one of the bearings on the basis of a chain reaction, could lead to damage to the whole assemblies and subassemblies, which in turn can lead to serious damage of for example drive unit or could affect the safety of the vessel. Early diagnosis of the wear or the damaged individual bearing of for example the engine has a significant impact on the reliability of the entire operation period (Guyer, 1996).

In order to increase safety it would be recommended to refer to objective and reliable methods for monitoring the condition of rolling bearings, especially given the high density of individual components on a small surface and their interaction. One of these methods for determining the condition of the bearings is the method using vibroacoustic method.

Figure 1.
Fuel centrifuge Alfa Laval.

Figure 2.
Two-stage air compressor.

Figure 3.
Outboard water pump.

2. THE BEARING AS A VIBRATION AND NOISE GENERATOR

Each even smooth bearing is the source of noise and vibration connected with the movement of loaded rolling elements (Momono and Noda, 1999). Periodically changing load on the rolling elements causes changes in the susceptibility of the contact zones that is the cause of the formation of mechanical vibrations (Łazarz and Peruń, 2008). Other important causes of vibrations are geometric imperfections such as wave and surface roughness, fracture and fatigue of the rolling elements and the raceway surface crumble, as well as operational negligence in the form of impurities or improper lubrication (McFadden and Smith, 1984).

The flexible nature of the contact between the elements of rolling bearings can be modelled in the form of non-linear springs with or without deadening elements (Dietl, 1997; Noda, 1986). The model taking into account the mass of the rolling elements and two springs modelling the contact of the rolling element with the raceway, both outer and inner is shown in Figure 4.

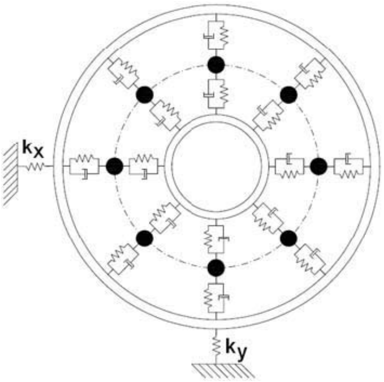

Figure 4.
Model of a dynamic rolling bearing: kx-modulus of elasticity seat in the direction of the x axis, ky-modulus of elasticity seat in the direction of the y axis.

The frequency with which any rolling item passes through the selected internal or external point of the ring of the bearing, depends on the number of rolling elements in the bearing. The frequency of the transition of a single-bead ball bearing through the bearing's circuit is:

$$f_c = \frac{\omega_c}{2\pi} \tag{1}$$

where:
ω_c - is the angular speed of the cart.

The frequency of the transition of all balls of ball bearing circuit (Eng. BPF - Ball Pass Frequency) determines the pattern:

$$f_{BPF} = zf_c \tag{2}$$

where:

z - the number of rolling elements.

The generated vibrations are poly-harmonic and stem from a change in the stiffness of the contact zone of the rolling element with treadmills and are created by the movement of rolling element bearings. The bearings are then subjected to bending and stretching, which is shown in Figure 5.

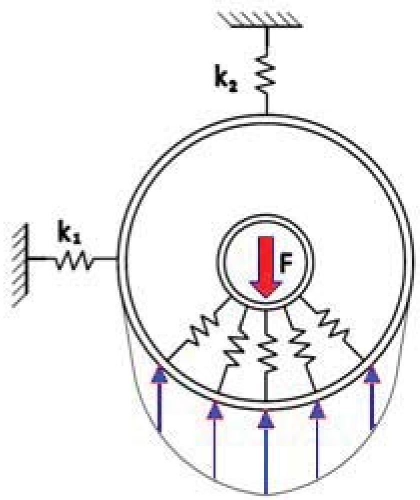

Figure 5.
Rolling bearing axial load.

A heavily loaded rolling bearing can lead to the loss of contact between the rolling elements and raceways. The phenomenon of this type produces strong chaotic vibrations. In addition, the effect of vibration caused by the movement of the roller may increase the uneven distribution of forces aggravating rolling bearing.

It is clear that each rolling bearing is made with different variations (Adamczak et al., 2011; Adamczak et al., 2013). But due to the fact that the bearings are made using the same mechanized devices, you can allow the repeatability of the characteristics of the produced bearings. In addition, striving to reduce production errors and a thorough quality control increase the coefficient of repeatability.

The presented causes of the vibration generated by the bearings make any, even the best made bearing, a source of vibro-acoustic processes of the spectral structure similar to noise. Vibration control positions used by manufacturers generally operate by the general measures, and on this basis make the classification of bearings in terms of fitness.

From the point of view of diagnostics, the level of vibration and noise of the new bearings is rather a kind of distortion, which should be specified in the calibration process while the determination of the parameters of vibro-acoustic processes accompanying all kinds of damage becomes important.

Bearings are inherent with generating audio signals that result from both natural conditions, and may herald the progressive damage if there are signals that the volume exceeds the expected values in the data. Compiling all sorts of sounds generated by the bearing is virtually impossible because of the wide range of frequencies in which the sound signals are contained, and some of them exceed significantly the scope of perception of the human ear in both low and high band. In addition, the difficulty stems from the simultaneous generation of vibration and audio signals by the working bearing.

3. GENERATING VIBRATIONS DUE TO THE DAMAGE - PULSE MODEL

Applying impulse force to the elastic system causes its dynamic response dependent on transfer function of the system. The response to the sequence of pulses is, as known, another sequence of pulses. According to equations defining the kinematic dependences determining mutual velocities of bearing's moving parts, the excitation frequency will be different depending on which of the elements have been damaged. To illustrate the phenomenon, we consider flat linear model. Assume that the outer race of bearing is fixed at the same time that the inner race is movable (Figure 6).

Using the proposed linear model, load distribution can be presented as in Figure 7.

It follows that the failure of the outer race will result in almost constant pulse sequence when the fault location of race is in the zone of maximum load. In case of damage of both the rolling element and the inner race, there is a sequence of pulses periodically increasing and decreasing. For bearings loaded only by transverse force, it can be assumed that about half a turn will be devoided of impulse interference.

As follows, the pulse load model can be represented as in Figure 8. The red line on the graph shows the distribution of the load on the bearing.

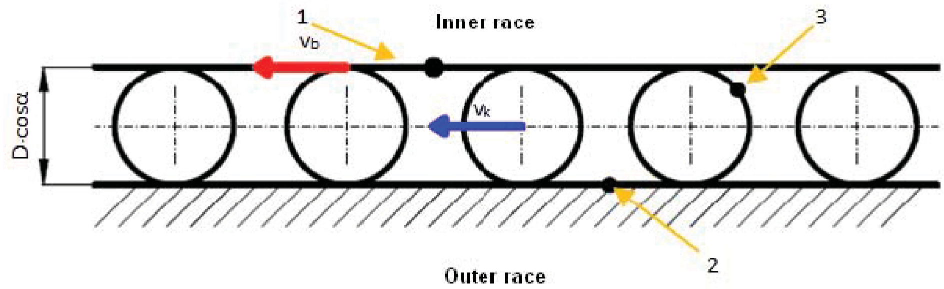

Figure 6.
Model to determine the contact frequency of the damaged component with the other parts of the bearing: v_b – race velocity, v_k – rolling element velocity, • - place of damage: 1 – inner race, 2 - outer race, 3 – rolling element.

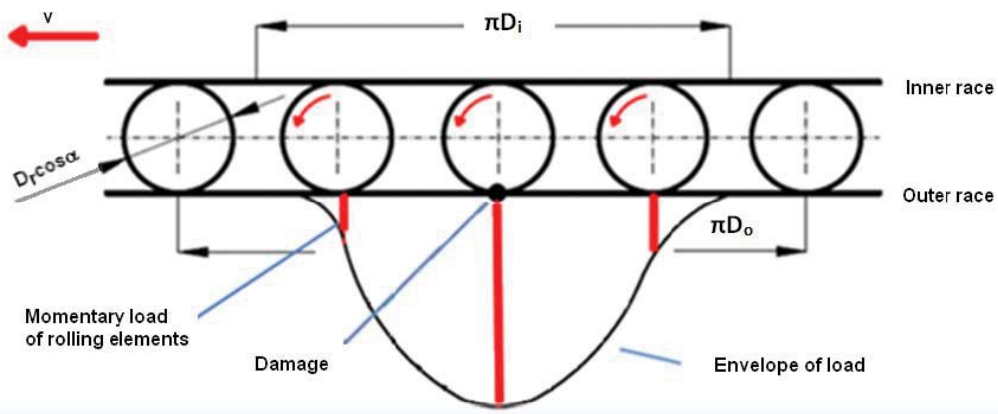

Figure 7.
Flat computational model for determining characteristic frequencies related to the point of damage of each bearing components: v - rolling velocity, πD_i - length of rolling way on the inner race, πD_o - length of rolling way on the outer race.

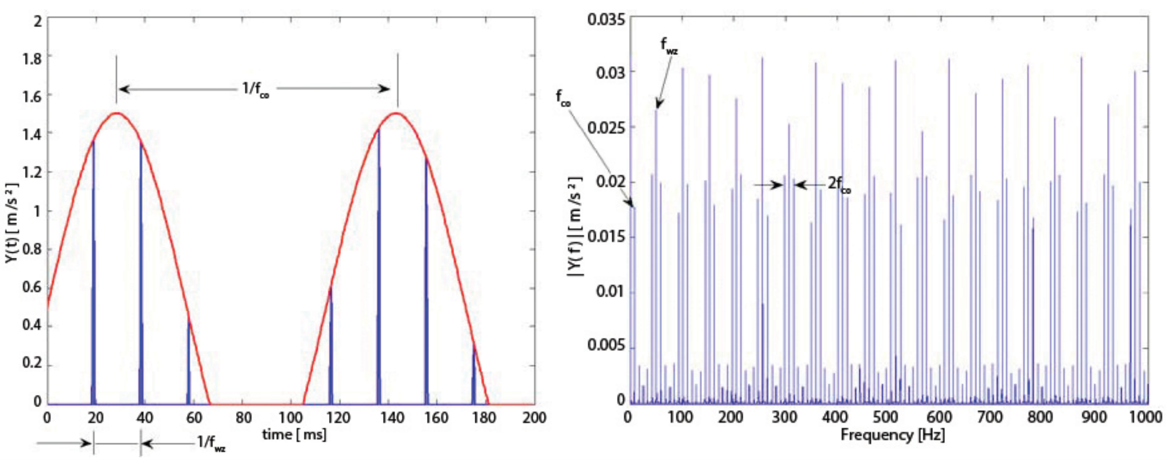

Figure 8.
Typical signals generated by damaged rolling element: f_{wz} - frequency vibrations induced by damage of rolling element f_{co} - frequency resulting from the rotation velocity of the rolling elements cage.

4. CHARACTERISTIC FREQUENCY OF ROLLING BEARINGS

In the course of the operation of bearings, the initial stages of damage to both the treadmill and rolling element, regardless of the type of damage (pitting, cracks, scratches, etc.) generally have a nature of local deformation. This type of consumption shall be accompanied by a specific vibration frequency suitable for the damage to individual items, this frequency is mainly from the rolling element bearings and its contact with a portion of the damaged figure and it stems from the basic kinematic dependence in the bearing (Cempel and Kowalak, 1980). Described dependences according to specific designs have been depicted in 3, 4, 5.

The frequency of the vibrations caused by damage to the inner raceway:

$$f_i = \frac{z \cdot f}{2} \left(1 + \frac{D_r}{D_m} \cos\alpha \right) \tag{3}$$

where:
z - number of rolling elements, f - frequency of rotation of the shaft, Dr - rolling element diameter, Dm- pitch diameter, α - angle of the bearing.

The frequency of the vibrations caused by the damage to the treadmill:

$$f_o = \frac{z \cdot f}{2} \left(1 - \frac{D_r}{D_m} \cos\alpha \right) \tag{4}$$

The frequency of the vibrations caused by the damage to the rolling element:

$$f_{wz} = \frac{D_m \cdot f}{2D_r} \left(1 - \left(\frac{D_r}{D_m} \cos\alpha \right)^2 \right) \tag{5}$$

Basing on the above characteristic frequencies is most appropriate in cases where the damage is a point e.g. the pitting or crumble, while for more complex damage there is a need to use more advanced methods of analysis vibration signals (Dziurdź, 2006).

For this purpose one can use e.g. measurements of the amplitude signal as well as dimensionless discriminants, and in more complex cases, for the diagnosis it may be necessary to use methods of analysis of signals in the field of time and frequency. Such methods include short-time Fourier transform and Pseudo Wigner-Ville transform.

5. ANALYSIS OF LATERAL VIBRATION ON SAMPLE BEARINGS' ENCLOSURES

Transverse vibration of bearing housing was measured in transverse plane in the zone of maximum load in bearing node with the use of vibration acceleration sensors allowing measurement in the frequency range up to 10 kHz. The signals were recorded with eight-pass data acquisition card VibDAQ+. Sampling frequency of signals was 31,2 kHz. Each time the measurement was about 60 seconds long. The results of the measurements were recorded on the computer's hard drive. During the test, temperature of the tested equipment was controlled. The temperature during tests corresponded to that of the normal operation.

During the test, the forces were affecting the single-row, angular ball bearing resulting from its normal operation. Figure 9 shows the results obtained from the analysis of the recorded signal on bearing after some time and a new one made using simple statistical measure. The measures were created on the basis of recorded vibration signals, which have good diagnostic sensitivity. Figure 10 shows the results of the dimensionless discriminant, often used in the diagnosis.

In the tests (C) the crest factor, (K) the form factor, (L) clearance factor and impulsivity factor were used and in addition, for both bearings the value of the kurtosis has been designated.

On the basis of the results shown, the growth of all designated measurement can be seen. In the case of the effective value of acceleration of vibrations and standard deviation of the increment amounted to approximately 20 %. Changing the average deviation was around 14 %, while the variance was of up to 40 %.

The largest recorded change among the dimensionless discriminants was that of clearance rate value. The change amounted to about 13 %. A little less increase took place in the value of impulsivity. The other coefficients have recorded growth of around 4-6 %.

The biggest difference was in the case of kurtosis. Here, the increment was over seven.

Figure 11 shows the amplitude spectrum of vibration acceleration recorded on the enclosures tested.

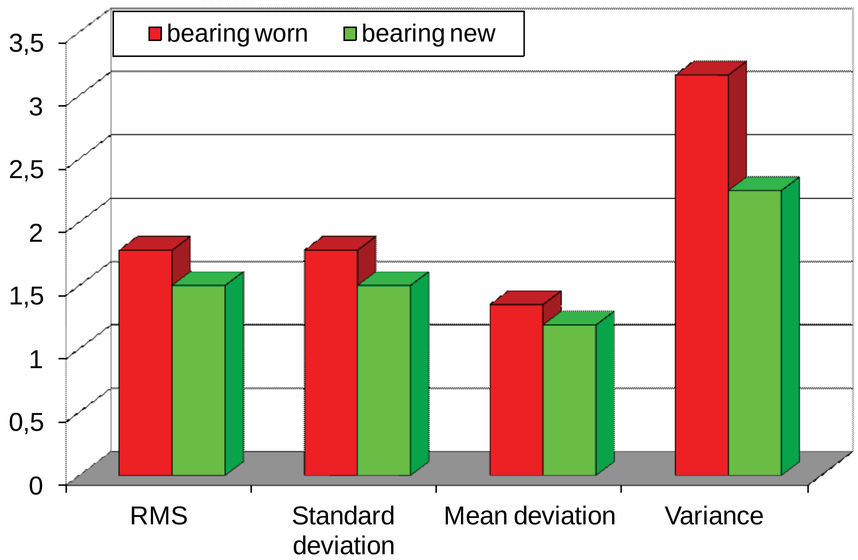

Figure 9.
The value of simple amplitude measures of the designated for the used bearings and the new ones.

Figure 10.
The value of the dimensionless discriminant designated for the used and new bearings.

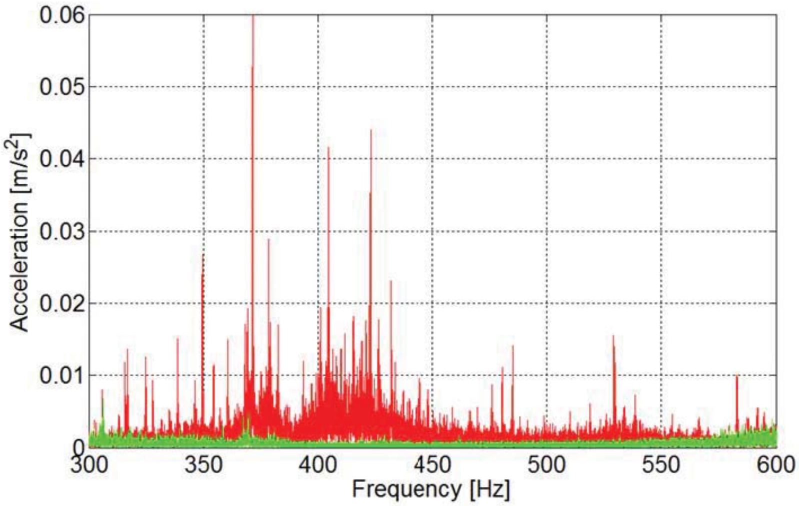

Figure 11.
Amplitude spectrum of vibration acceleration recorded on the tested enclosures.

In the selected range, the greatest diversity of amplitude spectra was observed with the new bearings and the one after some time. In the frequency range 300-600 Hz, vibration acceleration amplitude increase is visible after some time of exploitation.

For diagnostic reasons, it is advisable to conduct studies after varying periods of time. On the basis of the results obtained, it may be possible to determine the frequency intervals showing the greatest amplitude changes that will constitute the basis for making a certain diagnosis of the bearing arrangement.

6. CONCLUSION

Vibro-acoustic diagnosis of rolling bearings in vessels faces a number of problems encountered also when diagnosing bearings in automotive vehicles. The main problem is isolating the interesting and important from the point of view of the diagnosis, signals from interference. This refers mostly to acoustic signals, less difficulty occurs when diagnosing using vibration signals. For this reason, in the described research the emphasis was on the use of vibration signals.

On the basis of the studies conducted and of the analysis, the following conclusions are:

- wear and tear of bearings contributed to the increase in the value of measures assigned on the basis of vibration acceleration signal,
- increases in the value indicate a progressive wear allowing, however, for further exploitation,
- the largest difference between the values obtained was for the kurtosis as well as for the variance, in other cases they were less than 20 %,
- in the case of building measures based on signals distorted by the high-energy components generated by efficient or damaged elements, frequency or time-frequency analysis of recorded signal would be appropriate.

The test results show effectiveness of the methods of vibro-acoustic diagnosis.

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Liquefied Natural Gas Ship Route Planning Model Considering Market Trend Change

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KEY WORDS
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~ Supply chain
~ Ship routing
~ Boil-off gas
~ Stochastic programming

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We consider a new biannual liquefied natural gas (LNG) ship routing and scheduling problem and a stochastic extension under boil-off gas (BOG) uncertainty while serving geographically dispersed multiple customers using a fleet of heterogeneous vessels. We are motivated not only by contract trend changes to shorter ones but also by technological advances in LNG vessel design. The mutual coincidence of both transitions enables developing a new LNG shipping strategy to keep up with emerging market trend. We first propose a deterministic LNG scheduling model formulated as a multiple vehicle routing problem (VRP). The model is then extended to consider BOG using a two-stage stochastic modeling approach in which BOG is a random variable. Since the VRP is typically a combinatorial optimization problem, its stochastic extension is much harder to solve. In order to overcome this computational burden, a Monte Carlo sampling optimization is used to reduce the number of scenarios in the stochastic model while ensuring good quality of solutions. The solutions are evaluated using expected value of perfect information (EVPI) and value of stochastic solution (VSS). The result shows that our proposed model yields more stable solutions than the deterministic model. The study was made possible by the NPRP award [NPRP 4-1249-2-492] from the Qatar National Research Fund (a member of the Qatar Foundation).

1. INTRODUCTION

Global LNG industry is expected to grow about 40 % until 2016 not only as LNG is highlighted as a clean and efficient energy source than other fossil fuels but also as North America raises shale gas production and Asian demand increases steadily (US Department of Energy, 2005; US Department of Energy, 2014). Traditional LNG contracts have 20-30 years of long term duration which ensures stable energy supply and demand (Hartley et al., 2013). In recent years, however, it has been observed that the portion of short-term contracts and spot demand are rapidly increasing in LNG market (Christiansen et al., 2009). The changing demand pattern is directly relevant to the LNG supply policy to satisfy customers. Accordingly, it is required to review the current LNG transportation strategy.

LNG vessels usually sail in the fully loaded condition or with minimum filling of LNG to cool down the tank temperature because partly loaded vessels can make an adverse sloshing impact to the containment system and vessel structure (Shin, et al., 2003). Thanks to recent advances in ship design technology, newly constructed LNG vessels can voyage without completely filling the tanks (Tessier, 2001; Suvisaari, 2012).

With these supporting reasons, we are looking at the transformation of LNG marine transportation model to catch up with the changing business environment. Next generation of LNG shipping model may need to satisfy multiple customers with different contract durations utilizing various types of LNG vessels with different technological constraints and cargo capacities. If that happens, the total sailing time of a LNG vessel in a route may be longer than the schedule from the current LNG routing model. As a result, one must consider gas loss during the shipment because gas evaporates in proportion to the time of voyage.

As we will describe in the following paragraphs, this paper deals with three problems: 1) LNG inventory routing and scheduling, 2) stochastic or robust optimization modeling of uncertain factors in LNG supply chain, and 3) BOG in a cargo tank. In a previous study, an LNG inventory routing problem was formulated in mixed integer program to satisfy monthly demand considering sales activities and inventory level at the regasification terminal (Grønhaug and Christiansen, 2009). LNG supply chain optimization problems are proposed to decide sailing schedule and vessel assignments. This problem is similar to our study, but it differs as it serves single customer in a route (Andersson et al., 2010). Traditional LNG demand is mostly identified by well-determined long-term contracts, and so annual delivery program is developed with diverse fleet of LNG carriers. However, this model is not suitable to include spot-demand and short-term contracts (Rakke et al., 2011).

LNG supply chain inherently includes numerous uncertain factors. Nevertheless, uncertainty has drawn little attention in the quantitative research community. For example, Bopp et al. formulated price and demand uncertainty in natural gas distribution using stochastic programming (Bopp et al., 1996). Halvorsen-Weare and Fagerholt (2013) considered sailing time uncertainty in LNG supply chain caused by disruptive weather conditions. Their model was based on historical weather data in 3-12 month time horizon. However, neither of these studies have considered uncertain internal system dynamics of LNG carriers, but mostly focused on the impact from external environments.

We recognized that there are limited items of literature regarding BOG effect in LNG supply chain, which is discussed in this paper. In an early stage of research, the focus was on discovering the characteristics of BOG in a partially filled tank and developing mathematical models (Chatterjee and Geist, 1972). In addition, the occurrence and the effect of BOG on LNG supply chain have been examined dividing the time phases into three categories: loading, unloading and marine transportation (Dobrota, et al., 2013). Although the concept of evaporated gas involving LNG inventory routing problem has been studied, BOG was often considered as a constant (Grønhaug, et al., 2010).

Therefore, the purpose of this paper is to present a new mathematical formulation of LNG routing and scheduling in the form of vehicle routing problem (LNG VRP) that can cover overall contract patterns including long-term, short-term and spot demand. We exploit a fleet of LNG carriers with partial loading and unloading capability of cargoes to serve multiple customers in routes. We especially consider evaporated gas losses during voyage by developing a two-stage stochastic model.

The remaining part of this paper is organized as follows: Section 2 describes the proposed problem. Section 3 provides mathematical formulations of the LNG ship routing and scheduling problem in a deterministic form and stochastic extension considering BOG. Then Section 4 presents the computational study with test case description and settings, numerical results and sensitivity analysis. Finally, the paper is concluded in Section 5.

2. PROBLEM DESCRIPTION

This model generates biannual shipping schedule to maximize the profit meeting all customer demands while ensuring the optimal LNG production and inventory level at the liquefaction terminal in each time period. The shipping plan includes not only long-term contract but also short-term and spot. All operating vessels must initiate a tour from a liquefaction terminal at the depot and complete the tour after unloading cargoes visiting regasification terminals at remote demand locations by designated sea routes.

All LNG carriers have its own specific tank capacity, loading conditions and average vessel speed must observe. The tank capacity is from 140,000 billion cubic meters (bcm) up to 216,000 bcm. The fleet of heterogeneous vessels can be divided into two groups depending on loading conditions: Type I (no partial tank filling) and Type II (partial tank filling is allowed). Type I vessels are prohibited from partial loading, which means that the amount of LNG in a tank must be over any specific level or empty tank to avoid sloshing impact. This type of vessels can only serve individual customers unless the additional short-term or spot demand is very small. Type II vessels have no restriction on partial tank filling so that multiple customers can be served by an assigned LNG vessel within the given tank capacity. We formulate this problem as LNG VRP model in mixed integer programming considering the rate of BOG. In addition, we give a small buffer on the time window by allowing few days of plus and minus from the target delivery date to ensure a flexibility of transportation.

3. MATHEMATICAL FORMULATIONS

3.1 Deterministic model

The deterministic LNG VRP model is presented in this section and the indices and sets, data and decision variables are the following:

Indices and Sets:

S Set of LNG terminals;

T Set of time periods;

K Set of LNG tankers;

$s \in S$ Index of LNG terminal;

$t \in T$ Index of time period;

$k \in K$ Index of LNG tanker;

G(V,A) Directed graph nodes $V=\{1,2,\ldots,|S|=s+max(s)(t-1)\}$ as the set of terminals and $A=\{(i,j): i,j \in V, i \neq j\}$ as the set of arcs in the planning time horizon;

$h \in H$ Index of the origin (depot), where $h=1+|S|(t-1)=max(s)\cdot(t-1)$ in the planning time horizon, $H \subseteq V$;

$r \in R$ Index of Type I LNG tanker, $R \subseteq K$.

Data:

$DAY_{i,j}$ Estimated travel time from i to j;

DSC_k Daily shipping cost of vessel type k;

$D_{j,t}$ Demand at j in time period t;

REV Unit revenue of LNG per billion cubic meters (bcm) ;

CYC_j Expected target delivery date at j;

VC_k Cargo capacity of vessel k;

VN_k Total number of vessel k;

$STCOST_t$ Unit storage cost in time period t;

$PDCOST_t$ Unit production cost in time period t;

TM Maximum number of terminals can be visited in a route;

M Big-M;

α Cargo filling limit ratio (%) of Type I LNG tankers;

β Time window - number of acceptable days from target delivery date;

ε Boil-off rate (BOR) (%) $[\varepsilon, \bar{\varepsilon}]$;

δ Storage level at liquefaction terminal $[\delta, \bar{\delta}]$.

Decision variables:

$y_{i,j}$ Amount of LNG delivering from i to j;

$x^1_{i,j,k}$ = 1 if vessel k operates from terminal i to terminal j; 0 otherwise

x_t^2 Production level in time period t;

x_t^3 Inventory level in time period t;

x_i^4 Vessel arrival time (date) at i, and $x_i^4 = 0$;

x_i^5 Accumulated travel time (days) from initial supply terminal to j, and set departure time at the depot as $x_i^5 = 0$;

u_i Flow in the vessel after it visits i.

Then, LNG VRP formulation is as follows.

3.1.1 Objective function

Maximize

$x \in X, y \in Y$

$$\sum_{(i,j)\in A} REV \cdot (1 - \varepsilon DAY_{i,j})\, y_{i,j} \tag{1a}$$

$$-\sum_{t \in T} (PC_t x_t^2) \tag{1b}$$

$$-\sum_{t \in T} SC_t x_t^3 \tag{1c}$$

$$-\sum_{(i,j)\in A}\sum_{k \in K} (DAY_{i,j} DSC_k x^1_{i,j,k}) \tag{1d}$$

The objective function maximizes the overall revenue considering all potential cost factors in the supply chain.

The first term of the objective maximizes profit by subtracting the cost of evaporated gas in accordance with BOR, duration of shipping and the amount of LNG in a cargo tank (1a). The second (1b) and third term (1c) minimize production and storage cost. These values are dependent not only on the production level and storage level but also on the amount of BOG and ship routes decisions indirectly from the term (1a). The term (1d) of the objective is to minimize overall vessel operating cost based on daily shipping cost of each vessels and ship duration from a previous terminal to next destination.

3.1.2 Constraints

The LNG VRP model considers multiple time periods in a model. However, it is formulated as single time period model by re-indexing the terminal index with time period index. So, index of terminals implies about what terminal may be served in which time period. Therefore, constraints (2) and (3) nullify the repeating indices of liquefaction terminals in the model.

$$\sum_{k\in K} x^1_{s,s+|S|(t-1),k} = 0, \qquad \forall s\in S, t\in T\setminus\{1\}, \qquad (2)$$

$$\sum_{k\in K} x^1_{s+|S|(t-1),s,k} = 0, \qquad \forall s\in S, t\in T\setminus\{1\}, \qquad (3)$$

When a route decision is made, a vessel assignment also has to be determined simultaneously. Once a vessel is assigned, the vessel must complete the tour without being replaced by other vessels returning to the liquefaction terminal. Constraints (4) control this condition checking vessel flows from previous tour decision and the next tour decision.

$$x^1_{i,j,k} \le \sum_{l\in V} x^1_{j,l,k} \le N-(N-1)\, x^1_{i,j,k}, \qquad \forall (i,j)\in A, k\in K, \qquad (4)$$

When a ship is assigned to a route, the amount of laden LNG cargo must be less than the tank capacity of a vessel (5), while the number of operating vessels also must be less than the number of vessels in a fleet (6).

$$y_{i,j} \le \sum_{k\in K} VC_k x^1_{i,j,k}, \qquad \forall (i,j)\in A, \qquad (5)$$

$$\sum_{j\in V}\sum_{h\subseteq V} x^1_{h,j,k} \le VN_k, \qquad \forall k\in K, \qquad (6)$$

Constraints (7) ensure that all departed vessels must return to the original liquefaction terminal after completing yours. Constraints (8) and (9) establish the condition that a customer can receive a shipment by one designated vessel in each time period.

$$\sum_{j\in V}\sum_{k\in K} x^1_{h,j,k} = \sum\sum x^1_{i,j,k}, \qquad \forall h\subseteq H, \qquad (7)$$

$$\sum_{j\in V}\sum_{k\in K} x^1_{i,j,k} = 1, \qquad \forall i\in V\setminus\{1\}, \qquad (8)$$

$$\sum_{i\in V}\sum_{k\in K} x^1_{i,j,k} = 1, \qquad \forall j\in V\setminus\{1\}, \qquad (9)$$

As stated above, all departed vessels from the depot must return to the origin, and should not terminate the tour while making any sub-tours. For each routing decision, Miller-Tucker-Zemlin (MTZ) sub-tour elimination constraints filter any possible sub-tours in constraints (10) (Miller et al., 1960).

$$u_i - u_j + TM\sum_{k\in K} x^1_{i,j,k} \le TM-1, \qquad \forall (i,j)\in A, \qquad (10)$$

Constraints (11) denote the relation between the amount of LNG loading to a cargo tank and the demands in each time period. Particularly, as evaporated gas losses are expected during transportation, an additional amount of LNG is considered in the constraints.

$$\sum_{i\in V} (1-\varepsilon DAY_{i,j})Y_{i,j} - \sum_{t\in T} D_{j,t} = \sum_{l\in V} y_{j,l}, \qquad \forall j\in V\setminus\{1\}, \qquad (11)$$

Once a laden LNG vessel unloads all cargoes at regasification terminals, the returning vessel must be empty in practice excluding the minimum amount of LNG cargo for cooling purposes. So, constraints (12) set the cargo level of laden LNG vessel returning to a liquefaction terminal as '0'.

$$\sum_{i\in V} Y_{i,h} = 0, \qquad \forall h\in H, \qquad (12)$$

Based on LNG contract terms, a specific amount of LNG cargoes have to be delivered to customers at the expected time on regasification terminals allowing a few days grace period from the expected time. Constraints (13) and (14) accumulate the sailing time of an operating vessel and constraints (15) set the time window from an expected delivery date on a target customer.

$$x_j^5 \geq x_i^5 + DAY_{i,j} - M(1-x^1_{i,j,k}), \qquad \forall\, (i,j) \in A,\ k \in K, \qquad (13)$$

$$x_j^4 \geq x_i^5 + DAY_{i,j} - M(1-x^1_{i,1,k}), \qquad \forall\, i \in \backslash\{1\},\ k \in K, \qquad (14)$$

$$|x_j^5 - CYC_j| \leq 0.5\,\beta, \qquad \forall\, j \in A, \qquad (15)$$

As type I LNG vessels have strict filling limits on cargo tanks during voyages, constraints (16) set this condition based on the allowed filling limit ratio (α).

$$y_{i,j} \geq \alpha VC_r x^1_{i,j,r}, \qquad \forall\, (i,j) \in A,\ r \subseteq K, \qquad (16)$$

Planning inventories and production levels are determined by the demand level in each time period in constraint (17). Safety stock and maximum storage level at the depot is set up in constraints (18).

$$x_t^2 - x_t^3 + x^3_{t-1} = \sum_{j \in V} D_{t,j}, \qquad \forall\, t \in T, \qquad (17)$$

$$\underline{\delta} \leq x_t^3 \leq \overline{\delta}, \qquad \forall\, t \in T, \qquad (18)$$

3.2 A stochastic extension of BOG impact to the LNG VRP

We reformulated the proposed deterministic model into a two-stage stochastic model considering BOG uncertainty. The random elements are the following:

Random elements:

Ω	Set of scenarios;
ω∈Ω	Index of scenario;
$p_\omega \in P$	The probability mass function in accordance with scenario *ω*.

The stochastic model can be written as (Birge and Louveaux, 2011):

$$\min_{x \in X} c^T x + \varrho(x) \qquad \text{s.t.} \quad Ax = b \qquad (19)$$

and the recourse function ϱ(*x*) can be written as (20) as we consider discrete probability distribution *P*:

$$\varrho(x) = \mathbb{E}_\omega Q(x,\omega) = \sum_{(i,j) \in A} \sum_{\omega \in \Omega} p_\omega Q(x,\omega) \qquad (20)$$

where

$$\varrho(x,\omega) = \min_{y \in Y} d^T_\omega y \qquad T_\omega x + W_\omega y = h_w \qquad (21)$$

We denote $\mathbb{E}_\omega$ as a mathematical expectation, and ω as a scenario with respect to probability space (Ω,P). In the two-stage LNG routing problem, Q(x,ω)is the optimal value of BOG (second stage problem). First-stage decisions are expressed in vector x and second-stage decisions are actions represented by y. Accordingly, the objective function of deterministic model can be reformulated into a stochastic form in (22). Constraints (23) are replacing constraints (11) as well.

$$\sum_{(i,j) \in A} \sum_{\omega \in \Omega} REV \cdot p_\omega (1-\varepsilon_\omega DAY_{i,j}) y_{i,j,\omega} - \sum_{t \in T} (PC_t x_t^2 + SC_t x_t^3) - \sum_{(i,j) \in A} \sum_{k \in K} (DAY_{i,j} DSC_k x^1_{i,j,k}) - \sum_{i \in V} x_i^4, \qquad (22)$$

$$\sum_{i\in V}(1-\varepsilon_{\omega}DAY_{i,j})\,y_{i,j,\omega}-\sum_{t\in T}d_{j,t}=\sum_{l\in V}y_{j,l,\omega},\quad \forall j\in V\backslash\{1\},\omega. \tag{23}$$

3.3 Monte Carlo sampling

The stochastic version of LNG VRP model has an infinite number of BOG scenarios. In this research, however, we use the Monte Carlo sampling-based optimization that may reduce the computational burden while generating decent solutions in a reasonable time with a limited number of scenarios.

Let $\omega_1,\ldots,\omega_n$ be random generated sample drawn from *P*. Following the law of large numbers, for a given vector *x*, we have

$$n^{-1}\sum_{n\in N}Q(x,\omega_n)\longrightarrow \mathbb{E}_{\omega}Q(x,\omega)\quad \text{with probability one.} \tag{24}$$

Therefore $\varrho(x)=\mathbb{E}_{\omega}Q(x,\omega)$ is represented by the sample mean $\hat{\varrho}_n(x)=n^{-1}\sum_{n\in N}Q(x,\omega_n)$ and the constraints (22) can be rewritten as constraints (25).

$$\frac{1}{n}\sum_{(i,j)\in A}\sum_{\omega_n\in\Omega}REV\cdot(1-\varepsilon_{\omega}^{n}DAY_{i,j})y_{i,j,\omega_n}-\sum_{t\in T}(PC_t x_t^2+SC_t x_t^3)-\sum_{(i,j)\in A}\sum_{k\in K}(DAY_{i,j}DSC_k x_{i,j,k}^1)-\sum_{i\in V}x_i^4 \tag{25}$$

4. COMPUTATIONAL STUDY

The computational study presented in this chapter evaluates the deterministic LNG VRP model and two-stage stochastic model under BOG uncertainty by comparing each solution. In section 4.1 the numerical example is described along with the experimental settings to solve the models. In section 4.2 optimal routing solutions are depicted on a diagram with analysis on scheduling decisions. And then, the solution differences between deterministic and stochastic model is compared by means of Expected Value of Perfect Information (EVPI) and Value of Stochastic Solution (VSS). Further sensitivity analysis is done to investigate how the ratio between Type I and II vessels in a fleet influence to optimal solutions and what are implied meanings of the composition of vessels.

4.1 Test case description and settings

The LNG VRP has been solved by GAMS/CPLEX (Brooke, 2010). We set relative termination tolerance as 3 % (optcr = 0.03) and time limits as 10 hours (reslim = 36000) in GAMS/CPLEX model. All following experimental outcomes were optimized on a 3.00 GHz Intel Xeon machine with 400 GB of memory, running CPLEX version 12.6.

We tested the incidence of Qatar, the biggest LNG exporter with 5 contracted importers over the world planning a biannual shipping schedule. For the delivery, supplier owns total 18 LNG vessels including 12 Type I vessels and 6 Type II vessels (See Appendices A). The average sailing speed is 19.5 nautical miles per hour (kn). All sea routes are determined and the distances between terminals are given as constants (See Appendices B). Each demand is classified as long-term, short-term or spot with expected target delivery dates with ±4 days as time window (See Appendices C). Overall planning horizon is from D+0 to D+192 days. Daily BOG in a tank ranges 0.1 % ~ 0.15 % follows a normal distribution, $N(0.00125, 0.000104567^2)$. Inventory level is in between 5,000 bcm and 10,000 bcm at the depot (See Appendices D). To solve the stochastic model, we repeated 10 times of Monte Carlo optimization.

4.2 Numerical results

Figure 1 shows the optimized 6 month routing plan from D+1 to D+192 observing target delivery dates with times windows per each time period. In the schedule, 11 routes are generated and 9 LNG carriers are assigned to the routes. Among the assigned vessels, there are 4 Type II vessels serving two demand cargoes in a route, and another 7 Type I vessels deliver cargoes to single customer in a tour.

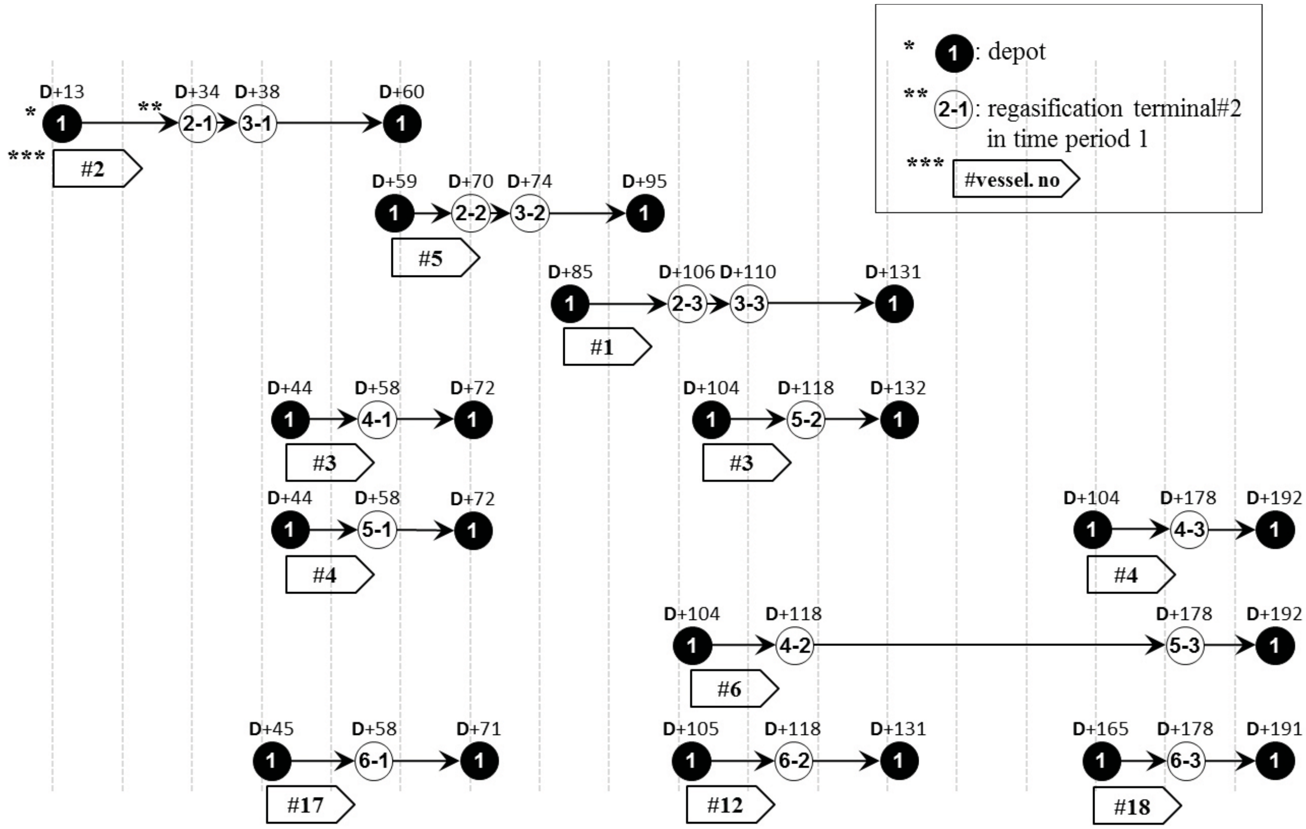

Figure 1.
LNG ship routing plan from D+1 to D+192.

The measures to evaluate stochastic solutions are EVPI and VSS. EVPI is the difference between Wait and See (WS) and stochastic solution (RP) which expresses the value of information. WS is defined as a probability-weighted average of deterministic solution assuming any specific scenario realization. In this experiment, we can calculate EVPI = WS - RP = 1,096,784,497-1,096,737,898 = 46,599. On the other hand, VSS is RP minus EEV in this maximization problem which is the expected result of using mean value problem. In this test problem, EEV=1,096,737,898 and so we can know the value VSS = RP - EEV = 12,557 verifying the general relations between the defined measures; EEV ≤ RP ≤ WS in Figure 2: (Birge and Louveaux, 2011).

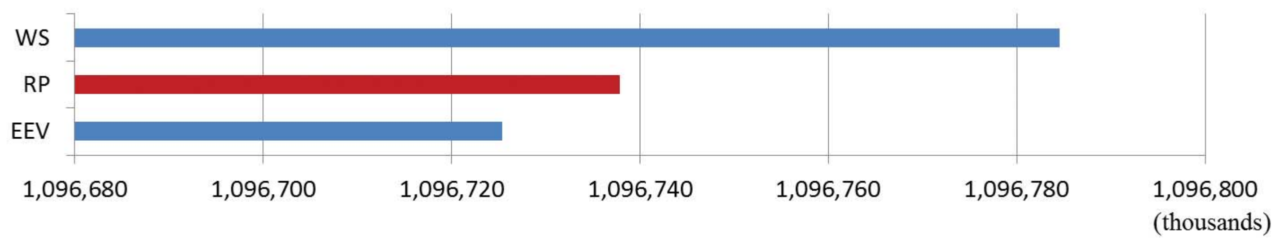

Figure 2.
Optimal solutions of WS, RP and EEV.

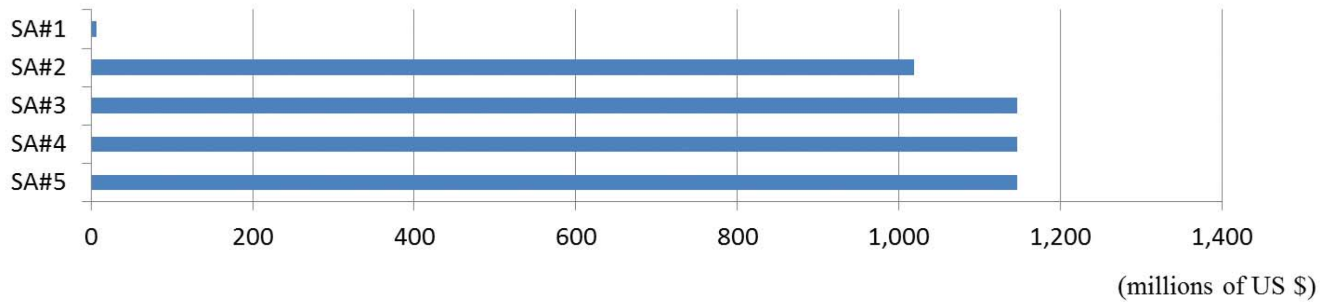

Figure 3.
Sensitivity analysis: SA#1-5.

We conducted sensitivity analysis (SA) by varying the number of vessels between Type I and II vessels in a fleet:

(1) SA #1-#5: SA#1is the instance that all vessels are in Type I. SA#5 is the case that all vessels are in Type II. In SA#2, 3&4, it examined the sensitivity of adding numbers of Type II vessels. As a result in Figure 3, we observed that there are significant gap between SA#1 and SA#2. This means that removing restrictions on cargo partial filling allows serving multiple customers if transportation is cost beneficial. In SA#3 and 5, there is no change because additional vessels are not necessary to maximize the profit. So, in term of long-term vessel procurement, decisions to acquire additional vessels may be critical to avoid unnecessary costs.

(2) SA #6-#10: It analyzes the impact of increasing number of vessels per each vessel type from 140,000 bcm to 216,000 bcm. Figure 4 shows that increasing profit is roughly proportional to the number of Type II vessels. Hence, it is recommended to replace the current Type I vessels to Type II.

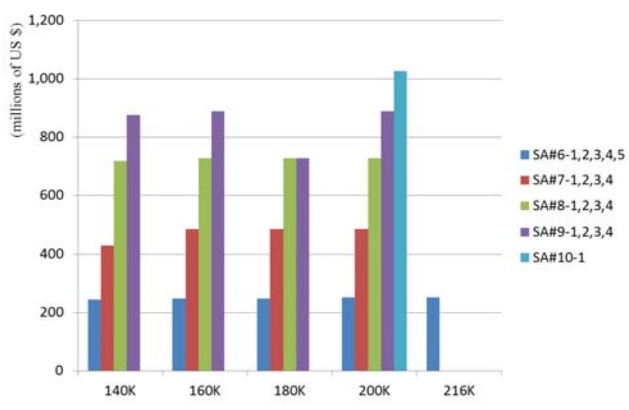

Figure 4.
Sensitivity analysis #6-#10.

5. CONCLUSIONS

In this paper, we proposed a deterministic LNG VRP model and formulated the problem using the notion of multiple vehicle routing problem. Based on this model, further extension of two-stage stochastic model was also presented applying Monte Carlo optimization techniques.

Traditional LNG ship routing and scheduling problem only aims to satisfy long-term contract. However, as short-term and spot demand are rapidly increasing in LNG market, and also as LNG vessel technology can relax strict restrictions on filling limits of cargo tanks, we exactly reflected these changing environmental factors into our model. The LNG VRP model can generate six months of shipping and inventory and production schedule to serve multiple customers in a route assigning an appropriate LNG vessel.

In the computational study, we showed the effectiveness of our model optimizing ship routes and schedules within the planning time horizon. As we compare the deterministic LNG VRP and its stochastic version by the measures of EVPI and VSS, we clarified the stability of stochastic solutions comparing to deterministic one. As verified in the sensitivity analysis, replacing Type I to Type II vessels in a fleet may increase more expected profit. However, it must be considered to identify how many Type II vessels are required to maximize overall profit.

As stated in the model, BOR is affected by various uncertain interactive factors, and so it needs further research to develop a mathematical model to measure accurate BOR. Even though we consider many elements as deterministic components, there are still many inherent uncertainties causing severe disruptions in LNG supply chain such as hurricane, dust storm, Tsunami, political unrest and piracy may significantly disturb planned shipping or degrade overall capability of LNG supply chain and so, we expect that this will be additional research interests in the future.

APPENDICES

Table 1.
Specification of LNG tankers.

No.	Tank capacity (unit: bcm)	Daily shipping cost (unit: US dollars)	Vessel type
#01	140,000	200,000	II
#02	140,000	195,000	II
#03	140,000	190,000	II
#04	140,000	185,000	II
#05	160,000	195,000	II
#06	160,000	190,000	II
#07	160,000	185,000	I
#08	160,000	180,000	I
#09	180,000	195,000	I
#10	180,000	190,000	I
#11	180,000	185,000	I
#12	180,000	180,000	I
#13	200,000	195,000	I
#14	200,000	190,000	I
#15	200,000	185,000	I
#16	200,000	180,000	I
#17	200,000	175,000	I
#18	216,000	180,000	I

Table 2.
Distance between terminals.

(unit: kn)

	Ter.#1	Ter.#2	Ter.#3	Ter.#4	Ter.#5
Depot	9,882	9,770	6,576	6,350	6,233
Ter.#1		533	9,191	5,073	9,940
Ter.#2			9,208	4,891	9,957
Ter.#3				11,513	954
Ter.#4					11,141

Table 3.
Customers demand in each time periods.

Time periods	No.	Demand (bcm)	Target date (from D+0 days)	Contract type
#1	#02	60,000	D+36	spot demand
	#03	62,500	D+36	short-term
	#04	65,000	D+60	long-term
	#05	175,000	D+60	long-term
	#06	60,000	D+60	long-term
#2	#08	60,000	D+72	spot demand
	#09	62,500	D+72	short-term
	#10	65,000	D+72	long-term
	#11	175,000	D+120	long-term
	#12	60,000	D+120	long-term
#3	#14	60,000	D+108	spot demand
	#15	62,500	D+108	short-term
	#16	65,000	D+180	long-term
	#17	175,000	D+180	long-term
	#18	60,000	D+180	long-term

Table 4.
Other parameters.

Item	Data	Unit
Unit Price	105	US dollars / bcm
Storage operating cost	105	US dollars / bcm
Production cost	105	US dollars / bcm
Maximum storage level	10,000	bcm
Minimum storage level	5000	bcm
BOG level	[0.001, 0.0015]	percent
Filling limit of vessels type #07- #18	0.9	percent
Vessel speed	19.5	kn
Time window (from a target date)	±4	days

Table 5.
Sensitivity analysis instances.

SA	Objective value	No. of Type II vessels				
		140K [0,4]	160K [0,4]	180K [0,4]	200K [0,5]	216K [0,1]
#1	7,137,500	0	0	0	0	0
#2	1,018,532,546	1	1	1	1	1
#3	1,146,492,567	2	2	2	2	1
#4	1,146,492,567	3	3	3	4	1
#5	1,146,492,567	4	4	4	5	1
#6-1	244,638,911	1	0	0	0	0
#6-2	248,293,911	0	1	0	0	0
#6-3	248,293,911	0	0	1	0	0
#6-4	252,543,911	0	0	0	1	0
#6-5	252,458,911	0	0	0	0	1
#7-1	430,355,322	2	0	0	0	0
#7-2	487,665,322	0	2	0	0	0
#7-3	487,495,322	0	0	2	0	0
#7-4	487,495,322	0	0	0	2	0
#8-1	718,026,733	3	0	0	0	0
#8-2	726,951,733	0	3	0	0	0
#8-3	726,781,733	0	0	3	0	0
#8-4	726,781,733	0	0	0	3	0
#9-1	875,478,702	4	0	0	0	0
#9-2	888,143,702	0	4	0	0	0
#9-3	726,781,733	0	0	4	0	0
#9-4	887,973702	0	0	0	4	0
#10-1	1,026,012546	0	0	0	5	0

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Fault Tree Analysis in the Reliability of Heavy Fuel Oil Supply

Ivana Golub Medvešek, Joško Šoda, Tina Perić

Marine systems are complex and through the analysis of their reliability it is necessary to observe the reliability of their subsystems and components. With regard to the fact that the reliability is functionally dependent on faults, for the purpose of this study special attention has been given to possible faults on the heavy fuel oil supply pump of a two-stroke marine diesel engine MAN B&W 5L90MC. A deductive approach to reliability analysis, i.e. fault tree analysis method (FTA), has been used. By the use of this method it is simpler to identify the system's weak link and it is shown that the method gives the basis for the ship's system reliability analysis. Based on FTA analysis this paper suggests system parameters that require continuous monitoring in order to achieve reliability. The results show the behavior of the components in case of faults and this approach can help to create a plan of action in order to enforce timely corrective and preventive action and, accordingly, increase the rate of reliability of the entire ship's systems.

KEY WORDS

~ Reliability
~ Marine systems
~ Supply pump
~ Fault tree analysis

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1. INTRODUCTION

Marine ship systems are very complex. They consist of a large number of subsystems and components whose functionality and quality interaction are of essential importance for high efficiency, long operational lifetime and safety. Therefore, the basic requirement that marine systems have to fulfil is reliability. The concept of reliability of marine systems means the probability that the system will successfully perform its function in terms of the environmental conditions and in specific period of time.

Reliability is functionally dependent on the failures that can occur in any component of marine systems. The aim of this study is to show the dynamics of reliability depending on the fault and the methods and procedures which actively participate in the identification of weak points of marine systems.

In this paper, a deductive approach to analyzing the failure, fault tree analysis method, is used. Special attention is devoted to the most common failures that can happen to a heavy-fuel-oil supply pump, which has significant consequences for the entire heavy fuel oil marine engine system.

The paper is organized as follows: the first paragraph is the introduction. The second paragraph describes reliability based on faults and gives mathematical backgrounds of the proposed paper. The third paragraph is the study of the fault tree analysis in the reliability of marine heavy-fuel-oil supply pump based on the MAN B&W 5L90MC marine engine. The fourth paragraph is the conclusion, where basic conclusions are given.

2. RELIABILITY BASED ON FAULTS

In the following paragraph basic definitions and mathematical backgrounds on reliability based on faults will be given. Operating reliability is a basic requirement that is put in front of marine systems and it is commonly violated by appearance of faults. Figure 1 shows the graph of fault rate as a measure of reliability. It is well known that reliability is the probability that the system will adequately fulfil its purpose. In the context of reliability, the concept of satisfactory performance is directly linked with the concept of fault or delay (Lovrić, 1989).

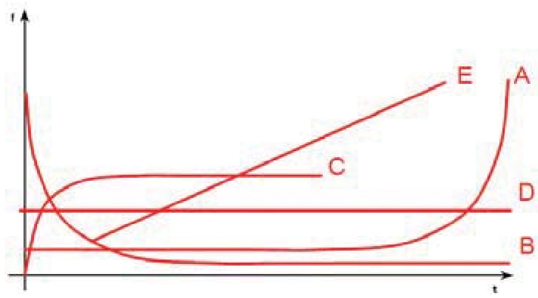

Figure 1.
Faults rate graph as a measure of reliability.

where (Barle, 2001):

t – time of use;

f – frequencies of faults;

A – a uniformed frequency of fault rate with a slight increase ending in the rapid increase i.e. wear period - typical for engines;

B – initial or early faults, after which the frequency decreases rapidly - typical for on-board electronics;

C – low faults frequency followed by its relatively rapid increase in steady state level which is often the behaviour of the system after processing cycles;

D – relatively constant value of probability of faults, unprofessional uses or unanticipated effects of the environment;

E – continuous increase in the faults frequency with no apparent wear period that is typical for turbines.

According to (Mrčelić, 2010) faults can be classified as:

1) non-inherent faults, i.e. faults characteristic for normal operation;

2) inherent faults, i.e. faults characteristic for the system

a) early,

b) chance,

c) wear-out faults.

The initial use of a system usually implies a higher number of faults that are attributed to errors in production and are called early faults. It is necessary to point out that with early faults fault frequency rapidly decreases over time. On the contrary, there are also chance faults that are of unknown cause, cannot be prevented, but the delays they cause can be prevented. Faults as results of wear and aging appear due to the process of wear and their characteristic is that their intensity grows with time. The combined reliability includes chance faults and faults due to wear.

2.1. Reliability based on chance faults

The ratio of the components in faulty and correct components represents the index of chance faults (Lovrić, 1989) that can be described as:

$$\lambda = \frac{1}{P_s} \cdot \frac{dp_f}{dt} \qquad (1)$$

where: λ - an index of faults, P_s -the number of components that remain correct at the end of this period, P_f - the number of components that have failed, t - time.

Equation of reliability for devices with the index of chance faults can be expressed by (2) and is valid only for the period of the initial fault for the period of wear (Mrčelić, 2010):

$$R(t) = e^{-\lambda \cdot t} \qquad (2)$$

Mean Time Between Failures (MTBF) is marked by the index m, and can be calculated according to (3):

$$m = \int_0^\infty R(t) \cdot dt = \int_0^\infty e^{-\lambda \cdot t} \cdot dt = \frac{1}{\lambda} \qquad (3)$$

The reliability of chance faults can be derived by using expression (3):

$$R(t) = e^{-t/m} \qquad (4)$$

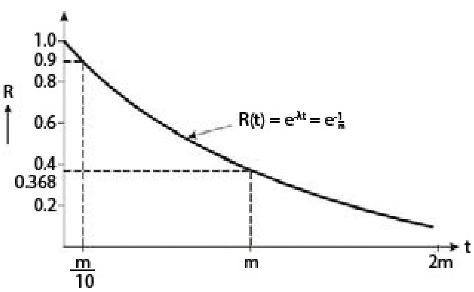

Figure 2.
Standardized curve of reliability.

Figure 2 shows the standardized curve of reliability that provides basic information about the degree of the remaining reliability as function of mean time, or a part of mean time between faults.

The characteristic parameter m is the point on ordinate axis where tangent from the maximum slope point crosses the ordinate.

2.2. Reliability based on wear-out faults

Without timely replacements of the worn parts, system reliability based on wear follows a normal (Gaussian) distribution according to expression (5):

$$R_W(T) = \frac{1}{\sigma \cdot \sqrt{2\pi}} \cdot \int_T^{\infty} e^{\frac{(T-M)^2}{2 \cdot \sigma^2}} \cdot dt \qquad (5)$$

where: $R_W(T)$ - reliability based on wear, σ - standard deviation, T - total accumulated time of system operation, M - average life time.

Also, the index of faults caused by wear is expressed in the number of faults per hour and shown in equation (6):

$$\lambda_m = \frac{r}{\sigma} \qquad (6)$$

where: r - index of wear-out faults.

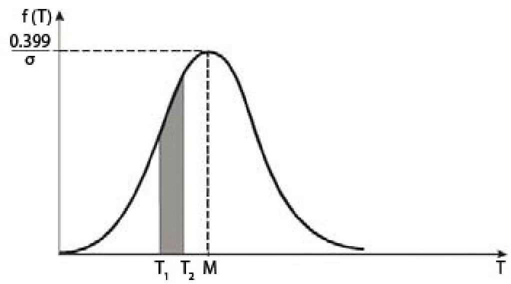

Figure 3.
Normal distribution because of wear-out faults.

Figure 3 shows a normal distribution of wear-out faults. The highest density of a system's faults occurs in an average lifetime M. The area under the density of faults curve in a determined interval, say T_2-T_1, gives the cumulative probability of the faults.

3. FTA FOR HEAVY FUEL OIL MARINE ENGINE SYSTEM

Complex marine ship systems are subject to extensive range of faults. In order to determine the reliability of the system, several methods for practical overview of a system's operation in various events were developed. This has been done in order to achieve understanding of the formation of faults, how their probabilities can be assessed and how to reduce the likelihood of their occurrence analysing the safety and reliability of the system by identifying the weak points of the system.

To analyze and determine the reliability of the system, both qualitative and quantitative methods can/could be used and they refer to the methods of finding the probability of system survival for a period of time and for the prescribed working conditions (Blagojević, 2005).

There are two types of applicable procedures: inductive and deductive. The former is the result of subjective qualitative analysis. In deductive procedures, system analysis begins with potential faults and descends through the system in order to identify a potential component failure mode and human errors that can cause faults. Methods for these procedures are FTA (Fault Tree Analysis) and ETA (Event Tree Analysis) (Rao, 1992).

3.1. Experiment case and results

It has to be emphasized that the analysis of engine faults that have occurred in two years, using RCM (Reliability Centred Maintenance) can be found and are dominant in the heavy-fuel-oil system (Bukša et al., 2008; Mokashi et al., 2002). Due to the reason mentioned, for this study a system of heavy-fuel-oil two stroke marine diesel engine MAN B&W 5L90MC, has been chosen. A simulation has been conducted on the Full Mission Engine Room simulator Kongsberg Norcontrol. The main engine is low-speed 5-cylinder configuration, two-stroke, turbocharged, reversible diesel engine. The main engine specifications: cylinder bore 900 mm; piston stroke 2,900 mm; number of cylinders 5; number of air coolers 2; number of turbo chargers 2; corresponding engine speed 74 rpm; mean indicated pressure 13.0 bar; scavenge air pressure 2.1 bar; turbine speed 8,000 rpm; specific fuel oil consumption 168 g/kWh.

Figure 4 shows fuel oil system of the mentioned marine diesel engine.

Heavy fuel oil preparation system consists of three phases:

1. phase: transfer of heavy fuel oil from storage tanks,
2. phase: purification of heavy fuel oil,
3. phase: supply of heavy fuel oil to the engine.

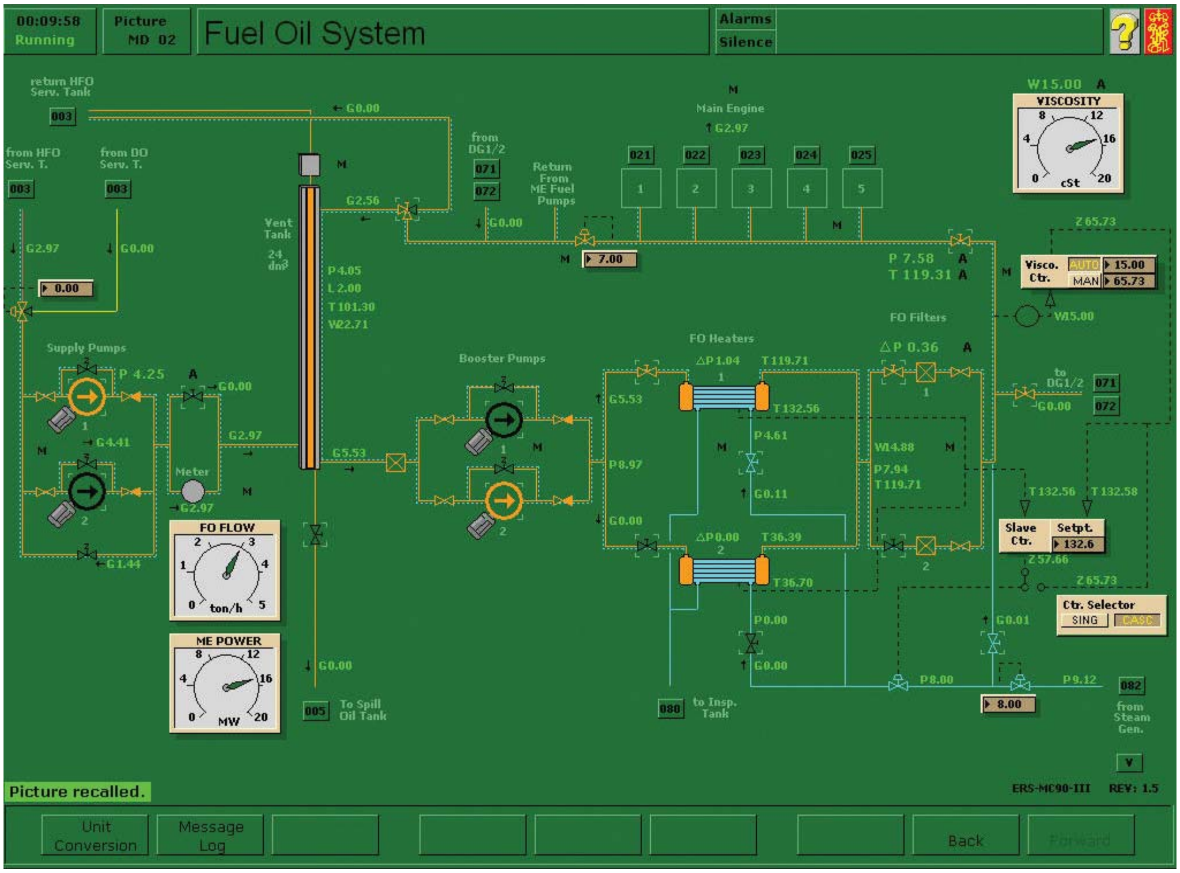

Figure 4.
Fuel oil system.

For the proposed study, the third phase in which low-pressure supply pumps take heavy fuel oil from the tanks and pressure it into a closed circulation loop, are of particular interest. Circulation (booster) pumps supply fuel oil from the injection pump to the engine through the heater, viscometer and filter. Excess fuel oil is returned from the engine and it is warmed to about 145° C, then it is sent to the venting box and returned to the circulation loop, according to (Figure 4).

In this study special attention is paid to common faults that can happen to the heavy fuel oil supply pumps and have significant consequences for the engine fuel oil system.

In this paper, FTA deductive method structured in terms of events, in which the primary fault is determined, has been used. The FTA graphically illustrates the relationships between faults and symptoms. This method provides a more complete understanding of each functional relationship of the analyzed system and easier identification of the component causing the fault (Golub et al., 2011). It is especially used for identifying and analyzing the occurrence of critical damage, simplifying finding of individual component fault and thus giving the basic system reliability analysis. FTA, as opposed to the methods of inductive approach, using a graphical model allows displaying in a clear way of concatenation of different symptoms that can result in failure of these systems.

The interactive connection of events and symptoms that could lead to the given fault has been inferred by Boole's logic expression. A relevant top event is "Supply pump fault" and a possible fault tree for this event is presented in (Figure 4). The lowest level in the fault tree is the failure mode of a technical item. Some of these items are complex and it might be of interest to break them down into sub-items and attribute failures to latter. For example, the failure of the sound of cavitations (E6) may be split in two parts, individual failure (E7) or common cause failures (E8).

Such analysis indicates that for the successful functioning of the system essential correctness of all elements of the system matters. Also, it facilitates finding faults in the event of individual component failure, thus speeding up the fault localization and influences on the increase in system's reliability.

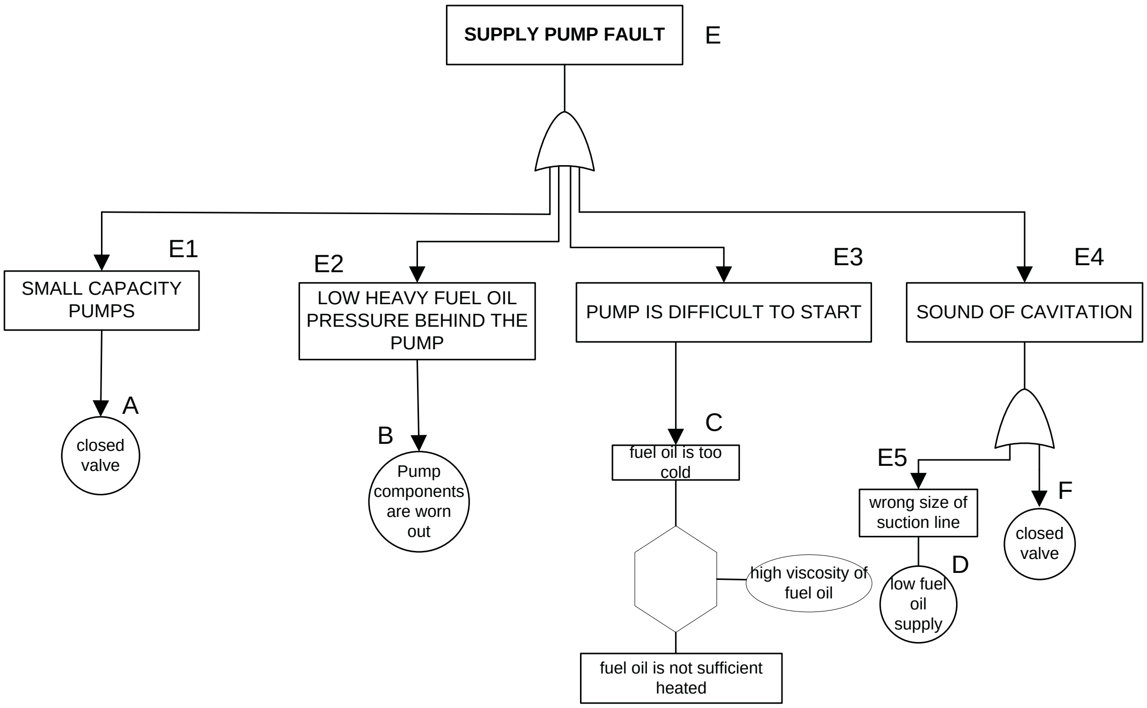

Figure 5.
Fault tree of heavy fuel oil supply pump.

$$
\begin{aligned}
&P(E) = P(E1) + P(E3) + P(E4) + P(E6)\\
&P(E1) = P(A) + P(E2) - P(A) \cdot P(E2)\\
&P(E2) = P(B) + P(C) - P(B) \cdot P(C)\\
&P(E3) = P(D) + P(E) - P(D) \cdot P(E)\\
&P(E4) = P(E5) + P(G) - P(E5) \cdot P(G)\\
&P(E5) = P(F)\\
&P(E6) = P(E7) + P(E8) + P(K) - P(E7) \cdot P(E8) \cdot P(K)\\
&P(E7) = P(H)\\
&P(E8) = P(I) + P(J) - P(I) \cdot P(J)
\end{aligned}
\tag{7}
$$

The set theory is a general approach which allows us to organize the outcome events of an experiment to determine the appropriate probabilities (NASA, 2002). Using the set theory, fault tree concepts of heavy fuel oil separator can be expressed as (7):

With presented FTA analysis of heavy fuel oil supply pump, it is possible to conclude which precautions should be taken for correct operation of the supply pump or, to put it simply, which of the system parameters must be continuously monitored in order to achieve, through their optimization, a more reliable operation of the heavy fuel oil system.

Particular attention should be paid to the maintenance of fuel temperature since it affects the viscosity and density of the fuel and its fluctuations are undesirable. It is also desirable to monitor the pressure after the pump since resistance in the pressure pipe can occur, which has a significant impact on the correct operation of the pump.

4. CONCLUSION

Marine systems are complex technical systems. In order to achieve their reliability it is necessary to achieve reliability, functionality and quality interaction between their subsystems and components.

This paper studies the functional dependence of ship's systems on the appearance of faults. On board, except for the chance faults, the most common are wear-out faults. Considering that failures can occur of any system component and seriously undermine the reliability of the system as a whole, the goal of this study was to present one of the detailed methods of analyzing failures.

Due to very frequent failures in the engine fuel oil system, for research in this paper the system of heavy-fuel-oil two-stroke marine diesel engine MAN B & W 5L90MC was chosen, and of particular interest were the possible failures on the heavy-fuel-oil supply pump.

This paper uses a deductive approach, or fault tree analysis method. This method is especially used in identifying and analyzing the occurrence of critical (disastrous) ways of damage, helps finding faults in case of individual component failure and thus provides the analysis of system reliability.

The system parameters that need to be continuously monitored in order not to jeopardize the reliability of the system were suggested to the featured FTA analysis.

Applying the proposed method showed suitable for a more complete understanding of each functional relationship between components in heavy-fuel-oil supply pump case. FTA maximally shortens the time required to find faults and failures which adds up to marine safety and protects the environment from pollution. Upon the occurrence of a fault it is simple, by observing the FTA diagram, to detect, localize and remove it in the shortest period of time. So, it can be concluded that FTA significantly contributes to reliability increase in the heavy-fuel-oil system and thus reflects on the reliability of other ship's systems.

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Dual-Fuel-Electric Propulsion Machinery Concept on LNG Carriers

Joško Dvornik, Srđan Dvornik

Human efforts to devise optimum propulsion for their vessels are as old as the vessels themselves. Today these efforts are even more determined as modern shipping requires propulsion systems that are increasingly reliable, available, cost-efficient and able to meet high ecological criteria. The heat transfer towards liquefied gas stored in tanks results in boil-off during cargo handling or voyage. The rate of the evaporated gas amounts to 0.13% per day during the voyage of a fully loaded ship.

Steam turbines have been a dominant form of propulsion on liquefied natural gas - LNG carriers for over forty years. Until recently, the possibility of using boil-off gas as fuel for boilers has been the reason for installing steam plants as the only means of propulsion of LNG carriers. However, it has been proved that these plants are not sufficiently efficient due to adverse impacts on both emissions and the vessel's operating expenses. It has also been found out that dual-fuel-electric propulsion is the most effective alternative to steam. Shipping companies select electric propulsion primarily because it provides excellent manoeuvrability and increased availability, allows reduction of the machinery space and better arrangement of shipping capacity and, naturally, because of lower fuel costs. This paper discusses the newest technologies and the operation principle of the low-pressure four-stroke dual-fuel diesel engine, specifically the 12V50DF and 9L50DF types produced by Wärtsilä company, and the concept of the dual-fuel-electric propulsion for the new generation of LNG carriers.

KEY WORDS

~ LNG carriers
~ Boil-off gas
~ Dual-fuel engine
~ Electric propulsion

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1. INTRODUCTION

Dual fuel diesel engines are the engines that can burn natural gas in addition to marine diesel oil or heavy fuel oil. In order to be efficient, such engines have to ensure stable combustion of gas fuel under any circumstances. Unlike liquid fuel which is self-ignited under compression in the cylinder, methane - the main component of the natural gas-cannot be self-ignited. Therefore its ignition is triggered by liquid fuel. The observed machinery comprises four main diesel engines-generators. Two Wärtsilä 12V50DF engines can develop 11.400 kW at maximum continuous rating (MCR) in diesel or gas mode, whereas two Wärtsilä 9L50DF engines have an output of 8.550 kW MCR in diesel or gas mode, according to (Machinery operating manual, 2009).

All engines are designed to run on boil-off gas from cargo tanks or marine grade diesel oil MDO from daily service tanks. Although the two fuel types have different density and calorific value, the engines can operate efficiently both on gas and MDO and develop the same output in both modes.

Boil-off gas (BOG) from cargo tanks is essentially a good fuel for combustion within the engine cylinders but due attention has to be paid to the gas contents, in particular the content of nitrogen in the natural gas as, unlike pure methane, nitrogen effectively reduces the gas energy contents.

The amount of nitrogen in BOG may amount up to 30 % in volume at the beginning of the loaded ship voyage. The engines and their fuel control systems are designed to adjust to all conditions and to enable each engine to be running on gas at their normal rating without evaporisation, according to (Machinery operating manual, 2009).

The engines are also fully capable of switching over from one fuel to another during operation and when running under load, without interrupting the electric power supply. Also, these engines are identical with regard to their components such as pistons, valves, injectors, etc. It is possible to choose nine or twelve cylinder engines, which allows for flexibility when installing the engines, in line with the supply demand.

The Wärtsilä engine control system 8000 (WECS 8000) monitors and controls the safety of operation, engine speed, fuel control and other relevant automated functions. Gas combustion gives rise to many issues regarding safety and protection and these issues are carefully addressed when designing and operating the engine. Separate systems are required for liquid and gas fuels, and due to low ignition level of natural gas, it is necessary to inject a small amount of pilot fuel to produce flame for igniting natural gas in the cylinder, according to (Machinery operating manual, 2009).

In gas mode, gas is admitted into the cylinder together with the combustion air during the intake stroke. It is mixed with the air inside the inlet channel in the cylinder head. The mixture of gas and air is then compressed and ignited by a small quantity of diesel pilot fuel at the end of the compression stroke, see Figure 1, according to (Norrgärd, 2006; Guidelines for Dual Fuel Diesel Engines, 2008; Kosomaa, 2002). The pilot fuel injection timing is closely regulated to provide flame for gas ignition at the correct moment. Gas ignites and burns, pushing the piston downwards as in a conventional diesel engine where power is developed by liquid fuel combustion.

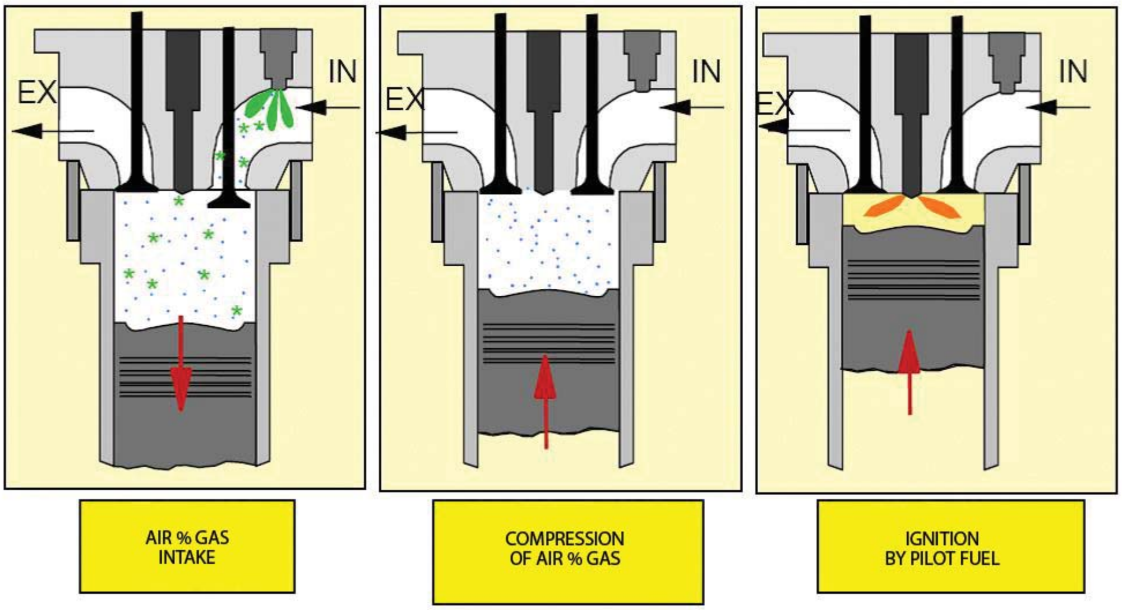

Figure 1.
Gas mode.

2. OPERATION PRINCIPLE

Wärtsilä 12V50DF and 9L50DF engines drive generators to supply electricity for all ship systems including the main propulsion plant. The latter employs two electric motors driving a fixed-pitch propeller via a reduction gearbox. Figure 2, according to (Machinery operating manual, 2009), shows a simplified diagram of the electric propulsion system for the new generation of LNG carriers.

The engines can operate in diesel mode or in gas mode: they can not run in both modes, using BOG and MDO at the same time, except for a short moment when using pilot fuel while running on gas. Starting up of the engine is always performed by using diesel fuel, see Figure 3, according to (Norrgärd, 2006; Guidelines for Dual Fuel Diesel Engines, 2008; Kosomaa, 2002).

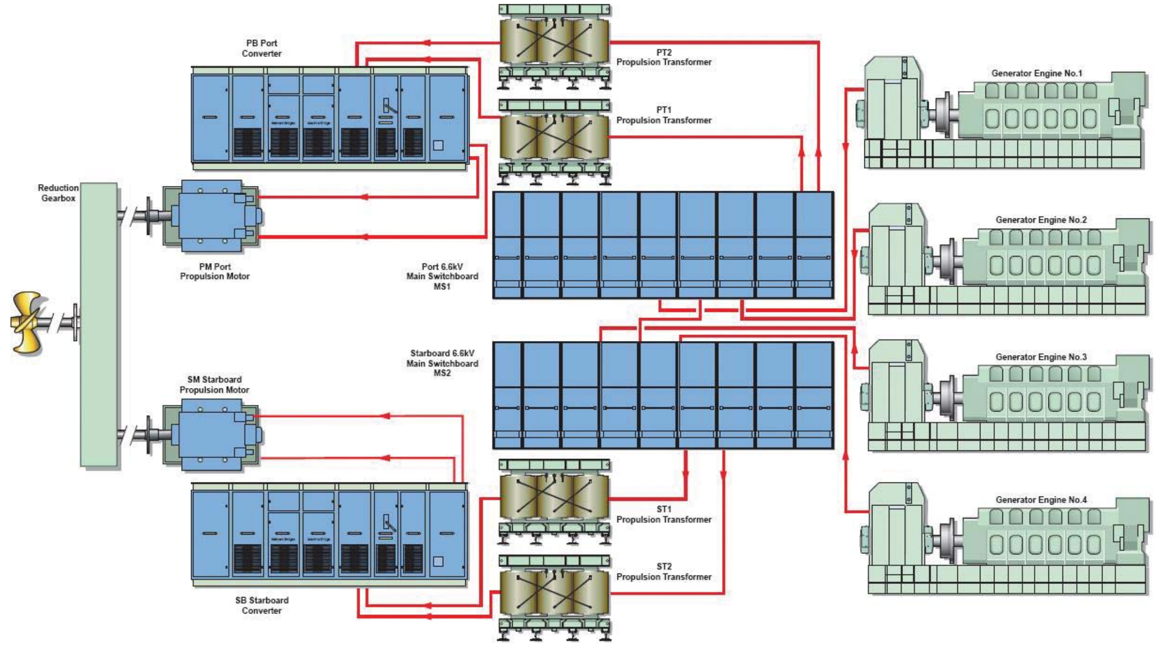

Figure 2.
Simplified diagram of the electric propulsion system on LNG carriers.

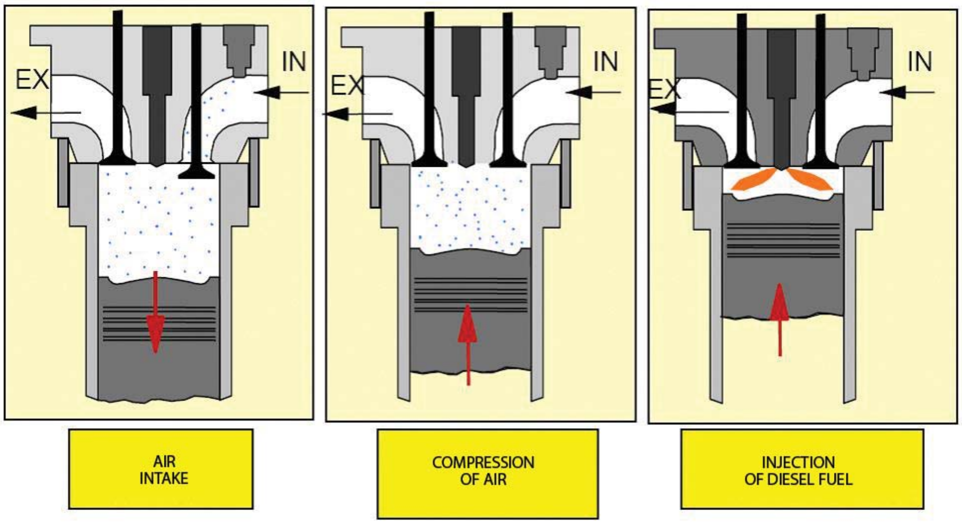

Figure 3.
Diesel mode.

2.1. Diesel fuel supply mode

In diesel mode, dual-fuel engines act like normal diesel engines using conventional high-pressure fuel injection pumps and injectors in each cylinder head. The high-pressure fuel pump is operated by the camshaft and the fuel injector operates normally by pressure action on the needle valve, see Figure 4, according to (Machinery operating manual, 2009; Olander, 2006).

The cylinder head of the Wärtsilä 50DF engine houses a centrally placed dual-needle fuel injector. The larger needle is used for injecting diesel, whereas the smaller one is used for injecting pilot fuel when the engine is in the gas mode. Pilot fuel injection is controlled electronically, while diesel injection in diesel mode is controlled in a hydraulic-mechanical way by means of the high-pressure fuel pump, see Figure 5, according to (Machinery operating manual, 2009; Olander, 2006).

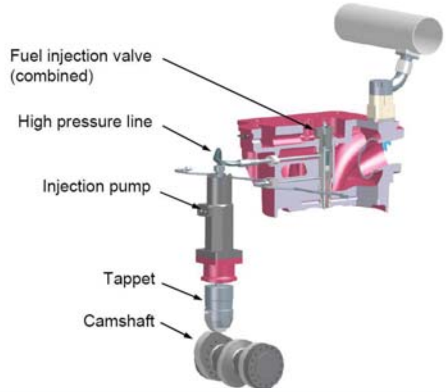

Figure 4.
Conventional fuel injection system.

Figure 5.
Diesel fuel injector and cylinder head.

The liquid fuel supply system consists of two parts: the system for supplying and injecting marine diesel oil (MDO) or heavy fuel oil (HFO) is separated from the pilot fuel system. Pilot fuel is compressed at the required pressure by the pump unit that includes pilot fuel filters, pressure regulator and engine driven radial reciprocating pump.

Pilot fuel is then conveyed through the common rail system to the injector in each cylinder head. It is injected at 900 [bar]. Metering and timing of the injection are electronically controlled, see Figure 6, according to (Machinery operating manual, 2009; Norrgärd, 2006).

The pilot fuel system remains switched on even when the engine runs on liquid fuel in order to prevent clogging of nozzles due to carbon deposits produced during the combustion process. Excess fuel is returned to the mixing tank and to the circulating pump inlet. The fuel return system is fitted with the cooler for reducing the temperature of the diesel that is warmed up by passing through the fuel system, see Figure 7, according to (Machinery operating manual, 2009).

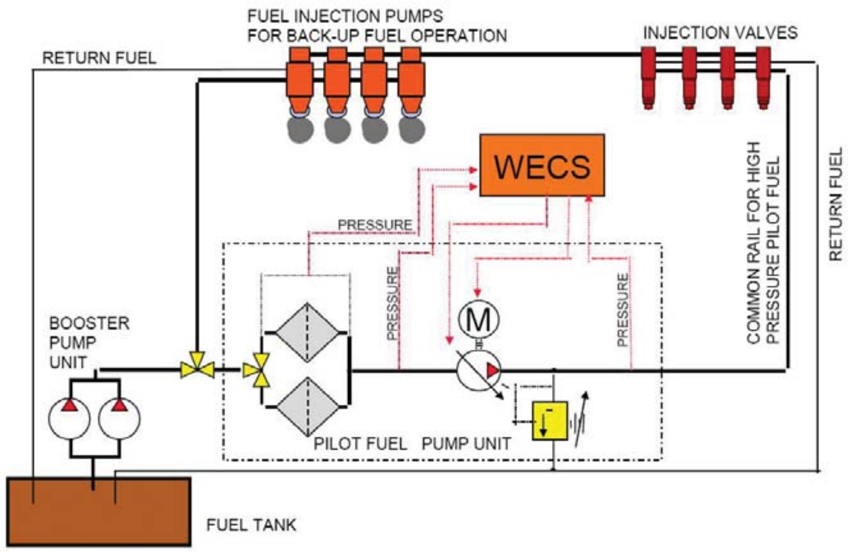

Figure 6.
Main fuel and pilot fuel supply control.

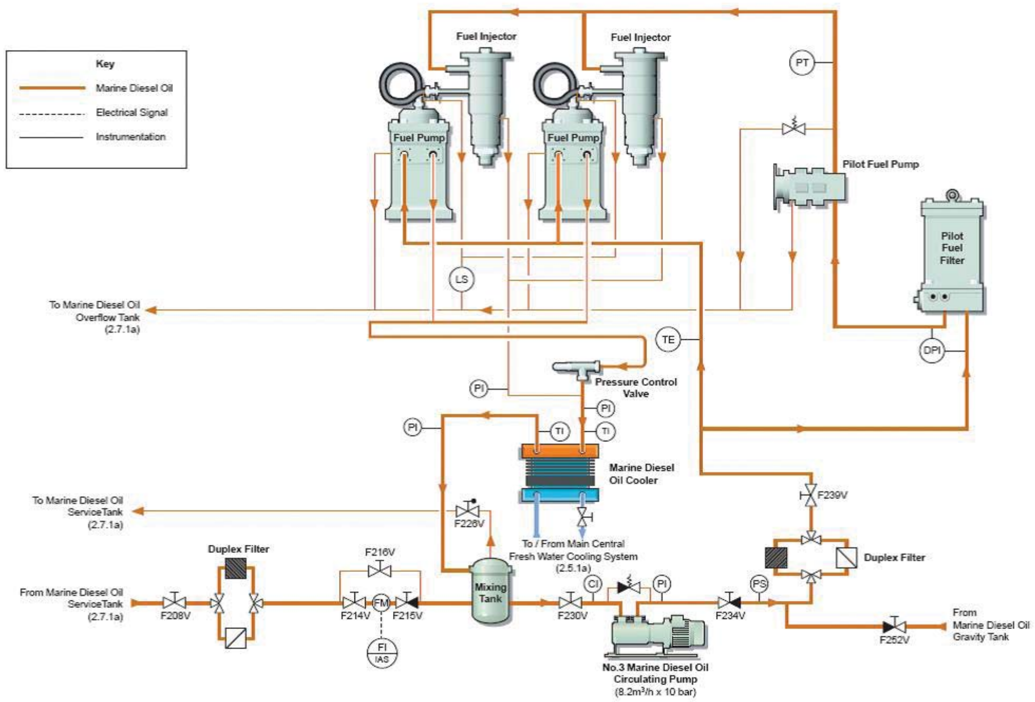

Figure 7.
Diesel oil and pilot fuel supply system.

Individually controlled solenoid valves of pilot fuel ensure optimum timing and duration of fuel injection while the engine is in gas mode. As the amount of NOx emission largely depends on the quantity of pilot fuel, this design ensures a very low NOx emission while using the stable and reliable system of igniting a lean, premixed air-gas mixture in the engine combustion chambers.

2.2. Gas supply mode

The evaporated gas from the cargo tanks is conveyed under pressure through the boil-off heater and natural boil-off mist separator (NBO) to the engine by means of centrifugal two-stage LD (low duty) compressors installed in the maindeck cargo handling room, at nominal temperature of 30 °C, according to (Machinery operating manual, 2009).

When the boil-off gas leaves the deck area at regular pressure of 6.3 [bar], it can be burned either in the gas combustion unit or the main engines. If one wishes to put the boil-off gas system into service, the gas is burnt until stable conditions for gas operation are reached and then the gas can be transferred for the use in engines.

Prior to entering the engine, BOG passes through the gas valve unit (GVU) which consists of a filter, temperature sensor, pressure sensor, pressure regulating valve, two safety tripping valves, and three remotely-controlled ventilation regulating valves, see Figure 8, according to (Machinery operating manual, 2009; Norrgärd, 2006).

The outlet gas pressure is controlled by WECS 8000 (Wärtsilä engine control system 8000) in line with the engine load and ambient state. The BOG pressure at the engine inlet is 5.1 bar.

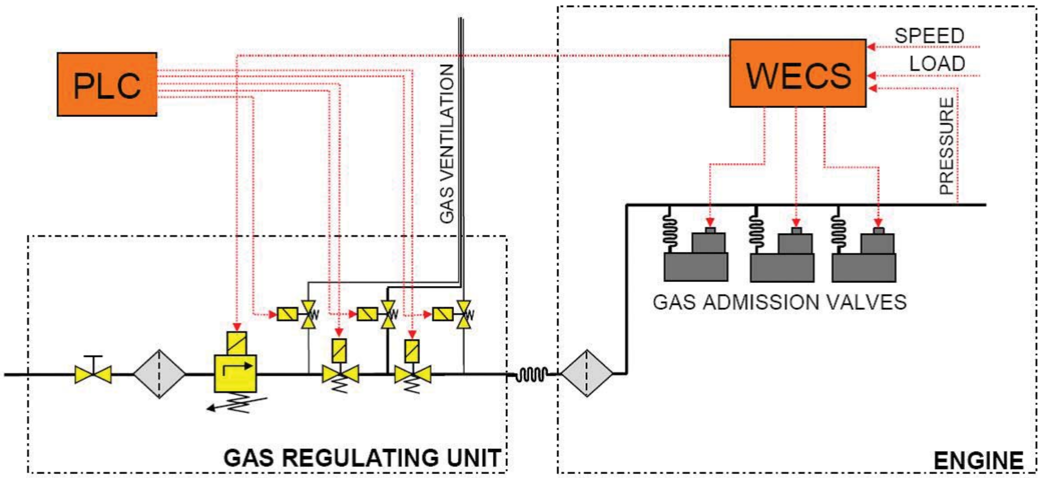

Figure 8.
Gas fuel supply control.

Safety and ventilation valves are solenoid electromagnetic valves and the control is carried out by the external integrated automation system (IAS), whereas the pressure regulating valve is directly operated by WECS 8000 controller. During the operations of starting and stopping the engine, the control of safety valves and ventilation valves communicates between WECS and IAS systems, including the checking of dribbling/leaking of valves prior to starting each engine, according to (Machinery operating manual, 2009).

Reference pressure of the gas supply is dependent on the engine load and is calculated by the WECS 8000 control module.

The electric signal of the reference pressure is forwarded to the pressure regulating valve. The real pressure in the engine is measured and compared with the reference pressure. If the deviation is excessive, an alarm will be sounded, and if the deviation continues to increase the safety valve will be immediately closed and the supply of gas to the engine will be interrupted. Upon passing through the GVU, gas enters the common rail manifold extending along the engine and is distributed through individual cylinder lines to the gas admission valve on each cylinder head, see Figure 9, according to (Olander, 2006). The valves are controlled by WECS 8000 system that regulates the amount of gas entering each cylinder, according to (Machinery operating manual, 2009).

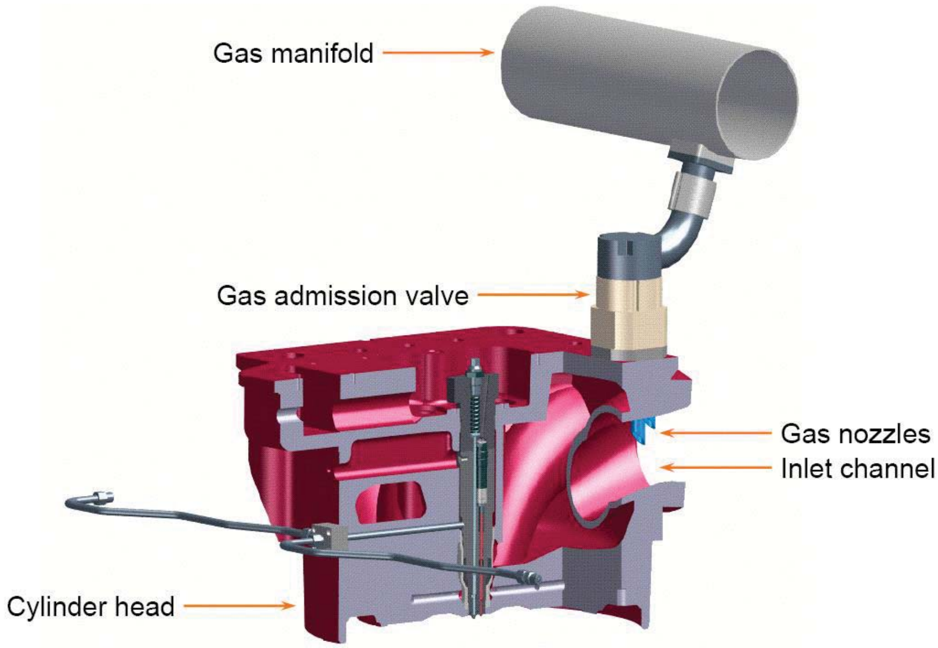

Figure 9.
Gas fuel supply system.

The gas supply line may feature a single wall – inside the valve unit (single wall piping) or a double wall – inside the engine room (double wall piping). The annular space in double wall piping (a pipe inside a pipe) is ventilated by air supplied either from the engine room or via special pipeline outside the engine room. The use of double wall piping fitted with adequate ventilation ensures maximum safety in the event of gas leakage, see Figure 10, according to (Olander, 2006).

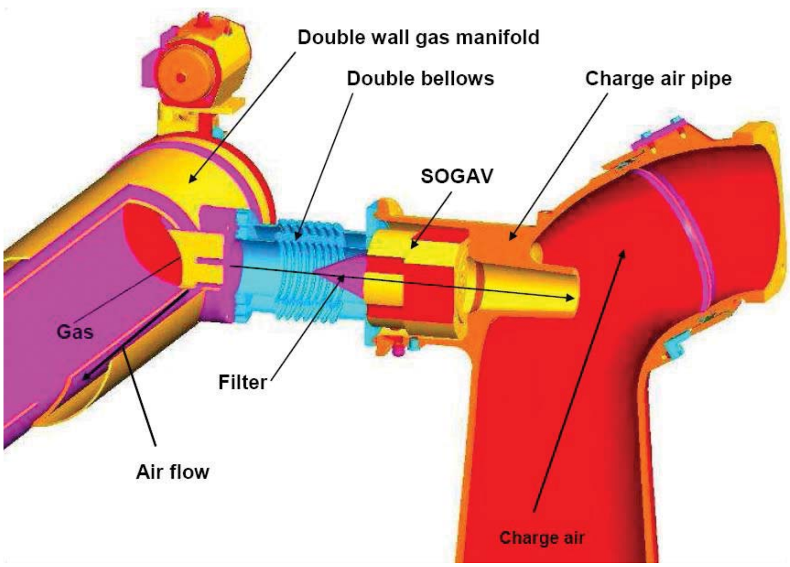

Figure 10.
Double wall piping in Wärtsilä 50DF.

2.3. Gas valve and the control of gas-air ratio

In Wärtsilä DF engines, boil-off gas is admitted to the cylinder through the electronically controlled gas admission valve which meters the gas into the charge air pipe immediately before the cylinder's inlet valve. The gas amount and pressure are regulated by a sophisticated electronic system for each cylinder separately. Opening of the gas admission valve is independent from opening of the inlet valve, so that during the scavenge process there is no risk of potential loss of gas fuel through the exhaust system, according to (Machinery operating manual, 2009).

The amount of the main and pilot fuel is controlled in the same way. Optimisation of the engine operation is performed on the basis of input data such as revolutions per minute (rpm), load, air/fuel ratio etc., which results in better thermal efficiency and reduced harmful emissions, in particular NOx, see Figure 11, according to (Norrgärd, 2006; Olander, 2006).

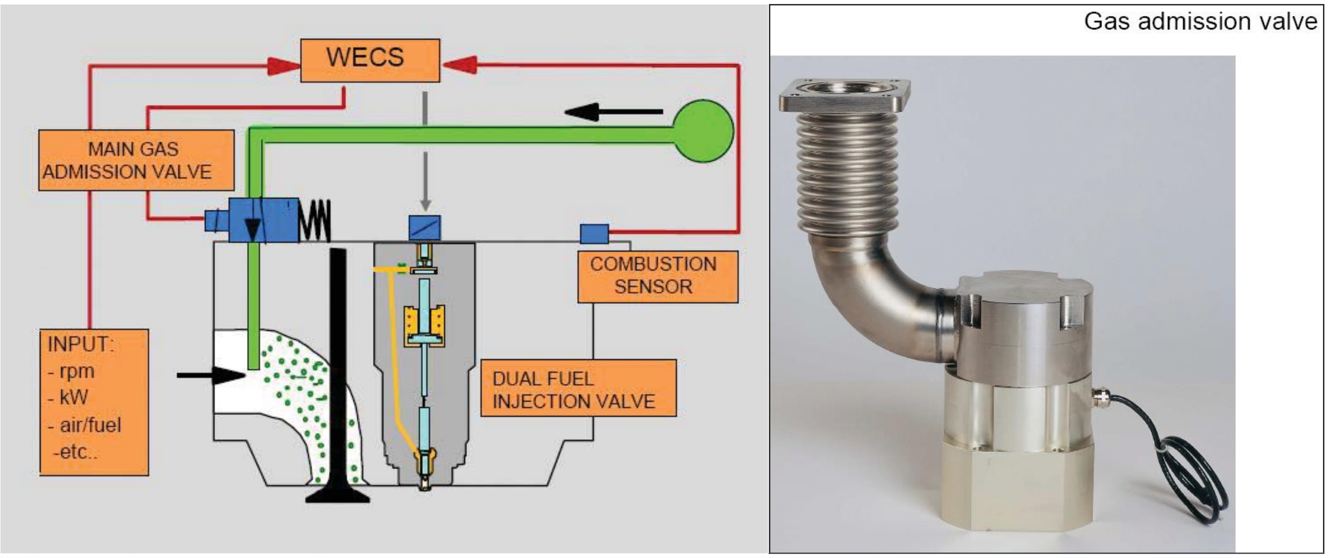

Figure 11.
Cylinder control principle.

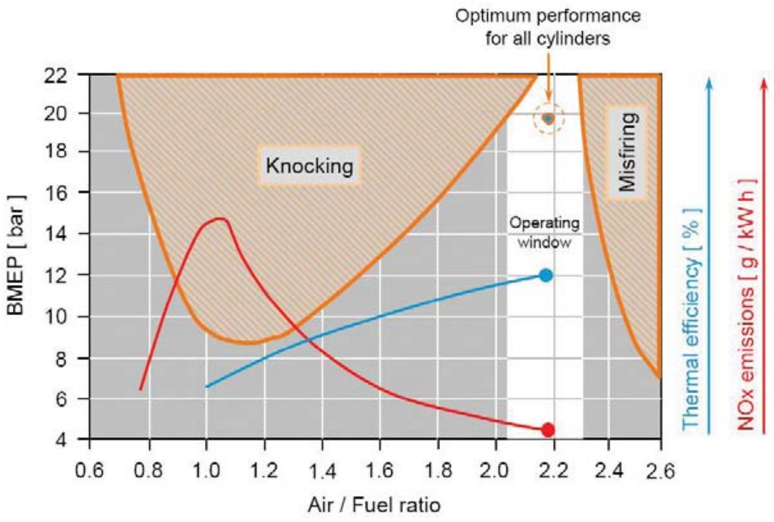

Figure 12.
Optimum combustion gas/air ratio.

When running on gas, dual-fuel engines act according to the Otto principle, by admitting the gas/air mixture into the cylinder. However, if the mixture is too rich, knocking in the cylinder and limited thermal efficiency occur during the combustion. In order to prevent such occurrences, it is necessary to apply lean air/gas mixture with the ratio of surplus air amounting to 2.2. The correct ratio of gas is ensured by the fact that the gas valve opens independently of the charge air valve, see Figure 12, according to (Olander, 2006; Henry, 2012).

When running on gas fuel, the engine acts according to the so-called lean burn concept, with the air/fuel mixture containing more air than it is necessary for complete combustion. The application of this principle results in lower peak temperatures, thereby considerably reducing harmful NOx emissions. Ignition of the lean mixture inside the cylinder is carried out by injection and compression ignition of a small amount of pilot fuel. The latter is injected through the injector's small nozzle, according to (Machinery operating manual, 2009).

The consumption of the pilot fuel is minimal and kept under control. It amounts to less than 1 % of the main fuel consumption at full load. When the engine is running in diesel mode, pilot fuel is not needed for igniting the main fuel but it is nevertheless injected for the purpose of injector cooling.

In diesel mode, the engine operates according to the conventional Diesel principle.

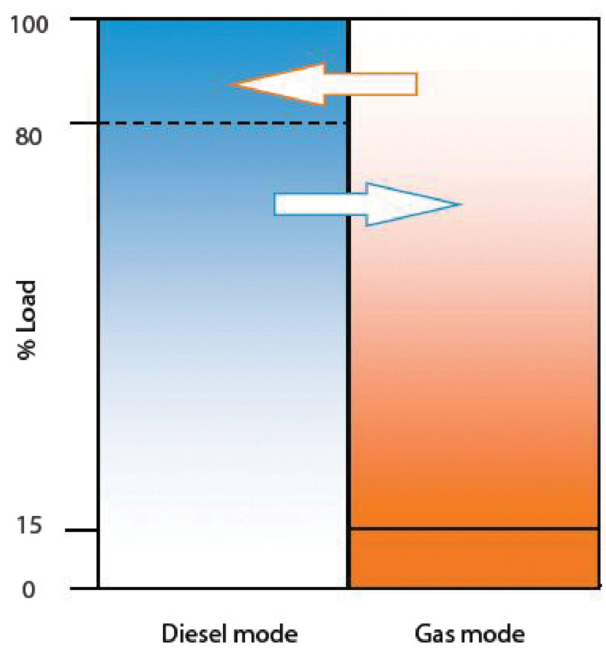

Figure 13.
Mode switching.

The engine is always started in diesel mode. Once combustion in all cylinders is stabilised, the engine is switched over to gas mode. At loads up to 80 % the engine can be transferred from MDO or HFO to gas mode. The entire procedure is carried out automatically within two minutes, without any changes in load. In the event of gas supply failure the dual-fuel engine automatically transfers to diesel mode, without loss of engine power or speed. If the engine load drops below 15 % for more than three minutes while in gas mode, the engine is automatically switched over to diesel mode. The transfer from MDO to HFO is also carried out automatically, while continuing to deliver full power, see Figure 13, according to (Olander, 2006).

The adequate ratio of the air/fuel amount is achieved by adjusting the speed of the exhaust turbine via an electronically controlled recirculating slide valve in the by-pass extension of the exhaust turbine pipeline, see Figure 14, according to (Paananen, 2007; Stenhede, 2006).

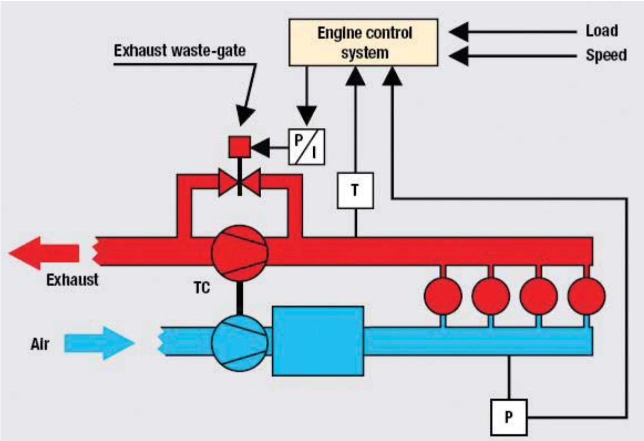

Figure 14.
Control of turbocharger speed.

2.4. Wärtsilä Engine Control System 8000

All engine functions are controlled by WECS 8000. The system consists of two main electronic modules: the main control module, MCM-700, and the cylinder control module, CCM-10, according to (Machinery operating manual, 2009).

The system also contains a number of interconnected electronic modules. The system's final architecture will depend on the number of cylinders. Electronic modules are interconnected via communication buses and the communication is based on the CNA (Controller Network Area) buses, including diagnostics. The main control module gathers and processes all data in order to optimise the engine operation by adjusting the speed, load and revolutions to the given operating conditions, i.e. by determining reference values of the needed fuel amount, air/fuel ratio, and amount and duration of pilot fuel injection. Gaseous fuel pressure, amount of fuel flow and pilot fuel injection timing are calculated depending on external control algorithms. The main control module uses the information provided by all other modules and sends reference signals for cylinder control modules.

Engine starting and stopping sequences, safety system and change in operation mode (diesel/gas mode) are also automatically controlled. If any input signal shows an incorrect value, the control system will give alarm, see Figure 15, according to (Olander, 2006; Henry, 2012).

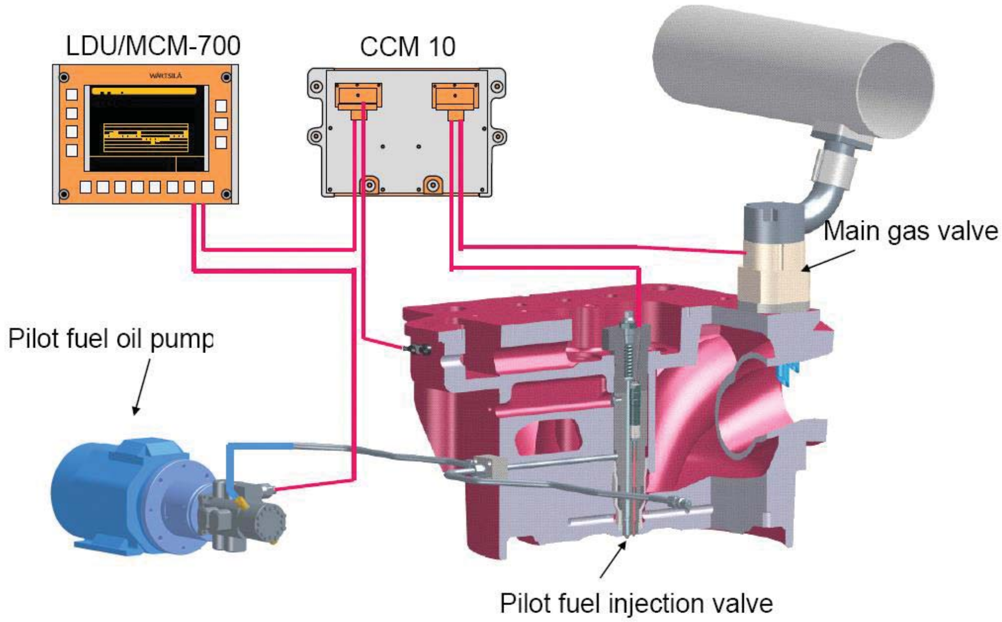

Figure 15.
Cylinder control principle.

The amount of gas admitted into the cylinder is controlled by separate gas admission valves on each cylinder. The valves are controlled by CCM-10 (cylinder control module). The latter controls the amount of gaseous fuel flow and pilot fuel injection by using high-energy output PWM (pulse width modulation) signals.

Each module gives signals for three fuel flow regulation valves and for three pilot fuel injection valves. The modules calculate the appropriate injection timing and duration, depending on the reference values provided by the main control module.

In order to provide control signals for pilot fuel injection at the appropriate angular position of the crankshaft, the modules have to obtain accurate information from the speed sensor and engine phase sensor, according to (Machinery operating manual, 2009).

The amount of the admitted gas depends on the supplied gas pressure and the time during which the main solenoid gas valve is open. The gas admission moment is controlled by opening the gas valve and the position of the piston with regard to the top dead centre for each cylinder. This results in the optimisation of air/gas mixture and enables good combustion. The WECS 8000 system uses the pre-set values which have been calculated for the purpose of optimising the air/gas mixture during engine operation.

In the WECS 8000 system, all sensors are connected to the CCM-10 modules (whose number depends on the number of cylinders) and two main control modules MCM-700.

One of the main control modules is used exclusively for processing the data provided by the sensors. The signals from the sensors are filtered, linearised and grouped. The system also checks errors in signals, i.e. errors in the sensors or network will always be detected and transformed into alarms. All measured values are sent to the machinery units and the information is transferred through CNA-buses or the communication protocol Modbus TCP/IP. In case of engine malfunction, the sensors will detect the occurrence and the WECS system will automatically perform adequate protection action, in order to ensure safe operation of the engine, according to (Machinery operating manual, 2009).

Figure 16, according to (Henry, 2012), shows the fuel system components in the cylinder head.

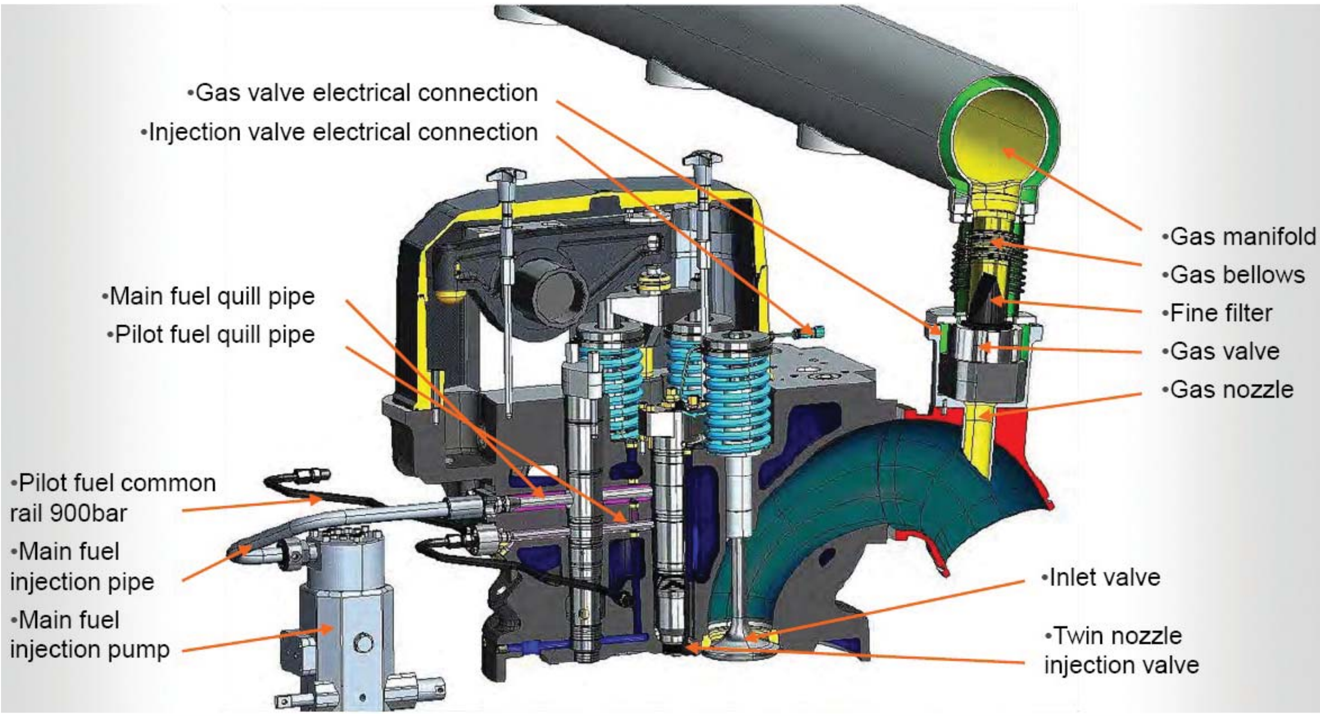

Figure 16.
Fuel system components in the cylinder head.

3. CONCLUSION

Dual-fuel engines successfully meet the requirements of the LNG transport when they are combined with electric propulsion. After a comprehensive comparison of all available alternatives for propelling LNG carriers, the concept of the dual-fuel-electric propulsion has clearly proved to be the optimum option, both from the commercial and technological points of view.

Due to losses in generators, transformers, converters, electric motors, gearboxes and shafts, the dual-fuel electric concept achieves the thermal efficiency of about 43 %. However, this compares very favourably with the overall thermal efficiency of the steam turbine drive system which is less than 30 %. Dual-fuel electric propulsion systems have ceased the domination of steam turbine propulsion systems in LNG shipping, according to (Thijssen, 2006a; Thijssen, 2006b).

This concept's performances surpass the steam turbine concept in the areas of cost-efficiency and redundancy, while providing equal safety, reliability and maintenance features.

Although the maintenance requirements are higher than in steam turbines, this does not reduce the overall cost-efficiency of the vessel.

If compared to diesel engines, the dual-fuel electric concept offers better cost-efficiency, redundancy and maintenance features. Emissions of dual-fuel-electric installations are generally lower than those of steam turbine (as a result of higher efficiency) and diesel engine installations (due to cleaner fuel), according to (Thijssen, 2006a).

Reduced harmful emissions and considerably increased safety of the vessels featuring electric propulsion, in addition to increasingly strict regulations in certain navigation areas and regarding certain types of dangerous cargo will continue to limit the exploitation area of the vessels fitted with diesel-mechanical propulsion.

Increased fuel prices caused by the exploitation of oil reserves and large increase in demand, as a result of rapid industrial and economic development of China and other economies in the Far East, will result in higher fuel costs and the likely reduction in the navigation speed. In such a scenario, the dual-fuel electric propulsion will gain a competitive advantage over the conventional diesel-mechanical plant due to a considerable higher fuel consumption of the latter concept.

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Contribution to ECDIS Reliability using Markov Model

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An Integrated Bridge System (IBS) contains a fully duplicated Electronic Chart Display and Information System (ECDIS). Although duplication should increase system reliability, reliability and availability are not improved. Proper ECDIS maintenance includes updating both: the information system and the provided chart system. This procedure, in practice, tends to decrease reliability and availability. A Markov ECDIS simulation model is given. A new design concept is presented and proposed. The entire ECDIS system is improved by adding a cold standby system preventing the occurrence of errors due to updating and upgrading of the system device.

KEY WORDS

~ Markov model
~ ECDIS
~ IBS
~ Reliability
~ Cold standby

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INTRODUCTION

The International Maritime Organization (IMO) adopted the International Convention of the Safety of Life at Sea (SOLAS), together with the amendments to SOLAS Chapter V Regulation 19 governing the statutory introduction of ECDIS (SOLAS; International Association of Marine Aids to Navigation and Lighthouse Authorities, 2004). The amendments to SOLAS Chapter V Regulation 19 –Carriage Requirements for Shipborne Navigational Systems and Equipment came into effect on 1 January 2011.

As of 1 July 2012 onboard mandatory implementation of ECDIS as the primary navigation system for different ship types and sizes came into force. This means that oceangoing ships are required to have ECDIS equipment. Whenever a new device or system are installed onboard a ship certain activities are required to be taken by appropriate administration, shipper and crew. Several years of its implementation confirmed ECDIS contribution to ship safety and efficient navigation. The ECDIS subsystem is a part of the IBS and a benchmark in navigation management compared to former methods. Due to the importance of ECDIS for safety and the fact that is not merely a matter of installation of new hardware only to meet a statutory requirement, this paper analyses and proposes its own contribution to successful implementation and use of the ECDIS.

IMO's Sub-committee on Safety of Navigation, Communication, Search and Rescue held its first session in London 30 June - 4 July 2014. The new sub-committee is a merger of the NAV Sub-committee on Safety of Navigation and the COMSAR Sub-committee on Communication and Search and Rescue (IMO, 2014).

1. INTEGRATED BRIDGE SYSTEMS

During its design and construction, every merchant fleet ship must meet all IMO, classification society and flag state requirements and regulations. This includes ship's Computer Based Systems (CBS) and Integrated Bridge Systems (IBS) which operate extremely complex marine applications. They provide advanced navigation capabilities and improve ship safety. These systems should ensure that the crew is made aware of failure of any subsystem by audible and visual alarms, and that the failure does not cause failure to any other subsystem. SOLAS stipulates that in the event of failure of a part of an integrated navigation system, all other individual items of equipment or system parts must be able to function independently (SOLAS).

An integrated bridge system (IBS) is defined as a combination of systems interconnected in order to allow centralized access to sensor information or command/control from workstations, to increase the safety and efficiency of ship management by suitably qualified personnel. Performance standards for integrated bridge systems were adopted by IMO in 1996 as Maritime Safety Committee (MSC) Resolution MSC.64 (67).

An example of an IBS system is analyzed in Figure 1. Integrated Navigation System (INS) is the latest generation of IBS, approved in keeping with IMO´s new INS performance standards MSC.252(83). It combines a plethora of individual navigation components into one seamlessly developed navigation and bridge system. The modern INSs not only fulfill basic IMO requirements but exceed them. The use of standard hardware and software allows the configuration of modular system solutions as illustrated in Figure 1. The proposed system and its components should, apart from IMO, also meet other relevant standards of International Hydrographic Office (IHO) and International Electrotechnical Commission (IEC).

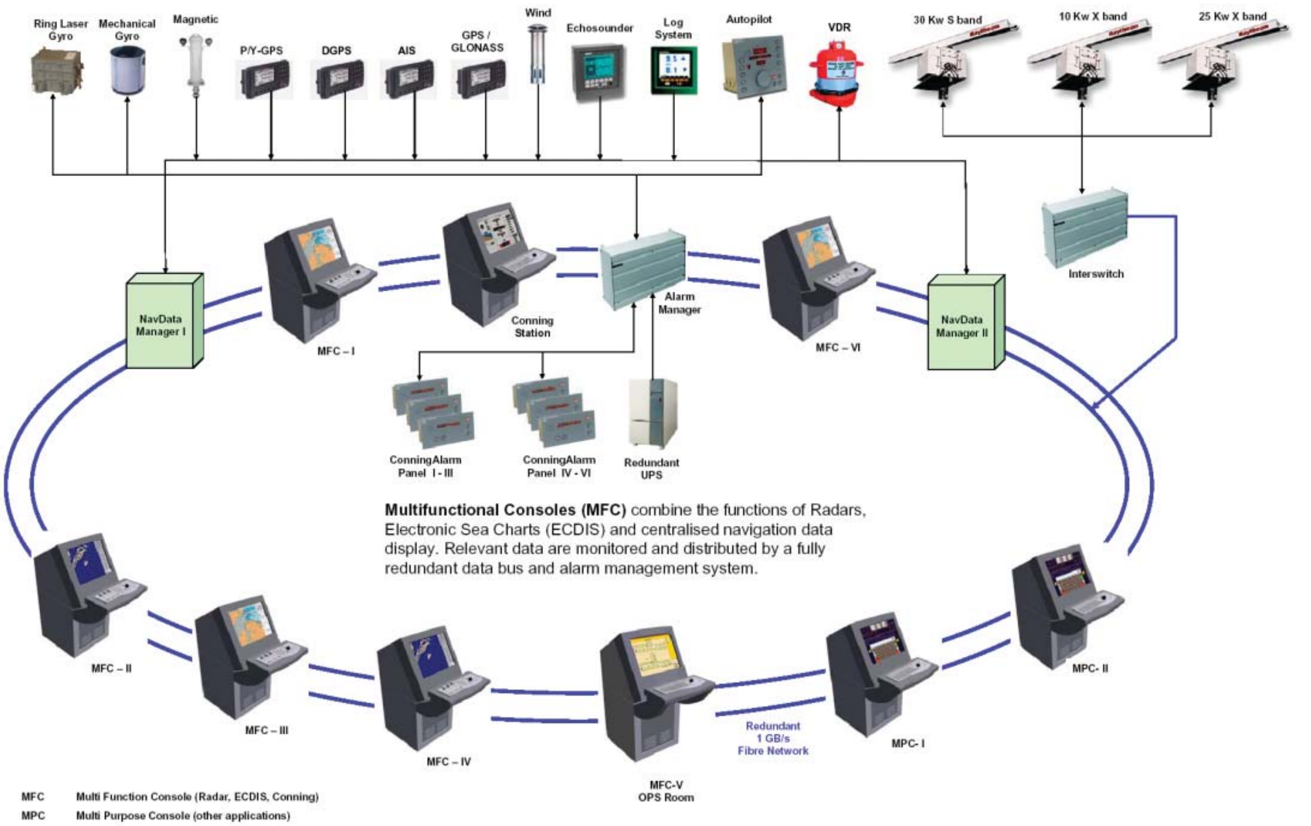

Figure 1.
Raytheon Anschütz's Synapsis Integrated Bridge System.
Source:Integrated Navigation - Synapsis Bridge Control, (2014).

doi: 10.7225/toms.v03.n02.006

INS incorporates the ECDIS solution as one of its most relevant subsystems. Figure 1 illustrates the integration of the ECDIS subsystem into a Multi Function Console (MFC). Reliable high-performance sensors (such as gyro compass, echo sounder, speed log, DGPS and weather sensors) provide all data required by the system, which are distributed and monitored by fully redundant data - and alarm management through 1GB/s fiber local area network (LAN).

Typical IBS/INS characteristics:

- Route monitoring,
- Autopilot operation integrated into radar and ECDIS,
- Central alarm management with integrated monitoring by watch officer,
- Alarm system alerting the captain / alert transmitted in the living quarters,
- Overlay of radar/ECDIS/AIS representations,
- Central presentation of navigation data (conning),
- Display of conning data on the ECDIS,
- Evaluation of remaining system performance and
- Remote diagnostics.

In spite of the greater quantity of technology and mandatory installation of equipment like ECDIS, the total number of navigational accidents of seagoing vessels is increasing according to (Nicholson, 2013).

For this negative trend to be reversed, the present interaction of the CBS and the crew operating the equipment must be analyzed and itself be made apart of the Systems of Systems (SoS). Bridge crew has to monitor and instruct the CBS. As bridge crew become accustomed to system operation, their reliance on the system grows and the actions of the crew adjust to the perceived equipment capabilities (Nicholson, 2013).

2. ECDIS

ECDIS is represented by means of a software system used to display nautical charts, voyage watch and voyage planning. ECDIS is defined in the IMO ECDIS Performance Standards, IMO Resolution A.817 (19), as follows:

Electronic Chart Display and Information System (ECDIS) means a navigation information system which, with adequate back up arrangements, can be accepted as complying with the up-to-date chart required by regulation V/19 & V/27 of the 1974 SOLAS Convention, by displaying selected information from a system electronic navigational chart (SENC) with positional information from navigation sensors to assist the mariner in route planning and route monitoring, and by displaying additional navigation-related information if required.

In addition to IHO/IMO compliant vector electronic navigation charts (ENC), ECDIS also displays raster charts (ARCS). Since raster charts are produced by scanning paper charts, they do not consist of database-based active alarms, and are not to be analyzed in this paper.

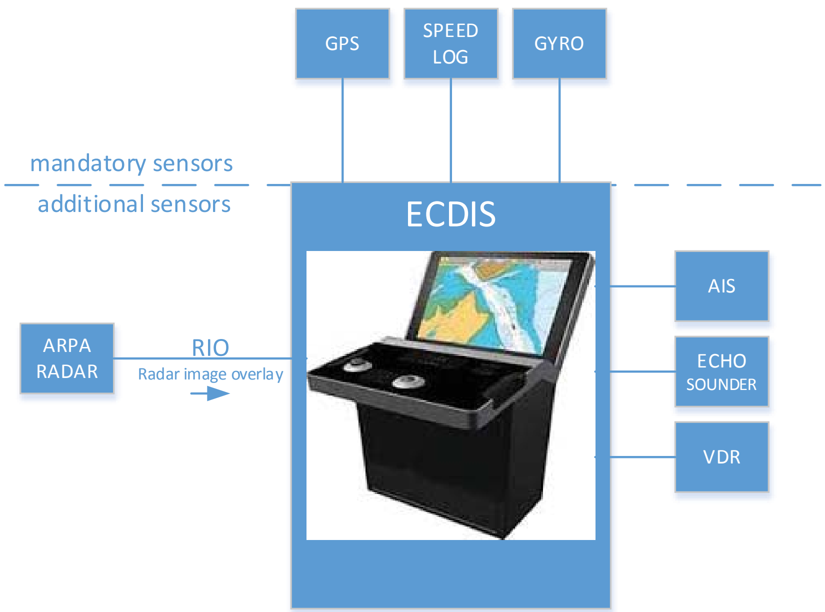

Figure 2.
ECDIS sensors plan.

ECDIS is connected to various subsystems and sensors as shown in Figure 2.

According to IMO performance standards, the ECDIS should be connected to ship's systems providing continuous position, heading and speed information. The ECDIS can also be connected to non-mandatory, additional sensors as illustrated in Figure 2. Mariners should not rely solely on GPS positioning when there are alternative positioning facilities available. GPS is subject to a variety of different errors.

ECDIS consists of three elements: hardware, software and database. ECDIS is the most complex, most sophisticated and most expensive marine navigation system. An ECDIS is capable of displaying all chart information necessary for safe and efficient navigation. It displays the ship's position, as well as the positions of other ships. The implementation of an onboard system of ECDIS's complexity implies the existence of a procedure in the Safety Management System (SMS) to be applied in the event of sensory input failure to ECDIS. As a vital part of SMS onboard implementation, a checklist should be put up on the bridge containing clear instructions on how to deal with sensory input failures and what effect they might have on ship's navigational safety.

Onboard system can be realized with standalone ECDIS. It can also be conceived as dual configuration, or be integrated into INS/IBS as part of MFC.

Electronic navigation systems cannot be guaranteed to be 100 % failsafe; with this in mind, there must be some form of back-up or redundancy in case of ECDIS failure. IMO performance standards require the 'overall system' to include both a primary ECDIS and an adequate, independent back-up arrangement to ensure the safe take over of ECDIS functions without causing a critical situation. The independent back-up arrangement must ensure safe navigation of the ship for the remaining part of the voyage in case of ECDIS failure.

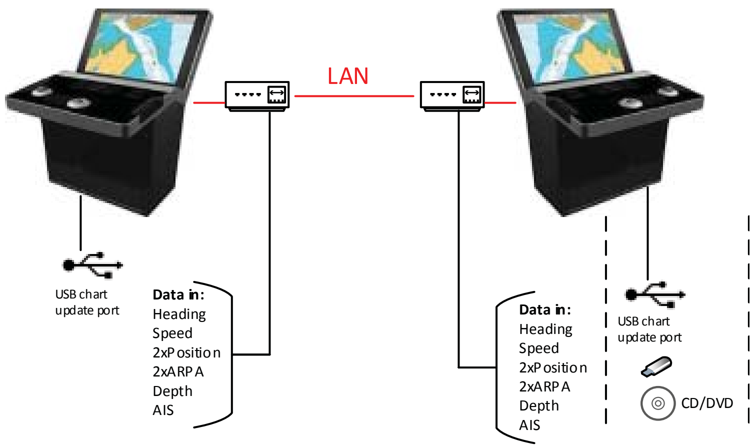

Figure 3.
Dual ECDIS configuration.
Source: Integrated Navigation - Synapsis Bridge Control, 2014.

ECDIS operators must ensure that their software always conforms to the latest IHO standards and that an officially recognized distributor/service provider delivers regular service updates on software and official ENC/RNC data.

All masters and navigation officers should know how to update and maintain their onboard ECDIS. It should not be left to the designated navigation officer to have sole knowledge on the updating procedure and process. Updating procedures should be covered under ECDIS generic training but, more importantly, under type specific training as well, since different ECDIS models vary in their updating processes.

Keeping the ECDIS fully up to date should be made high priority for the bridge team and treated as equally important as normal paper chart corrections. ECDIS updates normally coincide with weekly paper chart corrections. Updates can be sent via e-mail and transferred onto CD or USB flash drive for ECDIS needs. Any device used to transfer ECDIS updates should be a dedicated unit for that sole purpose and be free of any viruses that may corrupt ECDIS software. Software and extensive ENC/RNC updates are generally received on a data CD/DVD and delivered to the ship by a human agent on a weekly basis, particularly when files are too large or expensive to be sent by e-mail. ECDIS should store and display an updates record on demand, including the time of application of the ECDIS database, known as system electronic navigational chart (SENC). This record should include updates for each ENC until it is superseded by a new version. In order for the ECDIS to fully comply with IMO performance standards and display all relevant digital information contained within an ENC, it should be updated to the latest version of the ENC product specification. Additionally, any ECDIS that is not updated to S-63 Data Protection Standard may fail to decrypt or properly authenticate the ENC. When failure to update ECDIS properly occurs, it may result in the latest charted features not being displayed or failure of alarms/indications even if new charted features have been included in the ENC. An ECDIS that is not updated correctly and on a regular basis may not meet the chart carriage requirements as set out in SOLAS regulation V/19.2.1.4. Therefore, IMO published a Safety of Navigation Circular 266 'Maintenance of ECDIS software'.

Although ECDIS equipment and ENCs are designed to maintain a high level of reliability, there is a slightly increased risk of occurrence of problems when adding, removing or updating ENCs. Changes to installations AVCS ENCs when the equipment isused only for navigation or if the ship is about to leave port are not permitted. In (Admiralty Vector Chart Service Installation Guide, 2010) it is stated that every ECDIS update is potentially dangerous for ship safety.

In ships using ECDIS as their primary mean of navigation (no paper charts), an additional and independent ECDIS as a back-up option is generally accepted and meets SOLAS carriage requirements. The back-up ECDIS should be connected to an independent power supply and systems with continuous positioning capability.

When the ECDIS is being operated in Raster Chart Display System (RCDS) mode using RNC data due to the lack of suitable coverage by electronic navigational charts (ENC), an appropriate folio of up-to-date paper charts must be maintained for areas where only raster chart coverage is available.

3. AVAILABILITY CALCULATING MODEL

To obtain a mathematical reliability calculating model, some basic definitions must be known.

3.1 Reliability

The general concept of reliability is related to the qualitative properties of something/someone that is there, in the sense that something/someone is predictable and available when needed. Reliability can be defined as follows:

Reliability R(t) is the probability of performing a specific function under given conditions for a specified period of time without failure (O'Connor and Kleyner, 2012; Skomeršić, 2010; Specht, 2003).

Reliability function is a survival function designated as *R(t)*. *R(t)* is the probability that the considered item (device, system, etc.) will operate failure – free in [0, t] shown in (1). It is worth observing that the reliability function, being a probability, is dimensionless.

$$1 \geq R(t) \geq 0 \tag{1}$$

where:
R (0) = 1 and R (∞) = 0.
Reliability can be expressed with failure rate *α(t)* as an initial condition when reliability at time 0 is at a maximum and equal to 1; then we have (2):

$$R(t) = e^{-\int_0^t \lambda(t)\,dt} \tag{2}$$

Mean Time To Failure (MTTF) can express expected time between failures.

$$MTTF = \int_0^\infty t \cdot \left(-\frac{d}{dt} R(t)\right) dt \tag{3}$$

Common case is $\lambda(t) = \lambda_0$ equals to constant and then (2) becomes (4) and relation (3) becomes (5) (Lazzaroni et al., 2011).

$$R(t) = e^{-\lambda_0 \cdot t} \tag{4}$$

$$MMTF = \frac{1}{\lambda_0} \tag{5}$$

3.2 Availability

Availability is defined in (Lazzaroni et al., 2011) as "the aptitude of the element to perform its required function in given conditions up to a given point in time or during a given time interval assuming that any eventual external resource is assured."

The availability of a machine can also be defined as the percentage of time, in respect to total time, over which that machine is required to function.

Availability A(t) can be defined as "the ability of an item to be in a state to perform a required function under given conditions at a given instant of time or over a given time interval, assuming that the required external resources are provided (Ebeling, 2014; Skomeršić, 2010).

Availability is defined as the probability that an item will be available when required, or as the proportion of total time that an item is available for use (O'Connor, 2012). Availability can be expressed as (6) (Nakagawa, 2005). Limiting interval availability is the anticipated fraction of time over which a system will operate, which is given by

$$A = \lim \left\{ \frac{T_{uptime}}{T_0} \right\} \tag{6}$$

This quality system parameter requires the reduction of system downtime to the minimum. Therefore the availability of a repairable item is a function of its failure rate, λ, and its repair or replacement rate - μ.

$$A(t)= \frac{\mu}{\lambda + \mu} \tag{7}$$

3.3 Modeling

The dynamic modeling in the ITS environment requires the actual values of traffic variables to be known and operation in real time.

The studying of various maintenance policies is important in order to prevent the occurrence of system failures in the field and improve system availability. System availability can either be calculated by modeling the system as an interconnection of parts in series and in parallel, or by means of measuring the methods of an actual system. Both approaches require excellent knowledge of the system analyzed. For practical reasons, availability is often estimated based on an ideal model. On the other side, precise on-site measurements provide exact data, but are more labor-intensive and require significant resources (time, higher costs, dedicated onboard equipment, etc.)

Redundant IMO-compliant ECDIS for navigation, consisting of two identical devices can be modeled by means of two parallel identical system elements as shown in Figure 4.

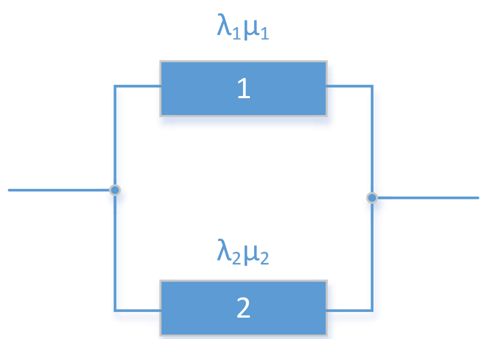

Figure 4.
Dual Redundant ECDIS model.

When Markov analysis is used, a two-component system can be in one of the four possible states as presented in Table 1. Any n component can have two possible states: working or failed. System states are defined as one of 2n possible combinations.

Table 1.
Possible system states.

State	Component 1	Component 2
1	Working	Working
2	Failed	Working
3	Working	Failed
4	Failed	Failed

For a parallel system, the system's failed or "down" state is S4. The corresponding system's "up" states are respectively [S1, S2, S3]. System reliability is defined as the probability of being "up", i.e. not being in a failed state. The aim is to calculate the probability of occurrence of each state (Lazzaroni et al., 2011).

$$R_p(t)= P_1(t) + P_2(t) + P_3(t) \tag{8}$$

Since the system must be in one of the four possible states at any given moment, we get:

$$P_1(t) + P_2(t) + P_3(t) + P_4(t) = 1 \tag{9}$$

where calculation of probabilities is needed: $P_i(t)$ for $i = 1, 2, 3, 4$.

Markov processes can be used to represent a system in which events take place according to specified probabilities. When a system can be modeled by taking into account all possible states the model is exposed to, it is advisable to make a Markov model. A stochastic model is a process in which the state depends on the previous states in a non-deterministic way. A stochastic process has Markov properties if the conditional probability distribution of future states of the process (conditional on both past and present values) depends solely upon the present state; that is, given the present, the future does not depend on the past. Markov processes are distinguished by being memoryless - their next state depends only on their current state, not on the history that led them there. Markov analysis provides a framework in which to study the behavior and emergent properties of these systems. To analyze system events as a Markov process, the system should transit from one state to another, and these transitions should occur in keeping with transition probabilities. This model allows the identification of long term behavior of the status of these systems. The consistent behavior of states of these systems is of great value to an analyst planning or budgeting resources or projecting costs or profit in systems in which events take place in an environment of uncertainty (Carter and Price, 2001).

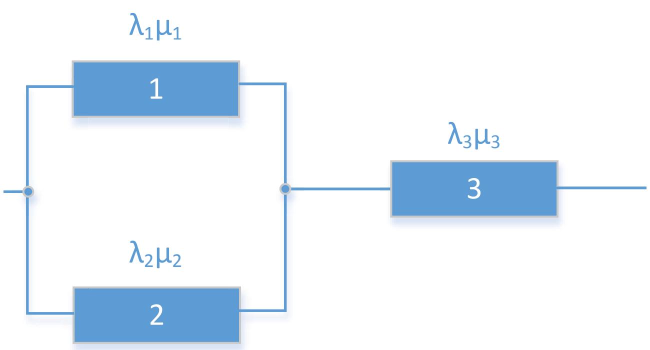

Figure 5.
Enhanced ECDIS model with update..

IMO regulations require a mandatory redundant system. This requires the modification of the model from Figure 4. Updating is common to both, elements 1&2, and must be taken into account when modeling. A new mathematical model, which also takes into account the updating process, is illustrated in Figure 5. The serial element of the parallel redundant model must be considered. The updating process involved is represented by serial element 3. This serial element compromises the achieved ECDIS reliability, in spite of IMO's intention behind the redundant system requirement.

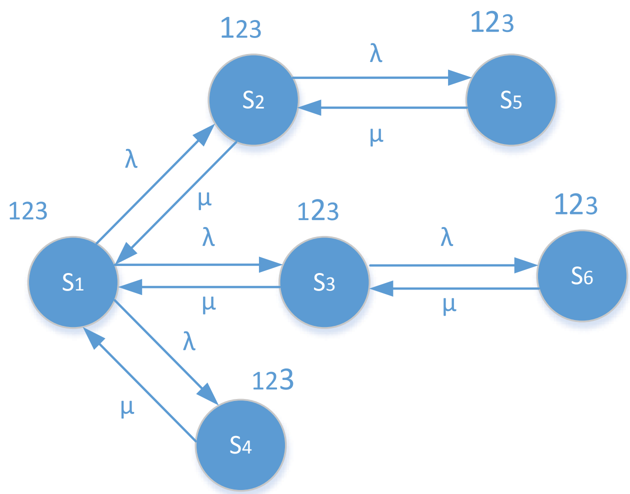

Figure 6.
Markov model structure.

According to model shown in Figure 5, Markov model proposed is shown in Figure 6. That model can be transformed into a simplified form shown in Figure 7.

If λ and μ coefficients are known, system reliability can be calculated. The calculation of a system's working state probability will show that the desired level of reliability is not achieved. A truly reliable, highly available overall ECDIS system is a must for truly paperless charting.

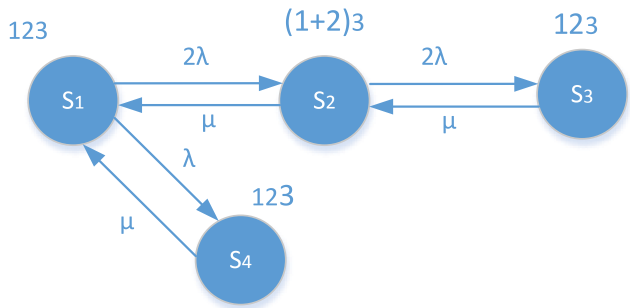

Figure 7.
Concise Markov model structure.

4. PROPOSAL FOR TECHNICAL SOLUTION

The analysis of models described in the previous chapter shows that the serial element degrades system availability and reliability. Adding a new element would not significantly increase availability. The same third parallel element added to the system would suffer from dependency on the serial element as well. Increasing the number of parallel elements increases overall system costs.

To increase overall system availability technical solution from Figure 8 is proposed, under the assumption that the existing, IMO mandatory ECDIS is capable of being upgraded to the new concept. This could be realized by means of cold standby device implementation. The cold standby system would be a real benchmark in maritime safety since existing mandatory reliability still needs backup in the form of paper charts in case of ECDIS malfunction (Admiralty Vector Chart Service Installation Guide, 2010).

The alternative to the proposed solution are paper charts. It is much more convenient for ship safety to obtain an alternative ECDIS from another device and ENC manufacturer than to rely, in case of a system malfunction, on paper charts. Paper charts are, even if available, not updated by the crew.

The additional ECDIS solution also needs to be updated, but overall system errors, which caused the malfunction, could be avoided if ECDIS and ENC came from different manufacturers. This can be accomplished by installing the equipment of totally different manufacturers of hardware with the ECDIS application and ENCs. This solution implemented onboard as a new backup option could make paper charts redundant. In Figure 8, primary redundant system runs AVCS ENCs on Raytheon ECDIS equipment, and cold standby system runs on Primar ENCs with Kongsberg ECDIS equipment is shown.

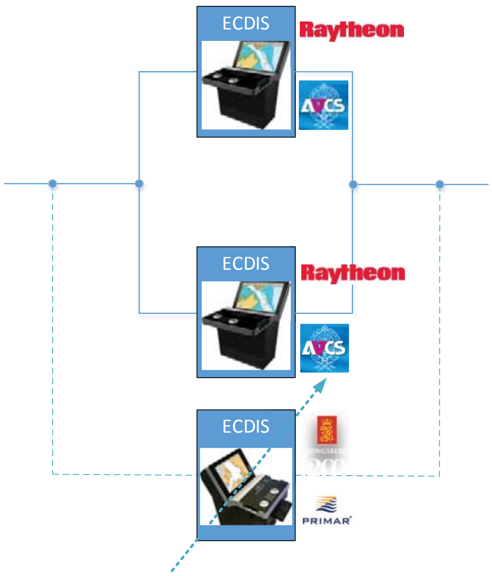

Figure 8.
ECDIS concept solution.

The overall cost of the proposed solution could be analyzed from the point of view of an emergency. This means that in case of emergency a cold standby system running on IBS/INS could be updated by means of temporary permit license keys that wouldn't be charged at commercial prices.

The proposed cold standby system shown in Figure 8 would improve maritime safety.

5. CONCLUSIONS

Modern e-navigation is a set of integrated technologies in IBS/INS. The navigator's mission is to safely pilot the ship across the desired route. ECDIS devices historically developed from devices facilitating navigation to mandatory devices used as primary, vital means of navigation.

Two redundant ECDISs are IMO mandatory devices implemented as subsystems of the IBS/INS design. IMO's assumption was that duplicating device equipment would increase overall system reliability. Equipment duplication does not double the reliability and availability of mandatory equipment.

Emergency backup usage of obsolete paper charts significantly decreases high levels of accomplished maritime safety.

The calculation of reliability of an existing, mandatory system, with known coefficients, gives unsatisfactory results. The calculation of reliability of the proposed system, based on the Markov model, with known coefficients, gives satisfactory results.

The proposed model of a cold standby device system would ensure higher level of maritime safety in case of malfunction of an active redundant system than paper charts. The use of a third ECDIS device produced by a different manufacturer, either device or chart system, would significantly improve maritime safety. IBS/INS safety function role would not be compromised.

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Essential English for Pilotage and Tug Assistance - Proposal for SMCP Extension

Adelija Čulić-Viskota

This paper aims at presenting the activities undertaken since 2012 by the G.A.M.E. – Gesellschaft für Ausbildung in Maritimem Englisch (German Association for Maritime English) with the seat at Bremen University of Applied Sciences, Nautical Department and presided by Capt. Willi Wittig, Head of the Department. The Association gathers Maritime English instructors and maritime professionals who have recently focused on updating the existing Standard Marine Communication Phrases – SMCP – in order to better match the ever growing requirements in maritime affairs. The emphasis has been put on the pilotage and tug assistance phrases, as the existing body of phrases has not been felt entirely suitable to the activities performed. Thus, Capt. Matthias Meyer, master mariner and lecturer at the Nautical Department of the University of Applied Sciences in Bremen, former elder brother of Port Pilot Society Bremerhaven, was entrusted with the task of proposing a further development of the phrases related to this particular seafaring activity. The other lecturers, including the author of the paper, contributed during the 2014 G.A.M.E. summer seminar to Capt. Meyer's proposal purely from the linguistic or methodical point of view.

KEY WORDS

~ SMCP
~ Maritime English
~ Extension
~ Pilotage
~ Tug assistance

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"Here's to the Pilot that weather'd the storm."
George Canning

1. INTRODUCTION

Since English has conquered seas worldwide and become the master key to communication on board every vessel, the need has been felt to provide a common, but limited set of phrases to allow seafarers to communicate in a simple, understandable, unambiguous and effective manner. This tendency gave rise first to SMNV (*Standard Marine Navigational Vocabulary*) in 1977, subsequently to Blakey's Maritime English in 1983 and Week's Wavelength in 1986, SEASPEAK project, also led by Weeks, and then SMCP (*Standard Marine Communication Phrases*) as they are globally used today. As described on the IMO's website, "?IMO's Standard Marine Communication Phrases (SMCP) were adopted by the 22nd Assembly in November 2001 as resolution A.918(22) IMO Standard Marine Communication Phrases. ... The IMO SMCP replaced the Standard Marine Navigational Vocabulary (SMNV) adopted by IMO in 1978 (and amended in 1985).

The SMNV was developed for use by seafarers, following agreement that a common language - namely English - should be established for navigational purposes where language difficulties arise and the IMO SMCP have been developed as a more comprehensive standardized safety language, taking into account changing conditions in modern seafaring and covering all major safety-related verbal communication.

The IMO SMCP include phrases which have been developed to cover the most important safety-related fields of verbal shore-to-ship (and vice-versa), ship-to-ship and on-

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board communications. The aim is to get round the problem of language barriers at sea and avoid misunderstandings which can cause accidents.

The IMO SMCP build on a basic knowledge of English and have been drafted in a simplified version of Maritime English. It includes phrases for use in routine situations such as berthing as well as standard phrases and responses for use in emergency situations.

Under the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 1978, as amended, the ability to understand and use the SMCP is required for the certification of officers in charge of a navigational watch on ships of 500 gross tonnage or above."

There are several points to be emphasized here:

1. The use of the mother tongues of crew members on board has never been encouraged in order for better understanding to be achieved among multicultural and multilingual crews, and the use of a common language is the most straightforward way of reaching this target. So, Trenkner (2013: 28) believes that the approach to the problem should be different from what is laid down in SOLAS 2004. In Nautilus Telegraph, dated February 2013, he says: "*SOLAS 2004 specifies that English must be used between ship and shore, and between a ship's crew and a pilot, but it does not actually require English to be used among fellow crew members*". Maritime professionals worldwide are definitely in favour of his proposal to make use of English for all forms of communication conducted on board vessels, just as it is the case in aviation. Moreover, Cole and Trenkner (2012: 5) support the overall use of the English language on board modern vessels by noting: "*It is worth noting, however, that on board Imperial German men –of -war of the period, at a time when relationships with the British Royal Navy were far from congenial, amazingly English was the command language up until 1905, and was frequently the medium of understanding among German navy men on shipboard, too. The crews for on board service were not drafted from conscripts but recruited from volunteers of the German merchant marine where English had already widely been accepted as sort of working language. From the last quarter of the 19th century until the 1920s and 30s so - called mixed crews were anything else but isolated cases, and ship owners or senior officers simply expected their ratings and junior officers to have sufficient English language skills to enable them to properly do their work on board –in fact, an insufficient command of English was regarded as "bad seamanship"*."

The use of SMCP is advisable as the best course of action in circumstances *"where language difficulties arise"*. The circumstances in which the bridge team is extended to the pilot, who often has to involve persons external to the ship's crew into communication during pilotage and situations requiring tug assistance, definitely call for use of an enhanced form of SMCP intended for this complex scene, the first and foremost objective being to avoid language difficulties leading to accidents.

2. The next important point is that SMCP have been established as "*standardized safety language*", which points out its particular purpose and importance for the safe operation of ships. They have been developed on the basis of SMNV to become its "*more comprehensive*" version aimed at covering an increasing number of ship's operations. Since it is important for a communication code to keep pace with the "*changing conditions in modern seafaring*", further initiatives of SMCP extension or enlargement of the body of phrases can be expected in the future.

3. It is of utmost importance to use a common communication tool such as SMCP to prevent misunderstandings which can lead to accidents. Thus, with such a large number of accidents occurring due to deficient, ineffective communication, it is definitely safer to resort to the common code in order to provide for the safety of all the parties involved.

4. Not only emergency situations are covered by SMCP, although in such cases the use of Phrases can be of vital importance. But they are also intended for "*routine situations*". It has been on the basis of this use of SMCP that the need has been felt to enlarge the body of phrases available so far for the pilotage and tug assistance situations. In his elaboration of the problem entitled "*English as Working Language during Manoeuvring*" at the 2012 38th IFSMA General Assembly held in Copenhagen, Capt. Meyer stated that „*...there is no doubt, more than 95 % of the daily work of a harbour pilot is standard*." So, although some 5 % of the situations refer to uncommon circumstances during berthing, unberthing, Capt. Meyer is in favour of extending the SMCP to those standard procedures. Consequently, after a discussion **IFSMA res. 1/2012 (AGA 38), Further Development of SMCP (Standard Marine Communication Phrases)** was accepted in Copenhagen.

5. The ability to understand and use the SMCP is required for the certification of officers in charge of a navigational watch on ships of 500 gross tonnage or above, which refers to all the participants in the Master-Pilot-Tug communication. Therefore, Capt. Meyer ends his contribution in the IFSMA Annual Review 2011-2012 (2012:12-13) by his deep conviction: *"All involved masters commanding the vessel, commanding the tug or serving as pilot are holding the same licence. Due to this standard the communication skills should be on B1 level in accordance with CEFR (Common European Framework of Reference for Languages). To improve the safety of the vessel and the traffic on the waterways, to provide a better legal protection for the master and, last but not least, to protect the environment, a standard vocabulary has to be developed and added to the IMO Standard Marine Communication Phrases Part A I¼."*

2. FURTHER DEVELOPMENT OF SMCP

Standard phrases and words to be used in maritime safety communications are laid down in IMO Standard Marine Communication Phrases. Among them, there is the phrase "Please, use SMCP!" meaning "Use SMCP during this conversation!", obviously with the aim of avoiding possible misunderstandings likely to arise. Likewise, whenever Maritime English tools, such as SMCP, are felt not to support appropriately the team work by allowing full grasp of the situation (situational awareness), i.e. in case they are felt as deficient in providing appropriate coverage of the activities taking place, such as the case with pilotage and tug assistance, the need is felt to elaborate on and extend the body of phrases. A participant in the on-board communication should always feel free to require from other participants to switch to SMCP in case he/she feels not able to follow. Such is the case of pilot on board arranging tugs to assist the vessel.

2.1. The role of G.A.M.E.

G.A.M.E. – Gesellschaft für Ausbildung in Maritimem Englisch (German Association for Maritime English) with the seat at Bremen University of Applied Sciences, Nautical Department and presided by Capt. Willi Wittig, Head of the Department, is a non-governmental, non-profit association of Maritime English lecturers and maritime professionals active worldwide either in maritime affairs, or education and training, or both. The Association is headed by Capt. Willi Wittig, with at his side the renowned prof. Hans Rummel, specialized in Maritime English during his long teaching career from 1972 to 2006 at the Universities of Applied Sciences in Bremen and Bremerhaven, retired but still active and sharing his enormous knowledge and experience with lecturers and students internationally. The Honorary Member of G.A.M.E., prof. Peter Trenkner, of Wismar University of Applied Sciences, the primary responsible for the development of the SMCP, was presented with the project idea, which was discussed and approved.

G.A.M.E. organizes workshops and seminars for Maritime English lecturers on a yearly basis, usually one-day workshop to shortly introduce and determine the topic to elaborate on the following year during the three-day seminar with the participation of all the lecturers interested in the topic and feeling capable of making a contribution. G.A.M.E. seminars are practically oriented, applied-linguistics seminars, their main purpose being Maritime English development and its implementation into maritime courses. Thus, G.A.M.E. 2014 summer seminar entitled "Proposal for Phrases on Pilotage and Tug Assistance (SMCP)" took place in Bremen from June 10-13, 2014. After a presentation by Capt. Meyer, the 2012 Annual General Assembly of the International Federation of Shipmasters' Associations (IFSMA) passed a resolution stating the need for an extension of the SMCP on pilotage and tug assistance. During the seminar, the lecturers gathered first to revise the first draft proposal made by Capt. Meyer during the 2013 Bremen workshop and then, after a discussion with pilots from the ports of Bremerhaven and Hamburg, to round up the picture of their needs during pilotage and tug assistance in order to be able to contribute to a further development and subsequent curricular implementation of the SMCP chapter extended. A subsequent professional contribution was also made by Capt. Russo, former chief pilot in the port of Split, Croatia.

3. THE NATURE OF MASTER-PILOT-TUG COMMUNICATION

The ship's master, pilot and tug master represent a form of joint enterprise with the aim of safely conducting the ship to her berth or seeing her out when she is leaving it. The importance of "good chemistry" between the pilot and the ship's master is often mentioned in this context, actually referring to the communication between them. The ship's master may, of course, decide to rely completely on the pilot's competency, but he should definitely be given the chance to decide so on his/her own by being able to follow the pilot's communication with the external parties, especially with the tug master(s).

3.1 The problems related to master-pilot-tug communication

A realistic account of the importance of good communication among the three pivotal points of the bridge team is provided in an article by Capt. Erik Blom, Master of the M/V BLACK WATCH, Fred. Olsen Cruise Lines, entitled "Is the pilot a part of the bridge team?". The author describes the situation as follows:

"I have recently returned from a voyage to the French part of Canada. In St. Lawrence River ships the same size as mine always have two pilots on board taking one hour watches. As in many other countries, a new generation of pilots is being trained and in addition to the two pilots we had apprentices on board. It was too easy for them to fall back on speaking French between themselves instead of speaking English and in turn creating two "bridge teams", which should be avoided. Sometimes it is not possible to avoid two teams due to communication difficulties, either on the crew or on the pilot's side. Based on my experience, most pilots speak more than good enough English, but as a pilot conning a ship heading for Mongstad oil terminal I have experienced that my helm orders had to be translated into three different languages before they were executed by the helmsman. In that situation it was difficult to establish a closed loop."

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Not only does Capt. Blom insist on the importance of effective communication among the bridge team members, but he also expresses his being in favour of communication conducted in one language only, which has already traditionally become English.

In another article entitled "Pilot on board!" other obstacles to effective communications are presented, which are so complex by nature that deficient knowledge or total inability to conduct communication in English can only make things even worse. Thus, cultural differences should also be taken into consideration:

"The pilot is perceived as an authority and in many cultures it is difficult to correct or even question a decision made by an authority. Corrections to obvious errors may therefore be delayed and in some cases not put forward at all. Reluctance to get involved in a situation has contributed to several severe marine accidents. In particular, this may be a problem when the master is not on the bridge. It is therefore important that all members of the bridge team have the necessary authority and confidence to interfere if they are in doubt. This can only be achieved by active leadership and involvement by the master. The IMO Code of Nautical Procedures and Practices also states: "If in any doubt as to the pilot's actions or intentions, the officer in charge of the navigational watch shall seek clarification from the pilot and, if doubt still exists, shall notify the master immediately and take whatever action is necessary before the master arrives".

This, obviously, also applies to the tug assistance and the relative communication, which should be conducted in a language common to all the parties involved. So, if communication is conducted in a common language, i.e. Maritime English, the possibility of a breakdown is minimized.

In another article entitled "Who is to blame?", which appeared in Gard News 173, February/April 2004, the author refers to this instance of communication while describing an accident which occurred during tug assistance:

"The pilot, when communicating with the tugs, was speaking a language that was not understood by the master. This made it difficult for the master to be fully aware of the situation."

The above mentioned communication breakdown is listed as one among several important factors which contributed to the accident and which can all be found in a large number of other casualty reports.

3.2. Early initiatives for the standardization

It was as early as September 21, 2009 that Capt. G. V. Brooks and Capt. V. J. Schisler published an article entitled "Standardized tractor tug commands for ship-assist work" in "The Professional Mariner", Journal of the Maritime Industry. They reported of their attempt to standardize tractor commands as they conducted training of pilots in the use of tractors at marine simulators. They also suggested: "*Of course, these commands, if used, need to be understood by the tug crews, and they need to have practiced the higher-speed manoeuvres before it would be appropriate to perform them with a ship*." Thus, the authors put emphasis both on the need to use standardized phrases and on the need to train the crews before they use the phrases in real-life situations.

In October 2009, the American tug masters decided to express their support to the standardization of pilot – tug master command language, the issue that had previously been considered by Capt.'s Brooks and Schisler, in an article on the international towmasters' forum by saying: "*As is often the case, different people will say (and mean) the same thing in varying (read: inconsistent) ways. Sometimes this inconsistency in the choice of words may even come from the same individual on the same job. When this happens misunderstandings can easily occur which may lead to groundings, damage to piers or other vessels, oil spills and personnel injuries. Capt.'s Greg Brooks and Victor Schisler are attempting to reduce some of these miscues and improve operational safety and effectiveness for tractor tugs by standardizing the terminology that ship pilots use to give them manoeuvring orders. Another key element is their recommendation to eliminate the use of words that may sound alike but have completely different meanings." ... "It should go without saying that this problem is by no means particular to tractor tugs, but I'll say it anyway. A lack of effective communication, directly or indirectly, is the root cause of many mishaps and everyone can improve their chances of safely completing any given evolution by continually working to fine tune the flow of information in both directions.*"

Furthermore, in April 2011 another article entitled "Side bitt or shoulder bitt? Mariners invited to standardize towing terms" and written by Brian Gauvin, the Journal's Gulf Coast correspondent appeared in "The Professional Mariner". The author reports of Capt. Eric Johansson's work on the standardization of towing nomenclature, a task undertaken by this professor at the State University of New York Maritime College following an invitation by his college back in May 2008. It was after a meeting of the representatives of the major U.S. towing companies, maritime academies and the National Maritime Safety Advisory Committee that the task of standardizing terminology to be put into consistent use was stated because, as prof. Johansson pointed out, "*Ambiguity is downright dangerous in any situation and a formidable link in the error chain*". (ibid.)

At the same time G.A.M.E. was invited to consider the communication problem of the bridge team during pilotage and tug assistance, and to propose an extended body of phrases that would allow pilots more precious time by relieving them from the obligation to translate their commands for the ship master into English if communication between the pilot and tug master(s) is conducted in the local language other than English.

Finally, it has to be mentioned that the need for the standardization was also felt among the Japanese and it resulted in a paper entitled "Proposal for Global Standard

Maneuvering Orders for Tugboats", by Ishigura & Sugita, Hayashi & Murai, published in TransNav, the International Journal on Marine Navigation and Safety of Sea Transportation after the presentation held at the 10th International TransNav Conference in Gdynia, in June 2013. The authors focused on investigating the time lag between when a manoeuvring tug order is given and when the expected action is taken. They emphasize that "*… also the purpose here is to propose the global standardization of maneuvering orders for tugboats, showing the problems caused by using special tug orders in Japan, and weighing how the orders for tugboats are employed in Japan and other foreign countries. … Here, we recommend and propose that globally-standardized orders for manoeuvring a tug are settled and included in SMCP for the bridge team to serve its function for maritime safety*". The authors expressed their awareness of the need for the standardization, which was based on their research, but did not make an actual proposal for the phrases.

3.3. The SMCP extension to provide for "English-biased" communication during tug assistance

The G.A.M.E. working group has taken into consideration the already existing body of the phrases intended for communication during pilotage and tug assistance. What was considered deficient were the commands issued by the pilot on the bridge to the assisting tugs, as it is of utmost importance that this instance of communication is understood by the master of the vessel being assisted.

The SMCP have been developed following certain "Basic communicative features" (IMO SMCP: 2-3) which means that *"It was drafted intentionally in a simplified version of Maritime English in order to reduce grammatical, lexical and idiomatic varieties to a tolerable minimum, using standardized structures for the sake of its function aspects…"; "This means that in phrases offered for use in emergency and other situations developing under considerable pressure of time or psychological stress, as well as in navigational warnings, a block language is applied which uses sparingly or omits the function words the, a/an, is/are, as done in seafaring practice."; "Further communicative features may be summarized as follows: avoiding synonyms, avoiding contracted forms,… providing one phrase for one event…".*

The G.A.M.E. working group has borne these principles in mind during the relative seminars and has done its best to remain on that course by making use as much as possible of the lexical items used in the rest of the SMCP and avoiding any varieties to make the phrases as easily memorable as possible, following the principle of consistency; also, the activities during pilotage and tug assistance bring about considerable stress to all involved, so that only the essential lexical items have been focused on, and function words, such as articles, omitted wherever possible.

3.4. Implementation of phrases on pilotage and tug assistance into teaching

An agreement has been reached that a consistent glossary of basic terms related to tugs and tug assistance should be developed in order for the body of phrases to be more easily introduced into a Maritime English course. Meanwhile, terminology can be taught at different stages of a Maritime English course, e.g. when teaching types of ships, tug-specific terminology can be more closely dealt with, while manoeuvring and tug assistance-related terminology can be taught while introducing berthing/unberthing. It is certainly the case that different lecturers favour different approaches, but it is always helpful to rely as much as possible on pictures and video clips when teaching terminology, since this allows the lecturer to elicit a number of wh-questions and answers. It also makes it easier to disambiguate certain lexical items, e.g. bitts and bollards, which are often confused by younger students. Also, exercises based on filling in the blanks with appropriate terms, where each term to be filled in a blank is described with relevant details. Next, exercises of guessing the term can be used. In this case, the lecturer provides pieces of information one by one until the students are able to guess the term in question, or vice versa: the lecturer introduces the term and asks the students to provide as much information on it as they can. This exercise can be prepared by the lecturer, or he/she can ask a group of students to search for information on several important terms and present it to the rest of the group in an interactive manner. Next, a useful exercise can be that of matching related terms with their descriptions, as it allows clear distinction among e.g. towing line, messenger line, hawser, monkey's fist. Although there are lots of possibilities in teaching terminology, a simple introduction of terms and assigning tasks related to the terms in question to students always works out best. It makes each student actively participate by his/her presentation of a term and eventually, they put their contributions together to make a presentation on tugs and towing equipment. The lecturer's task should be in the first place that of a consultant, e.g. in case the students find more synonymous terms for a single part of equipment, which are currently also in use or were formerly used, but are not recommended any longer. As for the newly developed phrases, they fall into three main sets according to their function. These are:

1. phrases intended for calling the tug(s),
2. phrases to express power commands,
3. phrases to express manoeuvring commands.

When calling the tug(s), different methods are used, and they have all been retained as alternative in the proposed phrases, i.e. calling the tugs by position (forward, aft) with regard to the vessel, by names (in case there is no possibility of their being misunderstood), or by numbers in combination with P for port and S for starboard.

As regards the phrases to express power commands, the instruction "Power up/down to…" followed by the numerical expression of percentage of engine power or bollard pull has been proposed. Such a phrase is immediately followed by the phrase expressing new speed in knots.

Finally, the most elaborate set of phrases refers to the tug's working directions or manoeuvring. The command "Pull to … " is followed by the direction expression using designation "… o'clock", as the assisted vessel's heading is considered to be 12 o'clock. Next, the length of and stress in the towing line have been taken into consideration, so that the following set of phrases refers to situations when the towing line has to be paid out or shortened up, kept tight or slacked away. Then, the situation when the tug accompanies the vessel with the towing line slack has been covered as well as the requirement for indirect towing. Finally, phrases intended for berthing the vessel by turning her, pushing or pulling have been added. Another important warning has also been included in the proposed phrases, i.e. the warning for the tug(s) that the vessel would start her engines ahead/astern, as well as the warning for the vessel not to start her engines. A final announcement for the tug(s) follows to state, before the "letting go" phrase, that the towing operation has finished. To finish with, there has been included a phrase allowing the pilot to announce to the tug(s) to stand by and, finally, to be released. The proposed extension has carefully been thought and adapted to the already existing SMCP phrases for tug assistance.

A suggestion for gap-filling exercise on SMCP phrases for tug operation was made by Uwe-Michael Witt, PhD., an independent expert in Maritime English delivering courses for crew members and shore-based staff, with an experience in teaching Maritime English to tug crews. The exercise includes inserting tug-operation-specific terms into the text after having heard the complete communication exchange between the pilot and the tug in order to berth the vessel safely. Next, reading the text in pairs is suggested. Finally, a still more active involvement of students is proposed by asking them to write an example of communication exchange for tug assistance during leaving berth and also to produce the exchange in speech.

Of course, the phrases developed to complement the already existing SMCP chapters on pilotage and tug assistance would also make part of the training courses for pilots and tug crews.

3.5. Current status of the Proposal

As required by the Annex 2 of the resolution A.918(22), "Procedure for amending the IMO Standard Marine Communication Phrases", the Proposal for the amendment to the SMCP for pilotage and tug assistance developed by G.A.M.E., after an invitation from IFSMA, is to be submitted to the IMO Maritime Safety Committee for examination and evaluation.

4. INSTEAD OF CONCLUSION

In this paper, the author's first and foremost objective has been to present an initiative not only to further develop Maritime English as working language, but particular emphasis has been put on the "English-bias" for pilotage and tug assistance activities. Namely, pilots on the bridge are certainly under pressure brought about by the nature of the activity itself, and what they need least is to take over another role, i.e. that of the interpreter. Communication with the members of the bridge team intertwined with communication with the tug master(s) is already a complex enough task for the pilot so as not to be overloaded with the responsibility of translating into English the tug commands for the ship's master. What is more, it is not only the question of overload, but very often it is the question of shortage of time at disposal. On the other hand, the ship's master has the overall responsibility for the ship and, as such, should definitely be in the position to object to the pilot's moves if he/she does not agree. This, naturally, can be done only if he/she can have a full grasp of the situation. In this way, the ship's master is not put under stress by being excluded from the process through which his/her ship is conducted. At the same time, the pilot can concentrate on his job instead of taking on an additional role.

In this sense, it should be the task of Maritime English lecturers and their associations to help develop Maritime English as working language whenever an initiative comes from the maritime industry for the coverage of a specific activity or a new form of marine business to be put into use and at the disposal of all those involved in maritime affairs, for better safety of persons, property and environment.

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CONTRIBUTION

News from IMO
Maritime heritage
News
Pjesma / Poem
Guidelines

CONTRIBUTION

News from IMO

Tatjana Krilić

The paper presents current work of selected IMO bodies in the period preceding the publication of this issue of ToMs. The outcome of IMO bodies responsible for safety and environment protection has been covered, aiming at informing seafarers and shipping industry at large on the decisions taken, as well as on the IMO instruments and/or their amendments that have entered into force.

KEY WORDS
~ IMO
~ Safety
~ Environment protection

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INTRODUCTION

Since the last issue of ToMS, the Maritime Environment Protection Committee (MEPC) met at the Organization's London Headquarters for its 66th session from 31 March to 4 April 2014, and the Maritime Safety Committee (MSC) held its 93rd session from 14 to 23 May 2014. Both committees made significant progress in various areas of their work. Their selected decisions and outcome of discussions have been presented in this review. Complete information is available to the public in the reports of the MEPC and MSC Committees on the Organization's IMODOCS website (http://docs.imo.org/).

66th session of the Marine Environment Protection Committee (MEPC 66)

Amendment on implementation date for Tier III adopted

The MEPC adopted amendments to MARPOL Annex VI, regulation 13, on Nitrogen Oxides (NOx), concerning the date for the implementation of "Tier III" standards within emission control areas (ECAs). The amendments provide for the Tier III NOx standards to be applied to a marine diesel engine that is installed on a ship constructed on or after 1 January 2016 and which operates in the North American Emission Control Area or the U.S. Caribbean Sea Emission Control Area that are designated for the control of NOx emissions. In addition, the Tier III requirements would apply to installed marine diesel engines when operated in other emission control areas which might be designated in the future for Tier III NOx control. The amendments are expected to enter into force on 1 September 2015.

NOx control requirements apply to installed marine diesel engines of over 130 kW output power, and different levels (Tiers) of control apply based on the ship construction date. Outside emission control areas designated for NOx control, "Tier II" controls, required for marine diesel engines installed on ships constructed on or after 1 January 2011, apply.

Other amendments adopted

- Amendments to MARPOL Annex I, the Code for the Construction and Equipment of Ships carrying. Dangerous Chemicals in Bulk (BCH Code) and the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code), on mandatory carriage requirements for a stability instrument for oil tankers and chemical tankers, expected to enter into force on 1 January 2016;
- Amendments to MARPOL Annex VI concerning the extension of the application of the Energy Efficiency Design Index (EEDI) to LNG carriers, ro-ro cargo ships (vehicle carriers), ro-ro cargo ships, ro-ro passenger ships and cruise passenger ships with non-conventional propulsion; and to exempt of ships not propelled by mechanical means and independently operating cargo ships with ice-breaking capability, expected to enter into force on 1 September 2015.

Draft Polar Code environmental provisions reviewed

The MEPC reviewed the environmental requirements under the proposed draft mandatory International Code for ships operating in polar waters (Polar Code) and considered the proposed draft amendments to MARPOL to make the Polar Code mandatory. The draft Polar Code covers the full range of design, construction, equipment, operational, training, search and rescue and environmental protection matters relevant to ships operating in the inhospitable waters surrounding the two poles. Environmental provisions include requirements covering prevention of oil pollution; prevention of pollution from noxious liquid substances from ships; prevention of pollution by sewage from ships; and prevention of pollution by discharge of garbage from ships.

Energy-efficiency measures for ships considered

The MEPC continued its work on further developing guidelines to support the uniform implementation of the regulations on energy-efficiency for ships that entered into force on 1 January 2013, and adopted the 2014 Guidelines on the Method of Calculation of the Attained Energy Efficiency Design Index (EEDI), applicable to new ships.

NOX Technical Code guidelines adopted

The MEPC adopted amendments to the NOx Technical Code, 2008, concerning the use of dual-fuel engines, as well as the 2014 Guidelines in respect of the information to be submitted by an Administration to the Organization covering the certification of an Approved Method as required under regulation 13.7.1 of MARPOL Annex VI (relating to "Marine Diesel Engines Installed on a Ship Constructed Prior to 1 January 2000"); and the 2014 Guidelines on the Approved Method process, which apply to new Approved Methods notified to IMO only.

2014 shipboard incineration standard adopted

The MEPC adopted the 2014 standard specification for shipboard incinerators, which covers the design, manufacture, performance, operation and testing of incinerators intended to incinerate garbage and other shipboard wastes generated during the ship's normal service.

Sulphur review correspondence group established

The MEPC considered the timing of the review, required under MARPOL Annex VI, regulation 14.8, on control of emissions of sulphur oxides (SOx) from ships, on the availability of compliant fuel oil to meet the requirements set out in the regulation. Following the inter-sessional work, the terms of reference of the study are expected to be adopted at MEPC 68 in 2015. The sulphur content (expressed in terms of % m/m – that is, by weight) of fuel oil used on board ships is required to be a maximum of 3.50% m/m (outside an Emission Control Area (ECA)), falling to 0.50% m/m on and after 1 January 2020. Depending on the outcome of a review, to be completed by 2018, as to the availability of compliant fuel oil, this requirement could be deferred to 1 January 2025.

Ballast water management systems approved

The MEPC granted Basic Approval to four, and Final Approval to two ballast water management systems that make use of Active Substances.

The MEPC also approved BWM-related guidance, including Guidance on entry or re-entry of ships into exclusive operation within water under the jurisdiction of a single Party and a revision of the GESAMP-BWWG Methodology for information gathering and conduct of work.

Guidance for port reception facility providers and users agreed

The MEPC approved consolidated guidance for port reception facility providers and users.

93rd session of the Maritime Safety Committee (MSC 93)

Polar Code and SOLAS amendments approved

The MSC approved, for consideration with a view to adoption at its November 2014 session (MSC 94), the draft new SOLAS chapter XIV "Safety measures for ships operating in polar waters", which would make mandatory the Introduction and part I-A of the Polar Code.

Mandatory audit scheme amendments adopted

The MSC completed the legal framework for the implementation of the mandatory IMO audit scheme from 2016, with the adoption of amendments to the following treaties to make mandatory the use of the IMO Instruments Implementation Code (III Code) and auditing of Parties to those treaties: SOLAS, 1974, as amended (adding a new chapter XIII); STCW, 1978, and the STCW Code; and the 1988 Load Lines Protocol), as amended.

This follows the adoption, by the IMO Assembly at its twenty-eighth session, of similar amendments to COLREG 1972, as amended, LL 1966 and TONNAGE 1969.

The Marine Environment Protection Committee (MEPC), at its 66th session, in April 2014, adopted similar amendments to MARPOL Annexes I through to VI.

Adoption of other amendments

The MSC also adopted, inter alia, the following amendments to SOLAS, which are expected to enter into force on 1 January 2016:

- amendments to SOLAS regulation II-1/29 on steering gear, to update the requirements relating to sea trials
- amendments to SOLAS regulations II-2/4, II-2/3, II-2/9.7 and II-2/16.3.3, to introduce mandatory requirements for inert gas systems on board new oil and chemical tankers of 8,000 dwt and above, and for ventilation systems on board new ships; together with related amendments to the International Code for Fire Safety Systems (FSS Code) on inert gas systems
- amendments to SOLAS regulation II-2/10, concerning fire protection requirements for new ships designed to carry containers on or above the weather deck
- amendments to SOLAS regulation II-2/13.4, mandating additional means of escape from machinery spaces
- new SOLAS regulation II-2/20-1 Requirement for vehicle carriers carrying motor vehicles with compressed hydrogen or natural gas for their own propulsion.

Passenger ships safety: revised action plan agreed

The MSC agreed a revised long-term action plan on passenger ship safety, following extensive discussion. A number of matters relating to damage stability and survivability of passenger ships were referred to the Sub-Committee on Ship Design and Construction (SDC) for further work. Meanwhile, the Committee instructed the Sub-Committee on Implementation of IMO Instruments (III) to complete its consideration of the report on the grounding, in 2012, of the Costa Concordia, as a matter of priority and to bring to the attention of MSC 94 the contributing factors, issues raised/lessons learnt and observations on the human element factors involved.

Revised IGC Code adopted

The completely revised International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (the IGC Code) was adopted by the MSC, following a comprehensive five-year review, and is intended to take into account the latest advances in science and technology. It will enter into force on 1 January 2016, with an implementation/application date of 1 July 2016.

Piracy and armed robbery against ships reviewed

The MSC reviewed the latest statistics on piracy and armed robbery against ships and discussed current initiatives to suppress piracy and armed robbery, noting that the number of worldwide piracy attacks had decreased and that no SOLAS ship had been hijacked in the western Indian Ocean area since May 2012, as a welcome result of the robust actions taken by the international naval forces in the region, the shipboard measures implemented by shipping companies, masters and their crews as well as the deployment of professional security teams.

However, the Committee noted with concern the situation in the Gulf of Guinea which had not substantially improved, noting that a revised and comprehensive IMO strategy for implementing sustainable maritime security measures in west and central Africa had been developed and was being implemented.

Other issues

In connection with other issues arising from the reports of IMO sub-committees and other bodies, the MSC, inter alia:

- adopted a number of new traffic routeing systems, including traffic separation schemes, as well as amendments to existing systems

- adopted performance standards for the shipborne "Beidou" satellite navigation system (BDS) receiver equipment
- approved guidance on the bridge navigational watch alarm system (BNWAS) auto function
- approved guidelines for the reactivation of the Safety Management Certificate following an operational interruption of the SMS due to lay-up over a certain period
- approved guidance on safety when transferring persons at sea.

Amendments to IMO instruments that have entered into force on 1 June 2014

- 2012 amendments to the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code) (resolutions MEPC.254(64) and MSC.340(91))

Amendments to IMO instruments that have entered into force on 1 July 2014

- Code on Noise Levels on Board Ships (under SOLAS 1974) and related 2012 amendments (chapters II-1, II-2 and III and appendix) to the International Convention for the Safety of Life at Sea, 1974, as amended (resolutions MSC.337(91) and MSC.338(91), respectively)
- 2012 amendments to the International Code for Fire Safety Systems (FSS Code) (resolution MSC.339(91))
- 2012 amendments to the Performance Standard for protective coatings for dedicated seawater ballast tanks in all types of ships and double-side skin spaces of bulk carriers (resolution MSC.341(91))
- 2012 amendments to the Performance Standard for protective coatings for cargo oil tanks of crude oil tankers (resolution MSC.342(91))
- 2012 amendments to the Protocol of 1978 relating to the International Convention for the Safety of Life at Sea, 1974, as amended (resolution MSC.343(91))
- 2012 amendments to the Protocol of 1988 relating to the International Convention for the Safety of Life at Sea, 1974, as amended (resolution MSC.344(91))
- 2012 amendments to the Protocol of 1988 relating to the International Convention on Load Lines, 1966, as amended (resolution MSC.345(91))
- 2013 amendments to the International Convention for Safe Containers (CSC), 1972 (resolution MSC.355(92))

Amendments to IMO instruments that have entered into force on 1 October 2014

- 2013 amendments to the annex of
- the Protocol of 1978 relating to the International Convention for the Prevention of Pollution from Ships, 1973 (amendments to Form A and Form B of Supplements to the IOPP Certificate under MARPOL Annex I) (resolution MEPC.235(65))
- 2013 amendments to the Condition Assessment Scheme under MARPOL Annex I (resolution MEPC.236(65))

The Adriatic's strong ships

Marijan Žuvić

On May 28, 2014 the Qatari port of Doha witnessed a humble maritime ceremony. The Croatian flag was lowered from the stern post of the 'Atlant Trina' and Panamanian ensign raised high. With a little help from paint and brushes the 'Atlant Trina' became the 'BSLE Nina'. In the hectic life of world shipping events like these are just a matter of everyday routine. But this particular event deserves a special, even historic place in the chronicles of Croatian shipping. You may be wondering if this is exaggeration. By no means, since 'Atlant Trina' was the very last Croatian-owned and operated heavy lift ship.

So a chapter on Adriatic's strong ships was closed after 35 years. A period long enough to be remembered. In all these years heavy lift shipping was an exclusive of Atlantska Plovidba from Dubrovnik. It was one of the leading shipping companies in the Adriatic for decades, dating back to the late 19th century. And a quite traditional one, firmly holding on to general cargo ships and bulk carriers. Therefore, the 1978 announcement of Atlantska Plovidba that it intended to purchase a heavy lift vessel the 'Super Scan' took everyone by surprise.

Over the years the company maintained a regular fortnightly line between the Adriatic and the UK's West Coast, with Rijeka, Šibenik, Salerno, Glasgow, Swansea, Newport, Lisbon, Venice and Trieste as regular ports of call. The heydays of the service, based on classic general cargo ships, passed a long time ago. In the summer of 1978 a new, promising cargo appeared: equipment for the huge new fertiliser plant planned to be constructed in the central Croatian town of Kutina. Enormous quantities of industrial equipment manufactured by British, and

Figure 1.
'Gruž' sailing by the ancient walls of Dubrovnik.
Source: Atlanska plovidba, Dubrovnik.

Figure 2.
'Gruž' at the open sea.
Source: Atlanska plovidba, Dubrovnik.

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Figure 3.
'Kutina'.
Source: Atlanska plovidba, Dubrovnik.

to a lesser extent, Dutch companies, had to be transported by ships to the port of Rijeka. Being a heavy oversized load, these cargoes required heavy lifters. So Atlantska Plovidba purchased the 'Super Scan', a six-year old ship.

In today's terms she was a small ship, only 80 meters in length but equipped with a 125 ton derrick. Built by the German shipyard Büsumer Werft G.m.b.H. she was owned and operated by Danish company Bjaesbjerg & Co. from Aarhus. Dubrovnik's crew took over the ship and christened it 'Kutina', in the port of Swansea on March 13, 1979. Several days later, the first of many shipments of equipment for the Kutina fertilising plant left Britain.

Being a pioneer among the strong ships of the Adriatic, she proved her worth by carrying heavy loads and sailed under the ensign of Atlantska Plovidba until 1990. And, believe it or not, a quarter of a century later she is still sailing! After being sold to a Lebanese owner, the ship was an active participant of commerce in the Mediterranean, sailing under various names and flags. She is currently sailing as the 'General' under the ensign of Palau, a tiny state in the Pacific.

The results of the 'Kutina's' operation, both technical and financial, were so satisfactory that Atlantska Plovidba decided to buy a second heavy lifter. In the summer of 1980 the 'Jahorina' joined the fleet. Likewise purchased from Danish company Bjaesbjerg, she was quite an unusual ship. She was built in 1969 by German shipyard Schlichting Werft of Travemünde, but as a pure container ship the 'Tipperary'! Ordered by a very old and renowned company, British & Irish Steam Packet Co. Ltd., better known as B+I Line, she was tailor-made for Dublin-Liverpool container services.

But, one of the first genuine box ships was only 78 meters long and with container capacity of scarce 74 TEU. And the boom of container trade across the Irish Sea was so tremendous that the 'Tipperary' became obsolete in only four years. She was sold to the Danish company and rebuilt into a really strong ship, equipped with two 350-ton derricks and named the 'Thor Scan'.

In a short time the 'Jahorina' proved very successful on the international market and prompted Atlantska Plovidba to expand her heavy lift fleet, soon to be known as the Atlant Heavy Lift. In late 1981 two further ships were purchased from Bjaesbjerg. The 'Titan Scan' was handed over in April 1982 and became the 'Molunat'. She was the smallest heavy lifter in the history of Dubrovnik's fleet, only 69 meters in length. And an oldie: built by Danish shipyard Sonderborg Skibsvaerft back in 1970. Nevertheless she proved useful. The so called Bjaesberg phase in the history of Atlant Heavy Lift ended in January 1983 when the vessel the 'Heavy Scan' joined the fleet as the 'Ston'. She was a sister ship of the 'Kutina'.

Boosted by the market success of her Danish quartet, Dubrovnik's shipping company made a big step forward in the summer of 1984 by purchasing a British-owned vessel the 'Starman Anglia'. She was launched at Wallsend-on-Tyne yard of Swan Hunter Shipbuilders in June 1977 and towed to Haverton Hill-on-Tees for a completion by Smith's Dock Co. Ltd. Delivered in early 1978, the vessel was 94 meters long and 16 meters wide, capable of carrying 1000 tons of cargo on the deck. She was equipped with a 300 ton German made Stülcken heavy derrick.

The most interesting feature of the 'Starman Anglia' was the possibility to have her port side funnel housing hinge outward or dismounted. The normal width of access to stern ramp with fixed funnel housing was 11 meters and the dismountable funnel gave her the additional flexibility of operation. Her owner, Blue Star Line of London, used the 'Starman Anglia' to carry large storage tanks from the Scottish port of Grangemouth to the massive Sullom Voe Oil Terminal in the North Sea.

Renamed the 'Lapad', she remained the most advanced heavy lift vessel in the fleet of Atlantska Plovidba for a long time. She served for 22 years and was finally broken up at Turkish Aliaga scrapyard in 2006.

Figure 4.
'Jahorina'.
Source: Atlanska plovidba, Dubrovnik.

Just a year after the 'Lapad' joined the fleet, two additional heavy lifters raised the flag of Atlantska Plovidba! The six year old Dutch sister ships the 'Elger' and the 'Enak' became the 'Plitvice' and the 'Kupari'. Both vessels were built by Scheepswerft 'De Waal' at Zaltbommel and delivered in the summer of 1979 to Linde Lloyd B.V. of Scheveningen. They were equipped with two heavy load derricks: with the capacity of 100 and 150 tons respectively.

So, in only six years, the fleet of Atlant Heavy Lift grew in size to the respectable seven ships. But that was only a prelude to the most important moment in our story: construction of the 'Gruž'! No other vessel in the Croatian shipping history attracted such attention in the world maritime community. In a short period of time, The Lloyd's List, the leading maritime publication in the world, published four articles on the 'Gruž'. Dutch naval architects, who designed her, and shipbuilders, who made her, were very proud of Dubrovnik's flagship. The world's leading classification society, Lloyd's Register of Shipping, was also proud. For the first time, the new term 'heavy lift, ro-ro, lo-lo, flo-flo' was used to describe this ship.

The story of the 'Gruž' begins in the late spring of 1985 when Atlantska Plovidba ordered her at Dutch shipyard Scheepwerf en Machinefabriek Ijsselwerf B.V. situated at Kapelle, a small town on the bank of the Ijssel River. The ship greatly differed from the heavy lifters of the time. Her dimensions were not so impressive:

Figure 5.
'Molunat'.
Source: Atlanska plovidba, Dubrovnik.

104 meters in length overall and 20.5 meters in breadth. But her possibilities were!

As a heavy lift ship she was equipped with twin electro hydraulic cranes mounted on the starboard side, each with a 200 ton main hoist (400 tons can be handled at 26 meters outreach) and a 25 ton auxiliary hoist. All were manufactured by specialized Dutch company Huisman Itrec of Schiedam. Owing to the sophisticated system of ballasting, 400 tons of cargo could be loaded/unloaded with only three degree inclination.

The main deck was built to support loads of 10 tons per square meter. Ship's hold, measuring 87.8 x 15.2 meters, had a double shell and was provided with a 15.52 meters wide stern

Figure 6.
'Lapad'.
Source: Atlanska plovidba, Dubrovnik.

ramp for ro-ro cargoes. And the same hold could be used as a floating dock! After opening 13 hatch covers the 'Gruž' could be submerged to the water depth of 3.5 meters above the hold floor and vessels weighting up to 2500 tons could be loaded in. Furthermore, containers could be carried on the main deck and hatches. We needn't list other technical details to understand that in 1985 she was a state-of-the-art ship.

The 'Gruž' was launched at Kapelle aan den Ijssel on November 28, 1985 and delivered to Atlantska Plovidba on March 27, 1986. Several days later, at Rotterdam, she loaded her first cargo, a heavy floating dredger for Morocco, and sailed as a dock ship on her maiden voyage.

A year after the entry of the acclaimed 'Gruž' into the fleet, yet another Dutch vessel came to the Adriatic. She was the 'Valkanier', built in 1978 by Gebroeder van Diepen's shipyard at Waterhuizen for specialized heavy lift shipping company Marlot of Rotterdam. Equipped with two derricks, each having the capacity of 180 tons, she was immediately chartered by Jumbo

Figure 7.
'Ston'.
Source: Atlanska plovidba, Dubrovnik.

Figure 8.
'Slano'.
Source: Atlanska plovidba, Dubrovnik.

Figure 9.
'Plitvice'.
Source: Atlanska plovidba, Dubrovnik.

Figure 10.
'Love Letter'.
Source: Atlanska plovidba, Dubrovnik.

Shipping to carry heavy equipment from Houston, Texas to the oil terminal on Arzanah Island in the Persian Gulf. In November 1987 the 'Valkenier' became the 'Slano' and continued world-wide trading until 2001.

The days of pride, sparked by the construction of the 'Gruž', soon became the years of silence. Faced with market turmoils and the consequences of brutal war against Croatia, the Atlant Heavy Lift was struggling to survive and over the following 15 years not a single ship joined the fleet. Older heavy lifters were sold and finally the glorious 'Gruž' left, sold in 1997 to the French company d'Orbigny of Boredaux. She became the 'Clipper Cheyenne' sailing under the flag of the Bahamas. Five years later her name was in the frontlines of world maritime publications. She sunk!

In early June 2002 she arrived to the Irish port of Foynes on the river Shannon to load a large dredger. While nearing the completion of the ballasting procedure to flood her cargo dock, the 'Clipper Cheyenne' rolled to starboard and hit the bottom. She rolled back up and rested on the seabed alongside the quay.

Figure 11.
'Atlant Svenja'.
Source: Atlanska plovidba, Dubrovnik.

Several crew members were thrown into the sea but luckily there were no fatalities and no serious injuries.

A renowned salvage company, Titan Maritime Industries of Fort Lauderdale, Florida, was hired to remove the ship from the port of Foynes. Former the 'Gruž' was raised on July 12, 2002 and a month later towed to Cherbourg for repairs. It took her over a year to return into service. After many name changes, flags and owners, the ship is still sailing. Her most recent name is the 'Papenburg', her owners are Germans and her flag that of the Caribbean state of Antigua & Barbuda.

After 15 long years, two ships finally joined the fleet of the Atlant Heavy Lift in 2002. These were second-hand sister ships with rather unusual names – the 'Love Letter' and the 'Love Song'. They marked the beginning of the German phase in the chronicles of Adriatic's strong ships.

Figure 12.
'Atlant Trina' – the last of ships.
Source: Atlanska plovidba, Dubrovnik.

Contrary to the previous practice of fleet renewal, these newcomers were already old: the 'Love Song' was built in 1986 and the 'Love Letter' in 1987. Originally they were called the 'Conti Nippon' and the 'Conti Gallia', as a part of a large series of ship designed and built by the renowned J.J. Sietas shipyard of Hamburg. Owing to German quality and reliable Finnish Wärtsilä main engine, the two Love boats were in good condition. Being 115 meters in length, the ships were equipped with a pair of 120 ton cranes.

Atlantska Plovidba purchased the duo from a heavy lift specialist company Schiffahrtkontor Altes Land G.m.b.H. of Steinkirch. Commonly known as SAL, it is a part of Heinrich family shipping business dating back to 1865. Nevertheless, with heavy lift equipment consisting of only two 120 ton derricks, these ships soon proved weak and were sold in 2006. But, a contract on the purchase of four heavy lifters was already signed with SAL.

These vessels were also built by J.J. Sietas shipyard and delivered between December 1994 and April 1996. Named the 'Frauke', the 'Regine', the 'Svenja' and the 'Trina', the sisters were 7 meters shorter than the Love boats but much better equipped to deal with heavy loads. Two 250 ton cranes allow 500 tons cargo to be handled. Furthermore they had the container capacity of 460 TEU. But their main new feature was a stability pontoon that was lowered into the water during loading/unloading operations. After joining the Croatian fleet, the quartet's names were changed by adding the prefix 'Atlant'.

It must be stressed that further fleet renewal based on second-hand vessels was not in the plans of Atlant Heavy Lift and that the purchase of four SAL sister ships was a forced decision. In June 2004, the Dubrovnik company signed a contract with Romanian shipyard Severnav S.A. of Drobeta-Turnu Severin to built two heavy lifters equipped with a pair of 250 ton cranes. It was stipulated that the first ship had to be delivered in December 2005 and the second in March 2006. But the contract, worth EUR 28 million, was cancelled already in September 2004, after Atlantska Plovidba refused to accept the builder's request for significant modifications.

After that, faced with the shortage of ships, the company opted for a further acquisition of second-hand tonnage. And the ships of choice were the SAL sisters. But it was the beginning of the end for the Adriatic's strong ships. Only four ships with classic technology and modest capacity were unable to play any role on the demanding international market. So in 2011, the ships were put up for sale, but at the worst possible moment. The crisis of the shipping industry was reaching its peak and no one was keen on buying Dubrovnik's lifters. It was months before the 'Atlant Regina' and the 'Atlant Svenja' found a buyer, a Chinese company. The farewell to the 'Atlant Frauke' and the 'Atlant Trina' had to wait until the spring of 2014.

At the very end of the story of Adriatic's strong ships it is worth noticing that all of them were lucky while sailing under

Dubrovnik's flag. Over quite a long period of 35 years, not a single seafarer's life and not a single ship were lost, quite a remarkable record indeed. Here is a dramatic photo that went around the world in August 2006.

The 'Atlant Trina' was unloading a shipment of huge plastic pipes at the Brazilian port of Niteroi when cargo on deck suddenly burst into flames. Intense fire was visible from many miles away and dozens of fire-fighters tried to extinguish it for over 24 hours. When it was all over, the 'Atlant Trina' looked devastated. But only a month later, in September 2006, she was repaired and returned to the sea...

Figure 13.
'Atlant Trina' in flames.
Source: Atlanska plovidba, Dubrovnik.

News

WÄRTSILÄ FOUND WAY TO REDUCE EXHAUST EMISSIONS

Wärtsilä is a global leader in complete lifecycle power solutions for the marine and energy markets. By emphasizing technological innovation and total efficiency, Wärtsilämaximizes the environmental and economic performance of vessels and power plants of its customers.

In 2013, Wärtsilä's net sales totaledto EUR 4.7 billion, with approximately 18,700 employees. The company has operations in nearly 200 locations in 70 countries around the world. Wärtsilä is listed on the NASDAQ OMX Helsinki, Finland.

The existing regulations of the International Maritime Organization (IMO) on air exhaust emissions and the efforts of the European Union to harmonize with IMO MARPOL Annex VI, have tremendous impact on shipping. Legislation already has effect on fuel markets in the regulated areas, since fuel prices are expected to increase even further in 2015 when the 0.1% fuel sulfur limit enters into force. As an alternative to the use of low sulfur fuels (Diesel or Natural Gas), the Finnish company Wärtsilä, as well as others, has developed exhaust aftertreatment systems which are already in use.

By January 1, 2015 all diesel engines of all seagoing vessels in the North- and Baltic Seas, the English Channel and in a 200 nautical mile zone along the U.S. Atlantic and Pacific coastlines, must either use fuels with sulfur contents equal to or under 0.1 percentage of weight, or be equipped with an exhaust aftertreatment device ensuring a corresponding low sulfur emission. The content of sulfur in ship fuels wasset at 3.5 percent and is intended to be reduced to 0.5 percent by 2020. The Norwegian cruise and transport shipping company Color Line in cooperation with Wärtsilä recently introduced its fleet retrofit program with scrubbers to reduce the sulfur emissions. As the Color Line's vessels operate solely in the Baltic Sea, they focused on three alternatives before they ordered scrubbers from Wärtsilä:

- Conversion of engines to use gas oil instead of heavy fuel, which may be the simplest but, due to significantly higher fuel price, an expensive solution.
- Conversion of engines to use natural gas instead of heavy fuel: Although this is an available technical solution and gas supply in Norway is plentiful, the conversion of engines and infrastructure onboard is very expensive.
- Continued engine operation within Wärtsiläwhich has a long and noted history of development of its scrubber system, working as closed loop systems with freshwater and caustic soda. In fact it was a pioneer among engine manufacturers in itsability to supply certified equipment.

In March 2014 Wärtsilä hadorders for the equipment for 45 vessels,i.e. for a total of 94 exhaust gas cleaning systemsfor both newbuild and retrofit projects – representing more than one year of production. However, Wärtsilä's scrubbers eliminate up to 98% of SOx from vessel emissions and reduce harmful particulate matter by up to 85%, allowing ferries to operate using conventional bunker fuel. Four separate Wärtsilä open loop scrubber systems will ensure a ship's full compliance with the International Maritime Organization's (IMO) MARPOL Annex VI regulations, and EU Directive 2055/33/EC.

Figure 1.
Source: https://www.flickr.com/photos/47392451@N07/5369914686/in/photolist-ebtAzB-9bt7SM-9bwdxY-4Cx6to.

Figure 2.

PRELUDE FLNG

Shell made its final investment decision on the Prelude FLNG Project on 20 May, 2011. It has started building a floating liquefied natural gas (FLNG) facility to produce and export LNG off the coast of Australia.Engineers worked over 1.6 million man hours during the front end engineering and design (FEED) phase of development for the Prelude FLNG Project. Shell has been pushing the Prelude FLNG project forward at a rapid pace.

It is now under construction and we are building up our organizational capacity in Australia to support the operations phase. The engineers cut the first steel for the facility's substructure in October 2012 and the major construction of the substructure and the topsides is currently well underway.

This follows from the cutting of first steel for the well heads in September 2011, the turret in May 2012 and the topsides in January 2013. Shell is preparing to drill seven Prelude development wells. This drilling program will be supported out of Broome, Western Australia.

The design and construction contract for the Prelude Darwin Supply Base has been awarded. Shell Australia is ramping up recruitment for the Prelude FLNG project. It launched the first major technical recruitment campaign in March 2013. Shell Australia is also working with universities and education providers to build expertise and capacity in Western Australia to support Prelude FLNG.

Through a multi-million dollar partnership with The University of Western Australia, Shell is funding a new chair at UWA's Energy and Minerals Institute to improve research and education in offshore engineering. The Global FLNG Training Consortium in Western Australia is a partnership between Shell, The Challenger Institute and the Curtin University. A multi-year training program under development will train FLNG technicians in Western Australia.

Prelude FLNG is the first of what we expect to be many Shell FLNG projects and builds on our existing capability and LNG leadership.

TECHNOLOGY

The floating facility will cool natural gas produced on site to –162 °C (-260 °F), shrinking its volume by 600 times so it can be shipped to customers around the world. Oceangoing carriers will load LNG and other liquid byproducts (condensate and LPG) for delivery to market. The Prelude FLNG facility will be 488 m (1,600-feet) long, 74 m (240-feet) wide and will displace around 600,000 tons of water.It will be the largest floating offshore facility in the world.The Prelude FLNG facility is being constructed at Samsung Heavy Industries' Geoje Island shipyard in South Korea.The Samsung shipyard is one of the few in the world big enough for the construction of a facility of this size.

Once constructed, the facility will be towed to its location, approximately 475 kilometers (around 300 miles) north-northeast of Broome, Western Australia. The facility will be moored and hooked up to undersea infrastructure and the whole production system commissioned.The Prelude FLNG facility was designed to withstand the most powerful tropical cyclones.

It will remain permanently moored at the location for around 20-25 years before being docked for inspection and overhaul. The LNG, LPG and condensate produced will be stored in tanks in the hull of the facility. LNG and LPG carriers will moor alongside to offload the products.The Prelude FLNG Project is well placed to help meet Asia's growing natural gas demand.

The project will create around 350 direct and 650 indirect jobs. The recruitment of staff to operate the facility will ramp up during 2013 and 2014. Prelude will also generate taxes and revenue to Australia, create opportunities for local businesses and result in Shell spending billions in capital and operating expenditure.The Prelude FLNG Project will use significantly less materials, land and seabed area than would be required for the production of the same amount of gas by a similar onshore facility.

Longer than four soccer fields and displacing six times more water than the largest aircraft carrier, the FLNG facility will be the biggest floating production facility in the world.

>600 engineers worked on the facility's design options

>200 km (125 miles) is the distance from the Prelude field to the nearest land

4 soccer fields, laid end to end, would be shorter than the facility's deck

175 Olympic-sized swimming pools could hold the same amount of liquid as the facility's storage tanks

6,700 horsepower thrusters will be used to position the facility

50 million liters of cold water will be drawn from the ocean every hour to help cool the natural gas

6 of the largest aircraft carriers would displace the same amount of water as the facility

93 meters (305 feet) is the height of the turret that runs through the facility, secured to the seabed by mooring lines

-162° Celsius (-260 °F) is the temperature at which natural gas turns into LNG

1/600 is the factor by which a volume of natural gas shrinks when it is turned into LNG

117 % of Hong Kong's annual natural gas demand could be met by the facility's annual LNG production

20-25 years is the time the Prelude FLNG facility will stay at the location to develop gas fields

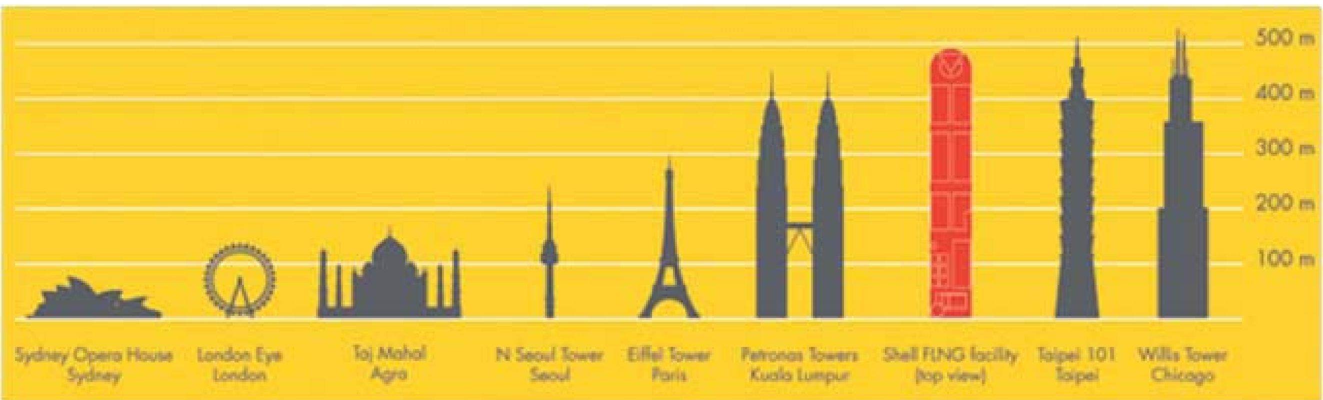

Figure 3.
From stern to bow the FLNG measures 488 m: its length is comparable to the height of iconic structures around the world.
Source: http://www.shell.com/global/aboutshell/major-projects-2/prelude-flng/by-numbers.html.

OLD MACHINERY IS NOT WELCOME AS OLD WHISKEY

The preliminary results of the Concentrated Inspection Campaign (CIC) on Propulsion and Auxiliary

Machinery, carried out between September 1 and November 30, 2013 in the Paris MoU region show that:

- 68 ships (41 % of all detentions) were detained for 3 months as a direct result of CIC for propulsion and auxiliary machinery deficiencies. Problem areas included main enginepropulsion, engine room cleanliness and emergency source of power/ emergency generator. In previous years propulsion and machinery installationdeficienciesin average accounted for 7% of the total number of deficiencies within the Tokyo and Paris MoU´s, ranking number six among all deficiencies in the categories statistics. Reason enough for the Paris MoU to focus on this area during CIC.
- More than half (54%) of all CICtopic related detentions involved ships older than 20 years. This category had a CIC-topic related detention rate of 3.6 %, which compares unfavorably to the overall 1.8% CIC-topic related detention rate. The CIC questionnaire was completed during 3,879 inspections on 4,126 individual ships. A total of 1,105 CIC-related deficiencies were recorded and 68 ships (1.8 %) were detained as a direct result of the CIC. 41% of the detentions during the CIC-period were CIC-topic related.

Other statistics of note include:

- During the campaign most inspections concerned general cargo/multi-purpose ships which accounted for 1,270 (33%)

Figure 4.

Source: https://www.flickr.com/photos/timzim/1824024699/in/photolist-jM8e9T-5mQMvN-dYGu5q-hkGGN7-gDTQNG-emAMxd-jNmQvG-ABA59-3MbAZH-33Eit-j7oyaS-gFS9Yw-abjjc3-2o17Y-6CzYig-9Q1jQJ-gDTZhh-gFSmGb-JCej-gFTfNV-dgtKbM-dgtM7s-dgtLkb-dgtJsn-dgtMDL-dgtLee-dgtLgN-dgtLH7-dgtLsG-dgtMqL-dgtM4j-dgtKkR-dgtMB1-dgtJin-dgtKDZ-dgtKhp-dgtMJd-dgtMbC-dgtJQc-dgtJKg-dgtKQg-dgtMfW-dgtJUv-fhoRYj-dgtLNu-fhoS3b-gFSua7-gFSGUY-8wDzNW-ABA2a.

inspections, followed by bulk carriers with 805 (21 %) inspections, containerships with 458 (12 %) inspections, chemical tankers with 343 (9 %) inspections and oil tankers with 272 (7 %) inspections.

- 34 (50 %) of the detained ships were general cargo/ multipurpose ships, 9 (13 %) bulk carriers and 9 (13 %) container ships. Among the other detained ships 6 were oil tankers, 4 chemical tankers and 3 refrigerated cargo ships.
- The analysis of the recorded deficiencies shows that most deficiencies pertain to main enginepropulsion (20 %), engine room cleanliness (18 %), emergency source of power/emergency generator (12 %) and emergency lighting/ batteries/switches (12 %).
- Most inspections were carried out on ships under the flags of Panama, with 495 inspections, Liberia, with 322 inspections, Malta, with 317 inspections and Antigua and Barbuda, with 246 inspections. The flags with the highest number of CIC-topic related detentions were Tuvalu with 1 CIC-topic related detention during 1 inspection, Tanzania with 6 CIC-topic related detentions during 27 inspections, Curacao with 2 CIC-topic related detentions during 16 inspections and Togo with 4 CIC-topic related detentions during 35 inspections. The CIC was a joint campaign with the Tokyo MoU.

COAST GUARD REPLACING AGING SHIPS WITH 91 NEW CUTTERS

The numerous cutters and craft of the U.S. Coast Guard — from sail training ship Eagleto large oceangoing patrol ships; from polar icebreakers to small utility boats — form a formidable fleet to meet the many challenging assignments undertaken by the service. In 2014 the Coast Guard continues its recapitalization program with its National Security Cutter (NSC), Fast Response Cutter(FPC) and Offshore Patrol Cutter (OPC). The service plans to procure 91 cutters (8 NSCs, 25 OPCs and 58 FRCs) to replace 90 aging cutters and patrol boats. The new ships will feature more automation and therefore have smaller crews.

Figure 5.
Source: Maritime Reporter &Engineering News • MARCH 2014.

DOES E-LEARNING WORK?

Once a question has been carefully analyzed and a reliable answer found, it is time to use this new knowledge to help answer the next series of important questions. This is the current situation in some parts of the maritime industry surrounding the question of whether eLearning works. To illustrate, some months ago there was a familiar discussion on an online maritime group debating whether eLearning works. Arguments on both sides cited anecdotes and conjectured on topics for which we already have solid answers provided by real research. This highlights the need for the wide dissemination of existing knowledge on this issue. Therefore, this article provides some of the most compelling evidence relating to the issue of whether eLearning works in the maritime industry. Thisknowledge can then be used to contribute to the discussion of other pressing, yet unanswered, maritime training questions such as how to overcome cultural and language barriers in training, how to raise the standard of all maritime training without increasing costs, and how to support a culture of safety through attention to training.

"Does eLearning work"? The answer is an unequivocal "YES". But as with any complex topic,there are many sides to that answer. So here are several quick, but very important, considerations.

Not All eLearning Experiences are Equal

Neither are all classroom experiences.There are excellent and poor examples of both online and classroom-based training. We don't abandon the classroom just because we had a terrible instructor once. Likewise, we should not abandon eLearning just because we have encountered poor implementations (of which there are many). So when considering the question of whether eLearning works, we are comparing offerings of roughly equal quality.

The Difference Between Knowledge & Skills

Maritime industry workers require both knowledge and skills to do their jobs safely and efficiently. It is important to realize that effective training techniques for knowledge are not the same as those for skills. All skills are built on a foundation of knowledge. Therefore even if you believe you are only learning a skill, there is always a strong knowledge component to that training. So both must always be considered.

Blended is Best for Knowledge

The evidence will be presented below, but here is a quick fact. All else being equal, when comparing online learning with classroom-based learning, they come out roughly equal for teaching knowledge, with eLearning offering a slight advantage. Yes, this is surprising, but it is a fact. More importantly, if you combine online and face-to-face training (a technique called "blended learning"), you get significantly better training outcomes than by employing either online or face-to-face training alone. This isvery important as it gives us an opportunity to make real training improvements that were simply not available to us 10 years ago.

No Substitute for Hands-On Training

This is one of the most common arguments I hear against online learning. Hands-on training for skills provides the context, experience, environment and tactile feedback that a simulation will approach, but never fully match. However, simulations will provide variety in, and control of, the training scenario that hands-on training can never match. Each approach offers something the other one does not. Therefore in this case we can use multiple, complementary training approaches to yield excellent results - better than either one approach is capable of producing alone.

Technology Offers Unique Benefits

In addition to improving training outcomes, adding a technology component to your training yields benefits not available otherwise. For example, eLearning systems are excellent providers of deep learning metrics and analytics. Theseare real-time data about how well your trainees are performing and where the gaps are. This allows you to continuously improve training at your organization and close gaps in training outcomes before they become safety or performance issues. Another example is how technology can bring training to the trainee. This has the effect of improving access to training, bringing it to those who might not otherwise have the opportunity. Technology also supports more flexible training delivery models. A very common and highly effective approach is to have trainees pre-train using eLearning, and then converge afterward at a central location for a shorter and more effective face-to-face experience. These are some of the quick facts. Let's take a look at the hard evidence now.

The Evidence

Arguably the best evidence in favor of the effectiveness of eLearning is a report published in 2010 by the U.S. Department of Education (U.S. DOE). The report is titled "Evaluation of Evidence-Based Practicesin Online Learning, A Meta-Analysis and Review of Online Learning Studies". The strength of this report comes from the fact that it is a meta-analysis. A meta-analysis looks at a large number of independent studies and draws a conclusion based on the strength of this large collection. This is powerful because the biases or flaws of individual studies are quickly filtered out

Figure 6.
Source: Maritime Reporter &Engineering News.

of the collective response. In the case of the U.S. DOE study, the meta-analysis looked at roughly 1,000 research studies, and then filtered them down to 45 which met rigorous design standards. From these studies the analysis came to several conclusions. Let' s look at some of the most notable quotes from this study:

Online Learning Outperforms Face-to-Face Learning

U.S. DOE Quote: "*Students in online conditions performed modestly better, on average, than those learning the same material through traditional face-toface instruction. Learning outcomes forstudents who engaged in online learning exceeded those of students receiving face-to-face instruction.*"

The difference in the effectiveness of online and face-to-face instruction is quite small, but it exists with the win going to online learning. From this we can say unequivocally that online learning most certainly does not produce inferior outcomes when compared to face-to-face instruction, as many incorrectly believe. In fairness, however, until I performed my own studies on eLearning effectiveness as a university researcher in the 1990s, I also assumed that eLearning would be inferior.
I was wrong.

Blended Learning is Best:

U.S. DOE Quote: "*Instruction combining online and face-to-face elements had a larger advantage relative to purely face-to-face instruction than did purely online instruction*."

The conclusion above indicates that when you use a combination of on-line and face-to-face training (referred to as "blended learning"), the learning outcomes are better than for either face-to-face or eLearning alone. This makes intuitive sense because each mode of learning has strengths the other one cannot offer. The implications are clear. If your goal is to provide the very best training possible, you should use a combined approach involving both face-to-face training and online learning.

Interaction with Peers and/or Instructors Improves Learning Outcomes:

U.S. DOE Quote: "*Effect sizes [i.e.the improvement in learning outcomes] were larger for studies in which the online instruction was collaborative or instructor-directed than in those studies where online learners worked independently.*"

This is a very important conclusion which cannot be stressed enough. One of the major advantages of online learning is its ability to connect people to one another, allowing them to learn from one another in a way that face-to-face training can't. While it is indeed possible and effective for trainees to learn online independently, the best outcomes are achieved when we use technology to connect people to further facilitate the learning process.

eLearning Works, Regardless of the Subject Matter:

U.S. DOE Quote: "*The effectivenessof online learning approaches appears quite broad across different content and learner types.*"

eLearning has been around long enough and studied long enough for us to safely conclude that it is effective for all kinds of knowledge acquisition. There is nothing about maritime knowledge ormaritime learners that makes the field immune to the benefits of eLearning. That is not to say that there are no hurdles to overcome in maritime eLearning - there are. For example, the availability of internet onboard, and the sophistication of vessel-based training both have slowed the adoption of eLearning in the industry. However, those obstacles are being (and have been) largely overcome by maritime-specific learning management systems (LMSs) and the industry is following suit by adopting eLearning methods. This study makes it clear that the benefits of eLearning are not domain-specific. eLearning works. It has strengths which create an opportunity to do better than we do now. It is not a replacement for face-to-face or hands-on training, that is the wrong discussion to be having because we already know the answer. The real discussion is about how we apply the strengths and advantages that eLearning brings to an industry that is in desperate need of better (not more)training, more uniform training, and a discussion on what we can do to achieve these.

FIRST ORDER FOR NEXT-GENERATION UEC50LSH-ECO MARINE DIESEL ENGINE DEVELOPED BY MHI-MME

- New Engine Offers Lower Fuel Consumption During Slow Steaming -

The first order for UEC50LSH-Eco low-speed marine diesel engine being developed by Mitsubishi Heavy Industries Marine Machinery & Engine Co., Ltd. (MHI-MME), a group company of Mitsubishi Heavy Industries, Ltd., was placed with Kobe Diesel Co., Ltd., a licensee of Mitsubishi UE engine technology located in Hyogo, Japan. The advanced low-fuel-consumption engine will ensure high efficiency even during slow steaming, and will be installed on a 35k chemical tanker being built by Shin Kurushima Dockyard Co., Ltd. The first UEC50LSH-Eco engine and chemical tanker are slated for completion in March and October of 2015, respectively.

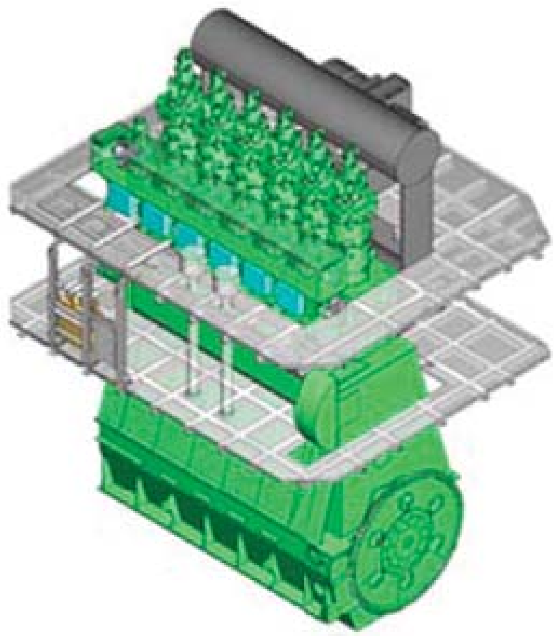

Figure 7.
Source: https://www.mhi-global.com/news/story/1405271803.html.

The UEC50LSH-Eco is the first in a new series of low-speed marine diesel engines that MHI-MME is developing to follow up on its LSE series. The new series is being developed in response to market demand for engines that offer lower fuel consumption with optimized performance at lower engine speed for slow-steaming, as well as better compliance with emission standards.

Based on thorough market research, the new engines will hold significant advantages in fuel efficiency achieving power output and engine speed optimized for bulk carriers (BC) such as Handymax BC, Supramax BC and Ultramax BC vessels, as well as medium size crude oil tankers, chemical tankers, and other similar vessels. In addition, the new series will maximize fuel consumption savings by enabling vessel operators to benefit from the enhanced propulsion efficiency of long-stroke, low-speed engine operation.

Using this first order for a UEC50LSH-Eco engine as a springboard, MHI-MME and its licensees will continue to propose various innovative energy-saving and environmental solutions to enhance seagoing energy efficiency and environmental preservation efforts, and will progressively apply these technological advances to a wide range of new engine products.

FIRST ORE CARRIER EQUIPPED WITH MITSUBISHI ENERGY RECOVERY SYSTEM (MERS) GOES INTO SERVICE

- Fuel Savings of 8% Achieved in At-Sea Trial-

A Mitsubishi Energy Recovery System (MERS) supplied by Mitsubishi Heavy Industries Marine Machinery & Engine Co., Ltd. (MHI-MME), a group company of Mitsubishi Heavy Industries, Ltd., has been installed on a VLOC (Very Large Ore Carrier) for the first time. The system significantly enhances power generation efficiency by maximizing recovery and utilization of exhaust gas waste energy from marine diesel engines, and demonstrated significant fuel consumption improvement compared with existing ships during at-sea trial. MERS ability to reduce fuel consumption and environmental impact has already been confirmed through installation and testing on container ships that consume large amounts of electricity, and this latest event successfullyconfirmed MERS' capability in other types of ships as well.

Figure 8.
In this instance, MERS was installed on an ore carrier of Mitsui O.S.K. Lines, Ltd. (MOL), built by Namura Shipbuilding Co., Ltd..
Source: https://www.mhi-global.com/news/story/1405221800.html.

MERS is a system that optimally controls exhaust gas turbines1 and steam turbines, enhancing fuel efficiency by recovering waste heat at a wide range of engine load. The latest MERS enables even greater waste energy recovery by incorporating shaft motors 2 that delivers surplus power back to the main engine. As a result, the new MERS is able to reduce fuel consumption by approximately 8%.

The number of MERS orders has progressively increased since the system's development in 2010, mainly for systems installed on refrigerated container (reefer) carriers that consume large amounts of electricity. The latest MERS at-sea trial, however, confirms MERS' ability to efficiently recover and utilize waste energy in smaller vessels as well. Leveraging these test results, MHI-MME intends to meet fuel efficiency needs in a wider range of seagoing vessels.

Going forward, MHI-MME will continue to propose various innovative energy-saving and environmental solutions to enhance seagoing energy efficiency and environmental preservation efforts.

Notes:
1. Turbines driven by engine exhaust gas.
2. Motors to assist propeller shaft rotation.

CAMPAIGN FOR JUSTICE FOR PANAMA CANAL WORKERS

The ITF (International Transport Workers' Federation) has ramped up its campaign against the Panama Canal Authority over its ongoing failure to provide decent pay and safe working conditions for more than 9,000 affiliated maritime workers in the canal zone.

The 44-mile canal is currently undergoing a $5.25 bn USD redevelopment, which will see the addition of two new locks and two new channels.

Today the representatives of four Panamanian unions, accompanied by ITF leadership, met with the Director-General of theInternational Labor Organization (ILO),Guy Ryderm at the ITF congress in Sofia, Bulgaria.

The ITF leadership, together with the Panamanian unions, submitted an application to the ILO Committee on Freedom of Association (CFA) against the Government of Panama.

They allege the violation of Conventions 87 and 98 on freedom of association and collective bargaining by the Panama Canal Authority.

The unions allege that the Panama Canal Authority failed to:

- demonstrate an appropriate level of observanceoflabor regulations;
- adequately observe the decisions of the National Labor Relations Board;
- provide compensatory guarantees due to the uniqueness of the Panama Canal working conditions;
- engage in good faith collective bargaining; and
- observe ILO freedom of association principles

ITF president Paddy Crumlin said the ITFwould continue to promote the best interests of workers.

"Panama is now a major transport, logistical and financial hub yet despite several meetings the Panama Canal Authority refuses to budge," MrCrumlin said.

"The ITF is very concerned about the lack of proper respect and bargaining on issues surrounding health and safety provision on the job and workers being forced to undertake double shifts and 18-hour workdays.

"This has an unacceptable impact on safety and there are also concerns around pay, training and freedom of association.

"That's why we've taken the step to submit an application to the ILO Committee on Freedom of Association against the Government of Panama."

The ILO set up the CFA for the purpose of examining complaints about violations of freedom of association, whether or not the country concerned has ratified the relevant conventions.

Complaints may be brought against a member state by employers' and workers' organizations.

"It is important for the Panamanian workers to know that the entire ITF congress is behind them and we will fight for better rights and conditions," ITF acting general secretary Steve Cotton said.

"Freedom of association and collective bargaining are among the founding principles of the ILO and we hope our intervention leads to an improvement in working conditions for the Panama Canal workers."

Figure 9.
Source: https://www.flickr.com/photos/lyng883/133066233/in/photolist-7ARGyu-cKZXp-cKZQT-cKZMs-7AMVe4-7ARGqm-7AMMKp-cKZxF-7ARGi1-7AMUQn-7AMVne-cKZHp-7AMV66-cL1xX-7dMPzE-7AMMZK-7AMMPt-7AMUSe-7ARK3w-7AMYtv-7AMVgv-7AMVbZ-7AMVhP-7AMV22-7AMVka-7ARLqd-7ARGv7-7AMVf6-aYNttZ-aYNvTD-7ANjdk-cL14e-cL14C-7h3aQr-cKZEM-cKZsS-7ARLaw-cL13X-7Qu6eT-7QxF1A-7QudjD-7QudjM-7AN3VX-mBxura-9QiD9K-cKZcg-cL19B-cL1AM-cL15V-7ARyXJ/.

Viški vàlcer

Ivica Roki

Jo son Višanin i volin Vis,
njegova poja, barda, moce,
maslinu, aloj i tamaris,
mendule, bore i rogoce.

Svaki Višanin voli svoj Vis,
njegovu more, vale, sike,
žoromod, smokvu, javor i vris,
levondu, lozu i planike.

Volimo Vis i višku rivu,
've store kuće i štitic jata,
svaku gomilu i stinju sivu,
is gradel ribu po sri pijata.

Jo volim Vis jer cvit je svita,
liposti take ninder vej ni,
divnja njegova svaka je lipa,
oci guštaju, sarce dunji.

Vis to je roj, beleca, pisma,
letrat kakov se ni ispenso',
puna je vecer kolica tisna,
vino se toci, a klapa kanto.

The Waltz of Vis

trans. by Mirna Čudić

I am a native of Vis and I love Vis,
its fields, hills, plains,
olive-trees, aloe, and tamarisk,
almonds, pine-trees, and carob-trees.

Every native of Vis loves his town,
its sea, bays, rocks,
its rosemary, fig-tree, maple-tree, and heather,
its lavender, vine, and macchia.

We love Vis and its sea promenade,
its old houses and flights of birds
every mound of stones and grey rock,
grilled fish served on a plate.

I love Vis because it is the flower of the world,
nowhere else can one find such beauty,
its every young maiden is beautiful,
making the eyes rejoice, and the heart throb.

Vis – it is a paradise, beauty, song,
a picture as yet unconceived,
the evening is full, the streets narrow,
wine is pouring while the merry company sings.

RJEČNIK

jo son	ja sam
moce	plodna oranica
mendula	badem, bajam
rogoc, rogoci	rogač, rogači
vala, vale	uvala, uvale
žoromod	ružmarin
vris	vrijes
levonda	lavanda
planika	česta biljka među makijom
‘ve store kuće	ove stare kuće
štitica	ptica
gomila	veća hrpa kamenja
stinja	stijena, kamen
gradele	roštilj
po sri pijata	posred tanjura
cvit	cvijet
svit	svijet
lipost	ljepota
ninder vej ni	nigdje drugdje nema
divnja	djevojka
lipa	lijepa
oci guštaju	oči uživaju
sarce dunji	srce tuče, bije
roj	raj
beleca	ljepota
pisma	pjesma
letrat	slika
kakov se ni ispenso’	kakav se nije izmislio
vecer	večer
kolica	kaleta, uličica
tisna	tijesna
toci	toči
kanto’	pjeva

About ToMS: Ethics, Conflict of Interest, License and Guides for Authors

The Journal is published in English as an open access journal, and as a classic paper journal (limited edition).

ToMS aims at presenting the best maritime research primarily, but not exclusively, from Southeast Europe, particularly the Mediterranean area. Papers will be double-blind reviewed by 3 reviewers. With the intention of providing an international perspective at least one of the reviewers will be from abroad. ToMS also promotes scientific collaboration with students and has a section entitled Students' ToMS. These articles also undergo strict peer reviews. Furthermore, the Journal publishes short reviews on significant papers, books and workshops in the fields of maritime science.

Our interest lies in general fields of maritime science (transport, engineering, maritime law, maritime economy) and the psychosocial and legal aspects of long-term work aboard.

1. PUBLICATION ETHICS

Ethical Policies of ToMS

Plagiarism is arguably the most complicated ethical issue. Our policies define plagiarism as "taking material from another's work and submitting it as one's own." ToMS *holds authors — not the Publisher or its editors and reviewers — responsible* for ensuring that all the ideas and findings included in a manuscript are attributed to the proper source. We also refer to our role as steward of what constitutes ethical conduct. Ethical misconduct is the reason for our commitment to continue to strive to educate all the parties in the publishing process how to handle this matter. As a member of Crossref, ToMS has a powerful weapon – iThenticate system, which is not perfect.

"Even if there were reliable and sensitive plagiarism detection software, many issues would remain to be addressed. For example, how much copying is legitimate? Clearly, the reuse of large amounts of others' text constitutes plagiarism. But what should one think about copying short passages from the author's own earlier work, such as commonly occurs in the Methods section? In the Nature article it is suggested that some journals set a quantitative limit whereby the amount of text that can be reused is limited to about 30 percent. This may be utilitarian, but it seems curious and arbitrary that 25 percent of copied text might be deemed acceptable whereas 30 percent might not. Indeed, two authors who copied the same number of words could find themselves on opposite sides of that border if one author simply was more verbose and thus diluted their plagiarized content below the threshold! No, this is not a simple issue at all." [cited from: http://newsletter.aspb.org/ethics.cfm]

Expectations for publishing in ToMS

Faculty of Maritime Studies expects authors submitting to and publishing in its journals to adhere to ethical standards to ensure that the work they submit to or publish in the journal is free of scientific misconduct. Authors must:

- Take credit only for work that they have produced.
- Properly cite the work of others as well as their own related work.
- Submit only original work to the journal.
- Determine whether the disclosure of content requires the prior consent of other parties and, if so, obtain that consent prior to submission.
- Maintain access to original research results; primary data should remain in the laboratory and should be preserved for a minimum of five years or for as long as there may be reasonable need to refer to them. All authors of articles submitted for

publication assume full responsibility, within the limits of their professional competence, for the accuracy of their paper. Instances of possible scientific misconduct related to papers submitted to or published in the ToMS will be addressed by following the procedure outlined below.

2. CONFLICT OF INTEREST

The authors, reviewers and other participant are obligated to clearly state possible conflict of interest. Editor-in-chief, senior editor and/or executive editors board decide on actions based on conflict of interest (COI).

Editors' Duty

Disclosure and Conflicts of Interest: The editor cannot use unpublished materials, disclosed in submitted manuscript for his/her own research, without prior written consent of the author(s).

If author(s) of submitted paper is a member of editorial board or editor-in-chief, the submission, review and decision process is carried by the highest ranking editor who is not the author.

Reviewers' Duty

All reviewers should have no conflict of interest with respect to the research, the authors and/or the funding bodies.

3. MALPRACTICE

Procedure for addressing allegations of scientific misconduct or other ethical violations

Scientific misconduct in publishing includes but is not limited to:

- Fraud: fabricating a report of research or suppressing or altering data;
- Duplicate publication;
- Plagiarism and
- Self-plagiarism.

Procedure for handling allegations of misconduct

- All allegations of scientific misconduct or ethical violation will be referred to the editor for research integrity or to the editor-in-chief. All allegations should be made in writing.
- Editor for research integrity will report the case in the meeting of the Editorial board and recommend the actions in 30 days.
- Except redraw of the paper, punishment could be inclusion in the black list of the journal and prohibition of further publishing in ToMS.

Submission declaration

Submission of an article implies that the work described has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere including electronically in the same form, in English or in any other language, without the written consent of the copyright-holder.

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For further details see the Creative Commons website.

5. PUBLICATION ETHICS AND MALPRACTICE STATEMENT

Unethical behavior is unacceptable and Transactions on Maritime Science does not tolerate plagiarism in any form. Authors who submit articles affirm that manuscript contents are original. Furthermore, authors' submission also implies that the manuscript has not been published previously in any language, either fully or partly, and is not currently submitted for publication elsewhere. Editors, authors, and reviewers, within the Transactions on Maritime Science are to be fully committed to good publication practice and accept the responsibility for fulfilling the following duties and responsibilities, as set by the COPE Code of Conduct for Journal Editors (http://publicationethics.org/resources/guidelines).

5.1 Duties of the authors

Reporting Standards: Authors should accurately present their original research, as well as objectively discuss its significance. Manuscripts are to be edited in accordance to the submission guidelines of the proceedings.

Originality: Authors must ensure that their work is entirely original.

Multiple, Redundant, or Concurrent Publications: Authors should not concurrently submit the same manuscript for publishing to other journals, or conference proceedings. It is also expected that the author(s) will not publish redundant manuscripts, or manuscripts describing the sameresearch in several publishing venues, after the initial manuscript has been accepted for publication.

Acknowledgement of Sources: Author(s) should acknowledge all sources of data used in the research and cite publications that have influenced their research.

Authorship of the Paper: Authorship should be limited only to those who have made a significant contribution to conceiving, designing, executing and/or interpreting the submitted study. All those who have significantly contributed to the study should be listed as co-authors. The corresponding author should also ensure that all the authors and co-authors have seen and approved the final submitted version of the manuscript and their inclusion as co-authors.

Data Access and Retention: Authors should retain raw data related to their submitted paper, and must provide it for editorial review, upon request of the editor.

Disclosure of Financial Support: All sources of financial support, if any, should be disclosed.

Fundamental errors in published works: When an author discovers a significant error or inaccuracy in his/her submitted manuscript, the author must immediately notify the editor.

5.2 Duties of reviewers

Confidentiality: Manuscript reviewers, the editor and the editorial staff must not disclose any information regarding submitted manuscripts. All submitted manuscripts are to be treated as privileged information.

Acknowledgement of Sources: Reviewers of manuscripts must ensure that authors have acknowledged all sources of data used in the research. Any similarity or overlap between the considered manuscripts, or with any other published paper, which is in personal knowledge of reviewer, must be immediately brought to the editor's notice.

Standards of Objectivity: Review of submitted manuscripts will be conducted objectively. The reviewers shall express their views clearly, with supporting arguments.

Promptness: If a reviewer believes it is not possible for him/her to review the research reported in a manuscript within the designated guidelines, or within stipulated time, he/she should notify the editor, so that the accurate and timely review can be ensured...

Conflict of Interest: All reviewers should have no conflict of interest with respect to the research, the authors and/or the funding bodies.

5.3 Duties of the editor

Publication Decisions: Based on the editorial board's review, the editor can accept or reject the manuscript or can send it for modifications.

Review of Manuscripts: The editor ensures that each manuscript is initially evaluated by the editor, who may make use of appropriate means, to examine the originality of the contents of the manuscript. After the manuscript passes this test, it is forwarded to two reviewers for double-blind peer review, and each of whom will make a recommendation to publish the manuscript in its present form or to modify or to reject it. The review period will be no more than30 days.

Fair Review: The editor ensures that each manuscript received is evaluated on its intellectual content without regard to authors' sex, gender, race, religion, citizenship, etc.

Confidentiality: The editor must ensure that information regarding manuscripts submitted by the authors is kept confidential.

Disclosure and Conflicts of Interest: The editor cannot use unpublished materials, disclosed in submitted manuscript for his/her own research, without prior written consent of the author(s).

6. GUIDELINES FOR AUTHORS

The Journal is published in English as an open access journal, and as a classic paper journal (limited edition).

ToMS aims at presenting the best maritime research primarily, but not exclusively, from Southeast Europe, particularly the Mediterranean area. Papers will be double-blind reviewed by 3 reviewers. With the intention of providing an international perspective at least one of the reviewers will be from abroad. ToMS also promotes scientific collaboration with students and has a section entitled Students'ToMS. These articles also undergo strict peer reviews. Furthermore, the Journal publishes short reviews on significant papers, books and workshops in the fields of maritime science.

Our interest lies in general fields of maritime science (transport, engineering, maritime law, maritime economy) and the psychosocial and legal aspects of long-term work aboard.

6.1 Before you begin

6.1.1 Ethics in publishing

For information on Ethics in publishing and Ethical guidelines for journal publication see Publication Ethics

6.1.2 Conflict of interest

All authors are requested to disclose any actual or potential conflict of interest including any financial, personal or other relationships with other people or organizations within three years of beginning the submitted work that could inappropriately influence, or be perceived to influence, their work.

6.1.3 Submission declaration

Submission of an article implies that the work described has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis or as an electronic preprint), that it is not under consideration for publication elsewhere, that its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and that, if accepted, it will not be published elsewhere including electronically in the same form, in English or in any other language, without the written consent of the copyright-holder.

6.1.4 Changes to authorship

This policy concerns the addition, deletion, or rearrangement of author names in the authorship of accepted manuscripts:

Before the accepted manuscript is published in an online issue: Requests to add or remove an author, or to rearrange the author names, must be sent to the Journal Manager from the corresponding author of the accepted manuscript and must include:

a. the reason the name should be added or removed, or the author names rearranged and
b. written confirmation (e-mail, fax, letter) from all authors that they agree with the addition, removal or rearrangement. In the case of addition or removal of authors, this includes confirmation from the author being added or removed. Requests that are not sent by the corresponding author will be forwarded to the Journal Editors and to the corresponding author, who must follow the procedure as described above.

Note that:
- publication of the accepted manuscript in an online issue is suspended until authorship has been agreed.

After the accepted manuscript is published in an online issue:

Any requests to add, delete, or rearrange author names in an article published in an online issue will follow the same policies as noted above and result in a corrigendum.

6.1.5 Copyright

Upon acceptance of an article, authors will be asked to complete an 'Exclusive License Agreement'. Permitted reuse of open access articles is determined by the Journal Open Source License (CC-BY).

6.1.6 Role of the funding source

You are requested to identify who provided financial support for the conduct of the research and/or preparation of the article and to briefly describe the role of the sponsor(s), if any, in study design; in the collection, analysis and interpretation of data; in the writing of the report; and in the decision to submit the article for publication. If the funding source(s) had no such involvement then this should be stated.

6.1.7 Open access

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6.2 Guidelines for authors: manuscript preparation and submission

6.2.1 Organization of the manuscript

First (title) page

The first page should carry:
a. the paper title;
b. full names (first name, middle – name initials, if applicable), and last names of all authors;
c. names of the department(s) and institution(s) to which the work should be attributed. If authors belong to several different institutions, superscript digits should be used to relate the authors' names to respective institutions. Identical number(s) in superscripts should follow the authors names and precede the institution names;
d. the name, mailing address and e-mail of the corresponding authors;
e. source(s) of research support in the form of financial support, grants, equipment or all of these.

Last page

The last page should carry:

a. ethical approval, if required;

b. authors' declarations on their contributions to the work described in the manuscript, their potential competing interests, and any other disclosures. Authors should disclose any commercial affiliations as well as consultancies, stock or equity interests, which could be considered a conflict of interest. The details of such disclosures will be kept confidential but ToMS urges the authors to make general statements in the Acknowledgement section of the manuscript.

c. a list of abbreviations used in the paper (if necessary);

Other pages

Each manuscript should follow this sequence:

- title page;
- abstract;
- text (Introduction, Methods, Results, Conclusions/ Discussion);
- acknowledgments;
- references;
- tables (each table complete with title and footnotes on a separate page);
- figures and figure legends, and the last page.

6.2.2 Text organization and style

6.2.2.1 Abstract

The second page should contain the Abstract. ToMS requires that the authors prepare a structured abstract of not more than 250 words. The abstract should include (at least) four sections: Aims, Methods, Results, and Conclusion, not necessarily separated.

Aim. State explicitly and specifically the purpose of the study.

Methods. Concisely and systematically list the basic procedures, selection of study participants or laboratory/ experimental/simulation setup, methods of observation (if applicable) and analysis.

Results. List your primary results without any introduction. Only essential statistical significances should be added in brackets. Draw no conclusions as yet: they belong in to the next section.

Conclusion. List your conclusions in a short, clear and simple manner. State only those conclusions that stem directly from the results shown in the paper. Rather than summarizing the data, conclude from them.

6.2.2.2 Main text

Do not use any styles or automatic formatting. All superscripts or subscripts, symbols and math relations should be written in MathType or Equation editor.

Introduction

The author should briefly introduce the problem, particularly emphasizing the level of knowledge about the problem at the beginning of the investigation. Continue logically, and end with a short description of the aim of the study, the hypothesis and specific protocol objectives. Finish the section stating in one sentence the main result of the study.

Results

Key rules for writing the Results section are:

a. the text should be understandable without referring to the respective tables and figures, and vice versa;

b. however, the text should not simply repeat the data contained in the tables and figures; and

c. the text and data in tables and figures should be related to the statements in the text by means of reference marks.

Thus, it is best to describe the main findings in the text, and refer the reader to the tables and figures, implying that details are shown there. The formulations such as "It is shown in Table 1 that the outcome of Group A was better than that of Group B" should be replaced by "The outcome of Group A was better than that of Group B (Table 1)."

The need for brevity should not clash with the requirement that all results should be clearly presented.

Discussion/Conclusions

The discussion section should include interpretation of study findings in the context of other studies reported in the literature. This section has three main functions:

a. assessment of the results for their validity with respect to the hypothesis, relevance of methods, and significance of differences observed;

b. comparison with the other findings presented in the relevant literature; and

c. assessment of the outcome's significance for further research.

Do not recapitulate your results, discuss them!

6.2.2.3 Tables

Information on significance and other statistical data should preferably be given in the tables and figures. Tables should not contain only statistical test results. Statistical significances should be shown along with the data in the text, as well as in tables and figures.

Tables should bear Arabic numerals. Each table should be put on a separate page. Each table should be self-explanatory, with an adequate title (clearly suggesting the contents), and logical presentation of data. The title should preferably include the main results shown in the table. Use tables in order to present the exact values of the data that cannot be summarized in a few sentences in the text.

Avoid repetitive words in the columns: these should be abbreviated, and their explanations given in the footnotes. Present data either in a table or a figure.

Each column heading for numerical data given should include the unit of measurement applied to all the data under the heading. Choose suitable SI units.

Place explanatory matter in footnotes, not in the heading.

Explain in footnotes all nonstandard abbreviations that are used in each table.

6.2.2.4 Figures

Figures should be numbered in sequence with Arabic numerals. Legends to figures should be listed on a separate page, in consecutive order. Minimum resolution for all types of graphics is 300 dpi and 600 dpi is recommended. The legend of a figure should contain the following information:

a. the word "Figure", followed by its respective number;
b. figure title containing major finding (e.g. Manuscripts which follow Guidelines for Authors had higher acceptance rate, and not Relationship with manuscripts style and their acceptance rate).

Use simple symbols, like closed and open circles, triangles and squares. Different types of connecting lines can be used. The meanings of symbols and lines should be defined in the legend.

Each axis should be labeled with a description of the variable it represents.

Only the first letter of the first word should be capitalized. The labeling should be parallel with the respective axis. All units should be expressed in SI units and parenthesized. Make liberal use of scale markings.

Graphs, charts, titles, and legends in accepted manuscripts will be edited according to ToMS style and standards prior to publication.

Preferred format for graphs or charts is xls. Graphs and charts saved as image (raster) files such as JPG, TIF, or GIF and imported or copied/pasted into Word or Power Point are not acceptable.

The resolution for photographic images should be at least 300 dpi, and minimum image width should be 6 cm. Please submit files in RGB format. For published manuscripts, image files will be posted online in their original RGB format, maintaining the full color of your original files. Note that we will still need to convert all RGB files to CMYK for printing on paper and color shifts may occur in conversion. You will not receive a CMYK proof. You can view an approximation of print results by converting to CMYK in Adobe® Photoshop® or Adobe® Illustrator®.

6.2.2.5 Authorship statement

All contributing authors must fill out and sign these statements and submit them to the Editorial Office. Accepted manuscripts will not be published until signed statements from all authors have been received.

6.2.2.6 Acknowledgments

Technical help, critical reviews of the manuscript and financial or other sponsorship may be acknowledged. Do not acknowledge paid services, e.g. professional translations into English.

6.2.2.7 References

References cited in the manuscript are listed in a separate section immediately following the text. The authors should verify all references. Usage of DOIs is encouraged.

Examples of citation in text:

It is well known fact (Strang and Nquyen, 1997; Antoniou, 2006) that FT is not an appropriate tool for analyzing nonstationary signals since it loses information about time domain.

First group of authors (Vetterli and Gall, 1989) proposed Multiresolution Signal Analysis (MRA) technique or pyramidal algorithm. Second group (Crochiere et al., 1975; Crochiere and Sambur, 1977) proposed subband coding algorithm. Legal acts are cited as in example: The Constitution of the Republic of Croatia (Constitution of the Republic of Croatia, 2010) is the main legal source for this subject matter, as well as any other subject matter relating to the Croatian legal system. References from the Web are cited in the text as (Author(s) last name, year of origin if known (year of accessed in other cases). If the author is unknown, such as in case of company web page, instead of author's name, title of the web page is used.

Examples for reference section:

Journals

Petrinović, R., Wolff, V. S., Mandić, N. and Plančić, B., (2013), International Convention on the Removal of Wrecks, 2007. – a New Contribution to the Safety of Navigation and Marine Environment Protection, Transaction on Maritime Science, 2(1), pp. 49-55.,
http://dx.doi.org/10.7225/toms.v02.n01.007

Pennec, E. and Mallat, S., (2005), Sparse Geometric Image Representations with Bandelets, IEEE Transactions on Image Processing, 14(4), pp. 423 – 438.,
http://dx.doi.org/10.1109/TIP.2005.843753

Web links

Donoho, D., Duncan, M. R., Huo, X. and Levi, O., (1999), Wavelab, available at: http://www.stat.stanford.edu /_wavelab/, [accessed 12 August 2011.].

Unknown, Wavelab, available at: http://www.stat.stanford.edu /_wavelab/, [accessed 12 August 2011.].

ToMS home page, available at: http://www.toms.com.hr, [accessed 12 July 2012.].

Books

Mallat, S., (2009), A Wavelet Tour of Signal Processing, 3rd Edition, New York: Academic Press.

Conference proceedings

Łutowicz, M. and Lus , T., (2013), Effect of Loss of Cylinder Pressure Indicating Channel Patency on Parameters Values Obtained from Indicating Graph, Proc. 5th International Maritime Science Conference, Solin, Croatia, April 22 – 23, pp. 382-389., available at: http://www.pfst.hr/imsc/archive/2013/IMSC2013_proceedings.pdf

Kingsbury, N.G. and Magarey, J.F.A., (1997), Wavelet Transforms in Image Processing. Proc. First European Conference on Signal Analysis and Prediction, Prague, Czech Republic, June 24 – 27, Birkhauser, pp. 23 – 24., available at: http://www.sigproc.eng.cam.ac.uk/~ngk/publications/ngk97b.zip, [accessed 12 August 2011.].

Regulations, standards or legal acts:

Constitution of the Republic of Croatia, (2010), Narodne novine, 2010(76), pp. (if known).

6.2.2.8 Supplementary materials

Supplementary materials are optional. Authors can submit different types of materials which will be available on-line.

6.2.2.9 Language

Authors may use standard British or American spelling, but they must be consistent. The Editors retain the customary right to style and, if necessary, shorten texts accepted for publication.

This does not mean that we prefer short articles – actually, we do not limit their size - but rather a resection of the obviously redundant material.

The past tense is recommended in the Results Section.

Avoid using Latin terms; if necessary, they should be added in parentheses after the English terms. Real names rather than “levels” or “values” should refer to parameters with concrete units (e.g. concentration).

6.2.2.10 Abbreviations

Only standard abbreviations and symbols may be used without definition and may be used in the title or the page-heading title.

Non-standard abbreviations should not be used in the title or page-heading title. They must be explained in the text in the following way: the term should be written in full when it appears in the text for the first time, followed by the abbreviation in parentheses; from then on, only abbreviation is used in the text. This applies separately to the Abstract and the rest of the text.

6.2.3 Submission of manuscripts

Paper submission via Open journal system.

Manuscripts can also be submitted to:

Editorial office
Transactions on Maritime Science,
Faculty of Maritime Studies,
Zrinsko-Frankopanska 38,
21000 Split, Croatia
www.toms.com.hr | office@toms.com.hr