

Impressum

EDITOR-IN-CHIEF

Ivica Kuzmanić
e-mail: ikuzman@pfst.hr

SENIOR EDITOR

Pero Vidan
e-mail: pvidan@pfst.hr

EXECUTIVE EDITORS

Research Integrity: Joško Šoda
Student's ToMS: Igor Vujović
Electronic Publishing: Vedran Elez,
Jadranka Kljajić, Luka Vidoš
Management: Nikola Račić
Language Editors: Adelija Čulić-Viskota,
Sanja Demut
Book Reviews: Andrija Nenadić
Manuscript Editor: Branka Bedalov

REGIONAL EDITORS

Andrej Dávid (Slovakia)
Andrzej Grzadziela (Poland)
Danilo Nikolić (Montenegro)
Frank Witlox (Belgium)
Mirsad Kulović (Bosnia and Herzegovina)
Nebo Jovanović (South Africa)
Liane Roldo (Brasil)
Tatjana Krilić (UK)

ADVISORY BOARD

Sanja Bauk (Kotor, Montenegro)
Zlatimir Bičanić (Split, Croatia)
Rudolf B. Husar (St. Louis, USA)
Natalija Jolić (Zagreb, Croatia)
Josip Kasum (Split, Croatia)
Danko Kezić (Split, Croatia)
Tomislav Kos (Zagreb, Croatia)
Zlatan Kulenović (Split, Croatia)
Artur Makar (Gdynia, Poland)
Krešimir Malarić (Zagreb, Croatia)
Rosanda Mulić (Split, Croatia)
Sanja Steiner (Zagreb, Croatia)
Elen Twrdy (Portorož, Slovenia)

EDITORIAL OFFICE

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

PUBLISHER

University of Split - Faculty of Maritime Studies
Zrinsko-Frankopanska 38,
21000 Split, Croatia
office@pfst.hr

DESIGN

Offstudio, Zagreb, Croatia
Ana Banić Göttlicher and Maša Vukmanović

Abstracting/Indexing:

Hrčak
Index Copernicus
TRID (the tris and ITRD database)
BMT | Marine Science and Technology
Google Scholar
Digitale Bibliothek Braunschweig
INSPEC

Subscription

Subscription runs for full calendar year. The price per volume, supplements and surface postage included: institutional € 15, individual € 10, and student € 8, or equivalent in other currencies; for Croatia: institutional HRK 120, individual HRK 70, and student HRK 50. Orders can be placed at Faculty of Maritime Studies (for ToMS); IMEX Bank, account number 7000001039, IBAN HR7724920087000001030, BIC/SWIFT IMXXHR22.

Published twice a year.

Printed on acid-free paper (print ISSN 1848-3305).
ToMS on line (ISSN 1848-3313) offers free access to all articles.

www.toms.com.hr



Transactions on Maritime Science (ToMS) is a scientific journal with international peer review which publishes scientific papers in the following areas:

- ~ Marine Engineering,
- ~ Navigation,
- ~ Safety Systems
- ~ Marine Ecology,
- ~ Hydrography,
- ~ Marine Automation and Electronics,
- ~ Transportation and Modes of Transport,
- ~ Marine Information Systems,
- ~ Maritime Law,
- ~ Management of Marine Systems,
- ~ Marine Finance,
- ~ Bleeding-Edge Technologies,
- ~ Multimodal Transport,
- ~ Psycho-social and Legal Aspects of Long-term Working Aboard.

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

ToMS aims to present best maritime research from South East Europe, particularly the Mediterranean area. Articles will be double-blind reviewed by three 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 titled Students' ToMS. These papers also undergo strict peer reviews. Furthermore, the Journal publishes short reviews on significant papers, books and workshops in the fields of maritime science.

The views and opinions expressed in the papers are those of individual authors, and not necessarily those of the ToMS editors. Therefore, each author will take responsibility for his or her contribution as presented in the paper.

All papers are checked by
CrossCheck Powered by iThenticate



Contents

- 90 **From Editor-in-Chief**
Ivica Kuzmanić

REGULAR PAPERS

- 91 **Problem of Boil - off in LNG Supply Chain**
Đorđe Dobrota, Branko Lalić, Ivan Komar
- 101 **Reliability and Availability of the Vessel Traffic Management and Information Systems**
Pančo Ristov, Pavao Komadina, Vinko Tomas
- 109 **Maritime English - What Does it Communicate?**
Adelija Čulić - Viskota, Sara Kalebota
- 115 **Concerning Web - based e - learning at a Maritime Higher Education Institution: Case Study**
Sanja Bauk, Roland Radlinger
- 123 **Environmental and Economic Benefits of Slow Steaming**
Marina Zanne, Milojka Počuča, Patricija Bajec

CONTRIBUTION

- 130 **News from IMO**
Tatjana Krilić
- 133 **Maritime Heritage: Ugly Ducklings that Made the History of Mankind**
Marijan Žuvić
- 143 **Transas Conference: Baltimore and Easton - Maryland, USA**
- 145 **News**

ART

- 156 **Our Croatia**
Tin Kolumbić (trans. by Mirna Čudić)
- 158 **Guidelines for Authors: Scope of Transactions on Maritime Science**

From Editor-in-Chief

Ivica Kuzmanić



Dear Readers,

After an excellent reception of the previous issues, you have before you the fourth issue of the internationally reviewed scientific journal "Transactions on Maritime Science" published by the Faculty of Maritime Studies of the University of Split. The Journal is published in an electronic, open access and printed form. Our desire is for our readers to have an easy access at minimum expense.

In this issue we publish papers from the scientific areas of maritime engineering, maritime management, maritime information systems, ecology and contemporary approach to the faculty education of seafarers. The authors presenting their papers in this issue come from Croatia and abroad.

We have remained faithful to the decision of publishing in each issue a paper aiming to improve our readers' knowledge of the English language. There is no need to emphasize how important it is to anyone in the seafaring business. The paper is interesting because its topic is no less than "maritime English".

We have also remained faithful to the other area we wish to promote, the preservation of our cultural heritage. Again a poem,

this time written in the dialect spoken by the inhabitants of the southern side of the island of Hvar. And once again, this is the only contribution presented in bilingual form: the vernacular of the author Tin Kolumbić and the inspired English translation by Mirna Čudić. The poet Tin Kolumbić was born in the village of Sv. Nedilja on our sunniest island – Hvar.

Our valuable London collaborator Tatjana Krilić brings us first-hand news from the International Maritime Organization. We bring you all the news from the last six months: since the previous issue of our Journal.

We also present a paper by our eminent publicist Marijan Žuvić - a maritime heritage story of the famous Liberty Ships.

Apart from the above, we also bring you short overviews of the Transas Conference held in the USA, on the innovation of Azipod marine propulsion, introduction of robots for fighting fires aboard ships, new generation LNG carriers, ballast-water-treatment system engineering, etc.

We still hope that the papers we publish will urge you to cooperate.

Problem of Boil - off in LNG Supply Chain

Đorđe Dobrota, Branko Lalić, Ivan Komar

This paper examines the problem of evaporation of Liquefied Natural Gas (LNG) occurring at different places in the LNG supply chain. Evaporation losses in the LNG supply chain are one of the key factors for LNG safety, technical and economic assessment. LNG is stored and transported in tanks as a cryogenic liquid, i.e. as a liquid at a temperature below its boiling point at near atmospheric pressure. Due to heat entering the cryogenic tank during storage and transportation, a part of the LNG in the tank continuously evaporates creating a gas called Boil-Off Gas (BOG), which changes the quality of LNG over time. The general methods of handling and utilization of the Boil-Off Gas at different points in the LNG supply chain are presented. Attention is given to the issue of LNG energy content transferred during loading and unloading of LNG tankers, as well as to the Boil-Off Gas generated by evaporation of the cargo during maritime transport. The results presented in the paper have been derived from the scientific research project 250 - 2502209 - 2366 „Management of Ship Power Systems under Fault Conditions and Failure“ supported by the Ministry of Science, Education and Sports of the Republic of Croatia.

KEY WORDS:

- ~ Liquefied
- ~ Natural gas
- ~ Supply chain
- ~ Boil-off gas
- ~ Gas utilization and use
- ~ LNG energy content

1. INTRODUCTION

Owing to the ever increasing share of the natural gas in the world consumption of power sources, international maritime traffic with liquefied natural gas is continuously growing, with even greater expectations for the future.

A large portion of natural gas is located far from large customers. Most of the international trade in natural gas, depending on the distance, takes place by pipelines and LNG ships in liquid form, and rarely in special heat insulated tanks by rail or road transportation. Due to lower investment costs, the transportation of gas by pipelines is preferred up to distances of about 2000 km. After that, the costs grow significantly faster than the costs of transportation of gas in liquid form, with a tendency for change if advances in technology are made. The LNG market has greater flexibility because, in general, the capacity of one exported unit may cover the capacity needed for two or three imported units.

Furthermore, it is clear from the current worldwide liquefied natural gas market that LNG tends to be exported to regions where gas prices are higher (Asia, USA and Europe), and this flexibility does not exist or exists to a lesser extent in transportation by pipelines.

LNG has been steadily increasing its market share in the global gas trade. According to data from the IEA (International Energy Agency) statistical review for 2010, the global LNG market now accounts for about 9% of demand for natural gas or 299 billion m³.

Liquefied natural gas is stored and transported in tanks as a cryogenic liquid, i.e. as a liquid at a temperature below its boiling point. Just like any liquid, LNG evaporates at temperatures above its boiling point and generates BOG. Boil-off is caused by the heat ingress into the LNG during storage, shipping and loading/unloading operations. The amount of BOG depends on the design and operating conditions of LNG tanks and ships.

University of Split, Faculty of Maritime Studies, Zrinsko-Frankopanska 38, 21000 Split, Croatia

E-mail: ddobrota@pfst.hr, blalic@pfst.hr, ivan.komar@pfst.hr

The increase in BOG increases the pressure in the LNG tank. In order to maintain the tank pressure within the safe range, BOG should be continuously eliminated. In the LNG supply chain, BOG can be used as fuel, re-liquefied or burned in a gasification unit. Furthermore, the more volatile components (nitrogen and methane) boil-off first, changing LNG composition and quality over time. This phenomenon, known as ageing, is especially important in LNG trade since LNG is sold depending on its energy content, i.e. specification at the port of unloading determined depending on the volume of the LNG transferred, its density and heat value.

This paper deals with the problem of boil-off in the LNG supply chain and its main causes. The general methods of handling and utilization of BOG at different points in the LNG supply chain are presented. Furthermore, the paper presents a calculation method used in the LNG industry to determine LNG energy content transferred during loading and unloading of LNG tankers.

2. FEATURES OF LNG AND ITS SUPPLY CHAIN

Liquefied natural gas is a liquid substance, a mixture of light hydrocarbons primarily composed of methane (CH₄, 85-98% by volume), with smaller quantities of ethane (C₂H₆), propane (C₃H₈), higher hydrocarbons (C4+) and nitrogen as an inert component. The composition of LNG depends on the traits of the natural gas source and the treatment of gas at the liquefaction facility, i.e. the liquefaction pre-treatment and the liquefaction process. It can also vary with storage conditions and customer requirements (Benito, 2009; British Petrol and International Gas Union, 2011).

Namely, LNG producers determine the quality of their LNG based on the composition of field gas and more importantly, market demand.

Liquefied natural gas is a colourless, odourless, non-corrosive and non-toxic liquid, lighter than water. Typical thermo-physical properties of LNG are presented in Table 1.

Table 1.
Thermo-physical properties of LNG.

Parameter	Value
Boiling point	-160°C do -162°C
Molecular weight	16 – 19 g/mol
Density	425 - 485 kg/m ³
Specific heat capacity	2,2 – 3,7 kJ/kg/°C
Viscosity	0,11 – 0,18 mPa·s
Higher heat value	38 - 44 MJ/m ³

LNG may be classified in accordance with several criteria: Density, Heat Value, Wobbe Index, Methane or Nitrogen amount, etc. The parameter most commonly used for its classification is density. Accordingly, we differentiate between heavy, medium or light LNG's. The typical composition and density of three typical LNG qualities are depicted in Table 2.

Table 2.
Classification of LNG by density (Sedlaczek, 2008).

Composition (%)	LNG Light	LNG Medium	LNG Heavy
Methane	98.00	92.00	87.00
Propane	1.40	6.00	9.50
Propane	0.40	1.00	2.50
Butane	0.1	0.00	0.50
Nitrogen	0.10	1.00	0.50
Density (kg/m ³)	427.74	445.69	464.83

The LNG supply chain consists of extraction and production of natural gas, liquefaction, marine transportation of LNG, and LNG storage, re-gasification and delivery of natural gas to consumers.

The extraction of natural gas from the earth's surface is the first step in the supply chain and includes drilling and gas extraction. The gas produced can come from a gas field (non-associated gas) or be produced along with oil (associated gas). The distinction between associated and non-associated gas is important because associated gas must have liquefied petroleum gas (LPG) components (i.e., propane and butane) extracted to meet the heat value specifications of the LNG product. Natural gas derived directly from the gas field is called "raw" gas. Such gas is associated with a number of other compounds and gases that may have an adverse effect on liquefaction and combustion.

The produced natural gas is transported by pipelines from gas fields to a liquefaction facility, located in large areas along the coast. One of the primary purposes of liquefaction plants is to ensure the consistent composition and combustion characteristics by cooling and condensing natural gas to allow its loading onto tankers as LNG and delivery to the end user. Therefore, their design must include several parallel processing modules (trains) for the preparation and liquefaction of natural gas, LNG storage tanks, facilities for loading LNG tankers, general purpose facilities, i.e. sea water pumping stations, electricity generation plants, nitrogen production plants, compressor stations, workshops and system security.

The technical processes of purification of gas from harmful components to obtain gas acceptable for use and liquefaction are performed in the preparation trains. Therefore the following need to be removed prior to liquefaction: components that would freeze at cryogenic process temperatures during liquefaction (carbon dioxide- CO_2 , water and heavy hydrocarbons), components that must be removed to meet the LNG product specifications (hydrogen Sulfide- H_2S), corrosive and erosive components (mercury), inert components (helium and nitrogen) and oil. Typical specifications of gas for liquefaction are less than 1 ppm of water, less than 100 ppm CO_2 and less than 4 ppm H_2S .

Following the removal of most contaminants and heavy hydrocarbons from the feed gas, the natural gas is subjected to the liquefaction process. Natural gas is converted to its liquefied form by the application of refrigeration technology making it possible to cool the gas down to approximately -162°C when it becomes a liquid.

The produced LNG is stored in cryogenic tanks below the boiling point at the pressure of 0.05-0.2 bar until an LNG tanker arrives to transport the product. Upon the arrival of the tanker, LNG from the storage tank is loaded from the loading plant into the LNG tanker, which will transport the gas to the receiving terminal. For safety reasons, storage tanks at loading and receiving terminals in which liquefied gas is stored usually consist of two tanks designed to be fully loaded. The inside of the container in which liquefied gas is stored is usually made of stainless steel resistant to low temperatures. The outer tank is made of pre-stressed concrete and designed to fully contain LNG in case of spillage and be fully loaded in the event of damage to the inner tank. Apart from safety aspects, LNG tanks are also designed to minimise the ingress of heat into the tanks to prevent the boiling (evaporation) of a fraction of the LNG. The usual tank volumes range from 80.000 to 160.000 m^3 .

Step three in the LNG supply chain is the transportation of liquefied natural gas to the receiving terminal. Liquefied natural gas is carried by specially designed ships, LNG tankers, in specially insulated tanks inside the hull at near atmospheric pressure, at the temperature of -163°C . In these tanks, the cargo is kept fully refrigerated using insulation and the effect of a small amount of evaporated cargo generated during the voyage. LNG tankers are a combination of classic ship design, special materials and advanced containment systems for handling cryogenic cargo. Today there are four containment systems in use on these vessels. Two of the designs are of the self supporting type, namely Moss spherical tanks and SPB tanks (Self supporting Prismatic type B tank). The other two are of the membrane type and today their patents are owned by Gaz Transport & Technigaz (GTT). Operating pressure in containment tanks ranges between 0.05 and 0.12 bar, at which LNG cargo reaches the equilibrium temperature corresponding to the operating pressure. All LNG

tankers have double hulled design, which greatly increases the reliability of cargo containment in the event of grounding and collision.

The majority of existing LNG tankers have the cargo capacity ranging between 120,000 m^3 and 150,000 m^3 , with some ships having the storage capacity of up to 264,000 m^3 . Due to the required high-capacity, re-liquefaction plants for evaporated cargo are generally not installed into these vessels. Since evaporated cargo provides a source of clean fuel, most LNG tankers have a steam-turbine propulsion system. The reason is high reliability and safe use of evaporated cargo that burned in the boilers. Q-flex type tankers having the capacity of 210,000-216,000 m^3 and Q-max tankers having the capacity of 260,000-270,000 m^3 constructed with re-liquefaction plants are exceptions. These vessels are intended for long distance transportation of liquefied natural gas, for example from Qatar to the United Kingdom or the United States. Loading and unloading rates vary between 12,000 and 14,000 m^3 per hour depending on the size of the LNG tanker. During loading, according to IMO (International Maritime Organization) requirements each tank is filled to 98% of its total volume. The remaining 2% of storage volume is required to prevent any entry of the liquid into ventilation pipeline and from spilling into the surrounding hull structure. Between 98.5 and 99% of the cargo is unloaded. The remaining quantity of LNG remaining on board after unloading, called a "heel", is used during the ship's ballast voyage to keep the tanks cold, as well as fuel for the propulsion system and the ship's energy system.

The receiving terminal (sometimes called a re-gasification facility) is the fourth and last component of the LNG supply chain. Its basic task is to receive and unload liquefied natural gas from LNG tankers, store, vaporise LNG and distribute the gas into the distribution network (Dundović et al., 2009). The receiving terminal is designed to deliver the specified quantity of gas into the distribution pipeline and maintain a reserve quantity of LNG. Therefore, its design must include the following elements: a system for receiving and discharging LNG tankers, storage tanks, a re-gasification plant, a control system to control the LNG boil-off gas, supplying their own consumption (utilities), equipment and facilities support. Since natural gas is odourless, the odourisation of the re-gasified natural gas is required in many regions and countries before its distribution to consumers. An atypical odorant is mercaptan or tetrahydrothiophene (British Petrol and International Gas Union, 2011).

3. BOIL-OFF IN THE LNG SUPPLY CHAIN

Liquefied natural gas is stored and transported in tanks as a cryogenic liquid, i.e. liquid at a temperature below its boiling point. Due to heat leakage into LNG and its cryogenic

nature, during storage, shipping and loading/unloading modes LNG continuously evaporates. Inside the tanks, LNG exists in an equilibrium between a thermodynamic liquid and vapour, depending on the given pressure and temperature. Since pressure in the tank is low, the multi-component mixture system acts in keeping with Raoult's law (Figure 1). In Figure 1, p is the total vapour pressure of the vapour phase, p_i^{sat} the saturation pressure of a pure component i in the liquid phase at temperature T , y_i and x_i the fraction of component i in the vapour phase and the liquid phase and K_i the dimensionless equilibrium ratio. Therefore, any heat ingress causes evaporation of the liquid on its surface without any visible bubbles. Namely, to keep the temperature constant and appropriate for tank pressure, LNG will cool itself (auto-refrigeration) by evaporating a small portion of the LNG and generated BOG (Dimopoulos and Frangopoulos, 2008; British Petrol and International Gas Union, 2011).

<p>Vapor at T, p, y_i</p> $y_i \cdot p = p_i^{sat}(T) \cdot x_i$ $K_i = \frac{p_i^{sat}(T)}{p} = \frac{y_i}{x_i}$
<p>LNG at T, p^{sat}, x_i</p>

Figure 1.

General criteria for the vapour-liquid equilibrium for LNG as multi-component mixture.

The quantity of BOG depends on the design and operating conditions of storage tanks and a ship's cargo tanks. The LNG supply chain with boil-off source is shown in Figure 2.

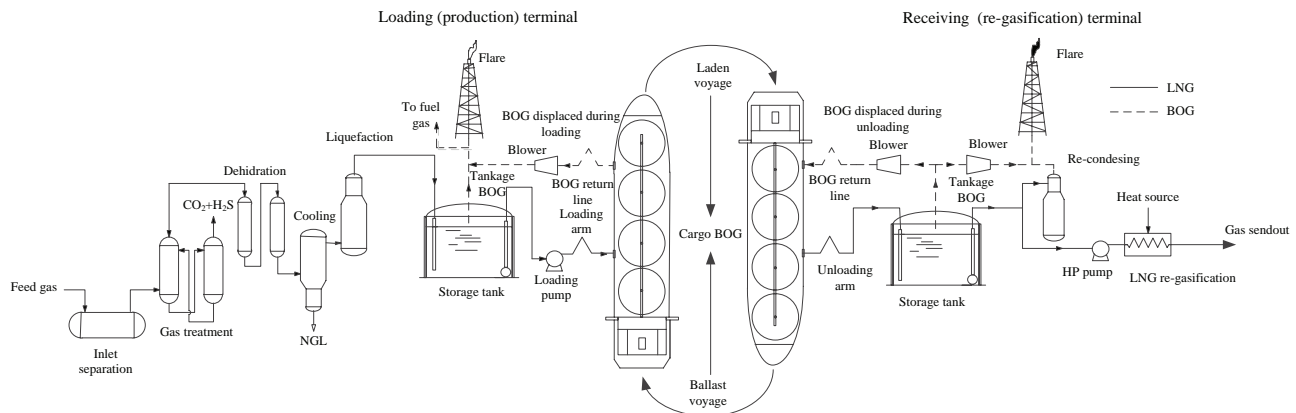


Figure 2.

LNG supply chain and boil-off source.

The increase of BOG in storage and ship's tanks increases the LNG operating tank pressure. In order to maintain the operating tank pressure within the safe range, BOG should be continuously removed. At the loading terminal, BOG is usually used as fuel in the liquefaction plant production process. At receiving terminals, it is either burned or sent to the re-gasification plant using BOG compressors.

During the journey of an LNG tanker, depending on the type of the propulsion system, BOG can be utilized as fuel, re-liquefied or burned in a gasification unit. Since the boiling points of different components of LNG widely vary, from -196°C to $+36^{\circ}\text{C}$, the rates of evaporation of more volatile components, such as Nitrogen and Methane, are higher than those of heavier components, i.e. ethane, propane and other higher hydrocarbons (Sedlaczek, 2008). Therefore, the quality and properties of LNG steadily change over time. This slow but continuous process is called ageing or weathering of LNG (Faruque, Zheng Minghan and Karimi, 2009; Głomski and Michalski, 2011; Benito, 2009; British Petrol and International Gas Union, 2011).

In the LNG supply chain, LNG is sold at the receiving terminal, depending on its energy content typically measured in GJ, GWh or MMBTU. Ship charterers, mostly oil & gas or energy companies, buy LNG cargo at the loading terminal at a certain production cost, i.e. Free On Board (FOB) price and sell LNG at the receiving terminal at a higher Cost-Insurance-Freight (CIF) price which includes the cost of fuel, insurance, port charges and charter rate. Since BOG reduces the quantity of cargo delivered by LNG tankers and increases the heat value of LNG in storage and ship's tanks, the quantity of BOG is a key factor for the technical and economic evaluation of the LNG supply chain.

3.1. Boil-off of LNG in storage tanks during holding mode

The holding mode is referred to as the period between loading/unloading of LNG tankers (Sedlaczek, 2008). At loading and receiving terminals, LNG is stored in cryogenic storage tanks at standard operating pressure ranging from 0 to 0.15 bar above atmospheric pressure. There are two main sources of boil-off gas during storage of LNG in holding mode, namely heat ingress into storage and pipes from the surroundings and changes in the ambient (barometric) pressure.

Heat ingress from the surroundings means that BOG is generated continuously in the tanks. In order to reduce boil-off, storage tanks have multi-layered insulation that minimizes heat leakage. The driving force for heat ingress into an LNG tank is the difference between the outside temperature and tank temperature. Due to the large temperature differences between the medium and the environment, the heat ingress into the LNG through floor, walls and roof of storage tanks (Figure 3) may occur in three ways: by conduction, by convection and by radiation.

Storage tanks are typically designed to reduce the ingress of heat from the surroundings and solar heating so that vaporisation is less than 0.05 % of the total tank content per day, although this can vary from 0.02 to 0.1% (British Petrol and International Gas Union, 2011).

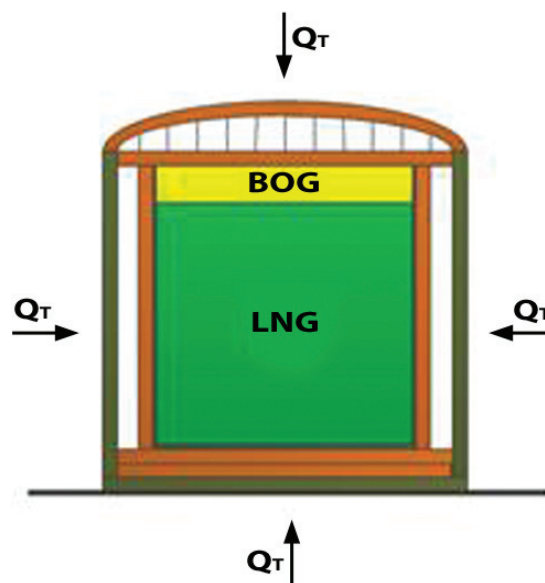


Figure 3.
Heat ingress into storage tank.

At loading and receiving terminals, a typical loading/unloading system consists of loading/unloading arms, circulation pipelines transferring LNG from ships to storage tanks and vice versa, pumps, etc. During the holding mode, a small portion of LNG circulates through the pipelines to maintain their cryogenic temperature. Circulating through the pipeline, LNG absorbs the heat from the surroundings and the heat generated from pumping, turbulent flow, and line friction. The absorbed heat generates additional BOG in storage tanks. This quantity of BOG depends on the length of the pipeline and the power of the pumps (Faruque et al., 2009; Sedlaczek, 2008; British Petrol and International Gas Union, 2011).

In storage tanks, a significant increase in the boil-off rate can cause a drop in atmospheric pressure. As atmospheric pressure drops, tank pressure and bubble point temperature of LNG decrease. To equilibrate with this lower pressure, the temperature of the LNG in the tank has to decrease by approximately 0.1°C for every 0.01 bar drop (Sedlaczek, 2008). This favours greater boil-off because the only way to decrease the temperature in the tank is to release some of the liquid into gas. A drop in atmospheric pressure only has effect if it is rapid, because it is only then that it can cause a significant increase in the boil-off rate from the storage tank.

BOG produced during holding mode in storage tanks is usually called tankage BOG (Faruque et al., 2009). When heat is added into LNG, the vapour pressure inside the tank increases. In order to maintain the tank pressure within the safe range, tankage BOG should be removed by compressors.

At loading terminals, BOG is usually compressed and exported to the plant fuel system. At receiving terminals, BOG is compressed in a re-gasification plant where it can be compressed and exported as gas or liquefied and exported as gas. In case of condensation problems, the vapour is burnt.

3.2. Boil-off during loading/unloading mode

The loading/unloading mode is the period when an LNG tanker is moored to the jetty at loading and receiving terminals and connected to onshore storage tanks with loading/unloading arms and insulated pipelines.

Modern LNG terminals are designed to accept LNG-tankers having the capacity from 87,000 m³ to 270,000 m³. Loading or unloading facility is of a size compatible with the standard loading rate of 10,000-12,000 m³ per hour, allowing LNG tankers to load or unload 125,000-270,000 m³ within 12-18 hours, depending on the size of the ship (Dundović et al., 2009; Faruque et al., 2009).

BOG generated during loading and unloading of an LNG tanker is typically 8-10 times greater than tankage BOG (Benito, 2009). The reason is mainly the return of vapour from the ship's or storage tanks. The main sources of BOG released during the ship loading/unloading process are presented in Table 3.

LNG tanker is loaded by the terminal's pumps and unloaded by the ship's pumps. During the loading/unloading operations, large quantities of LNG are pumped from the ship in a short time. This causes rapid change of pressure. During the loading process, the loaded LNG displaces an equivalent quantity of vapour in the

ship's empty cargo tanks. In order to maintain the cargo tanks at their operating pressure, the displaced vapour from the ship's cargo tanks is returned to the storage tank via the vapour return line. During the cargo unloading process, the vapour pressure of the boil-off gas generated during loading and unloading is of short duration at the high flow rate usually taking 12-18 hours, depending on the terminal's loading/unloading capacity. This flow rate depends on the pressure and temperature differences between the ship's tanks and storage tanks.

LNG tanker cargo tanks are maintained by returning vapour from the storage tanks (displaced by the terminal's blowers) to fill the ullage space in tanks. With this balanced system, under normal circumstances no BOG will be released to the atmosphere from ship or shore.

The energy used by the terminal's and ship's pumps greatly influences the boil-off rate. A typical LNG tanker having the capacity of 130,000 m³ requires over 3,000 kW of pumping energy. During pumping, due to friction and turbulence, almost all of this energy is converted into heat adsorbed by the LNG. This large amount of heat is sufficient to heat the LNG by as many as 0.5°C. To provide for the new tank conditions, LNG cools itself down by evaporating a small portion of LNG. This process is called auto - refrigeration and can generate approximately 20,000 kg per hour of BOG (Sedlaczek, 2008). Although the circulation pipelines are well insulated, some heat from the surroundings always leaks into LNG. The extent of the heat leak depends on pipeline length. If the pipeline is relatively short (under 1 km), the heat components from LNG pumping and heat leaks into pipelines are relatively small and generate typically around 5% of total BOG. In case of greater lengths, there is a significant increase in the quantity of BOG. For example, if the pipeline is 7 km long, the quantity of BOG generated by these heat components is estimated at 45% of total BOG (British Petrol and International Gas Union, 2011).

Table 3.
Main factors affecting the quantity of BOG released during the ship loading/unloading process.
Source: British Petrol and International Gas Union, (2011).

BOG generated during loading process	BOG generated during unloading process
<ul style="list-style-type: none"> • Vapour return from ship's tanks. • Heat transferred to LNG by loading pumps. • Heat leak into LNG from pipes and equipment. • Cooling down of the ship's manifold and loading arms. • Cooling down of jetty lines prior to loading if not continuous. • Mixing of loaded LNG with the initial amount of LNG (heel). • Cooling down of ship's tanks if necessary. 	<ul style="list-style-type: none"> • Vapour return to ship's tanks. • Heat transferred to the LNG by the ship's pumps. • Heat leak into the LNG through the pipes and equipment. • Higher ship's operating pressure than the LNG storage tank . • Cooling down the ship's manifold and unloading arms prior to unloading. • Cooling down of jetty lines prior to unloading if not continuous. • Mixing of unloaded LNG with existing stock of different quality.

If a ship's tanks are warm, they need to be cooled down prior to loading. The cooling down of a ship's tanks may be required prior to loading if an LNG tanker is returned with insufficient heel, after dry-docking, off-hire or during initial commissioning. The cool down is carried out by initial quantities of LNG, which is evaporated when it comes into contact with the warm sides of the tanks. In this case, the loading process takes longer.

During the unloading of an LNG tanker, differences in operating pressures between the ship's and the terminal's storage tanks can also influence the quantity of BOG. The LNG cargo attains an equilibrium temperature dependent on the cargo tank pressure. If operating pressure in the ship's tanks is by 0.01 bar higher than in the storage tank, the temperature of LNG in cargo tanks will be higher by approximately 0.1°C than in the storage tank. To establish a new equilibrium, a small portion of the LNG in the storage tank will be evaporated to cool itself down. For example, if the absolute pressure of an operating cargo tank is 1.060 bar and the absolute pressure of an operating storage tank is 1.050 bar, than at the typical unloading rate of 12,000 m³ per hour, the difference of 0.01 bar will result in a 3,600 kg per hour boil-off (Sedlacek, 2008). The mixing of unloaded LNG with existing stock of a different quality at LNG receiving terminals can cause stratifications and rollover processes in storage tanks. Stratification refers to the formation of LNG layers of different densities within LNG storage tanks. Rollover refers to the spontaneous rapid mixing of layers and release of LNG vapours from a storage tank caused by stratification.

During the ageing (weathering) process, the density of LNG gradually increases in the storage tanks. When LNG of different composition (density) is injected into the tank, LNG may stratify. The stratification in the tank is characterized by two homogenous layers of different density and temperature, separated by a buffer zone, called the thick interface layer. The upper layer is composed of the liquid less dense than the bottom layer. In the tank, these two layers may form a steady interface layer, i.e. stable stratification. However, due to the ingress of heat into LNG in the tank, the lower layer can eventually reach a temperature at which its density is reduced to such an extent that the interface becomes unstable. This process is intensified by the movement of heavier components from the lower layer to the top layer and the result is a sudden release of heat in the lower layer and an increase in vaporization. This leads to a spontaneous rapid mixing or rollover. In case of rollover, if LNG in the bottom layer is superheated due to the conditions in the tank's vapour space, the rollover can be accompanied by a transient high rate of vapour production that can be 10 to 30 times greater than the tank's normal gas boil-off rate and over-pressurisation of the tank.

The knowledge of LNG quality at any time before unloading helps the operators of the receiving terminals to take, in advance, actions which will prevent stratification and consequently, the rollover.

3.3. Boil-off during ship's voyage

Most of BOG is generated during transportation of LNG by ships. BOG released during the voyage of an LNG tanker may occur due to the following reasons (Faruque et al., 2009; Głomski and Michalski, 2011; Sedlacek, 2008; British Petrol and International Gas Union, 2011):

- the ingress of heat into cargo tanks due to the difference between the temperature in the cargo tanks and temperature of the environment,
- due to the cooling of a ship's tanks during ballast voyages, achieved by occasional spraying of LNG in the upper part of the tank,
- due to the sloshing of cargo in partially filled tanks due to the action of waves, causing friction on the inner wall of the tank creating an additional thermal effect.

Therefore, the quantity of BOG during a ship's voyage changes depending on the changes in ambient temperature, sea temperature, sea roughness and cargo tank's contents.

Heat ingress is the main reason for the generation of BOG on ships. In maritime transportation of LNG, the quantity of evaporated cargo is normally presented as loss expressed as a percentage of total volume of liquid cargo during a single day, i.e. as Boil-Off Rate (BOR). This value can be calculated by the expression:

$$BOR = \frac{V_{BOG} \cdot 24}{V_{LNG} \cdot \rho} = \frac{Q \cdot 3600 \cdot 24}{\Delta H \cdot V_{LNG} \cdot \rho} \cdot 100 \quad (1)$$

where BOR is in %/day, V_{BOG} volume of BOG in m³/s, V_{LNG} volume of LNG in cargo tanks in m³, ρ density of LNG in kg/m³, Q heat exchange in W, and ΔH latent heat of vaporisation in J/kg.

Typical BOR caused by heat ingress for newer LNG tankers ranges from 0.10 to 0.15% for laden (loaded) voyage and from 0.06 to 0.10 % for ballast voyage (Głomski and Michalski, 2011; Sedlacek, 2008; International Group of Liquefied Natural Gas Importers, 2011).

Cooling of a ship's tanks during ballast voyages is used to reduce the growing temperatures in cargo tanks. The cooling is achieved by sporadic spraying of LNG into the top part of the tank by pumping LNG from the bottom of the tank. LNG in contact with the warm sides of the tank evaporates and generates BOG.

In rough seas, hull movement causes the sloshing of LNG in the partially filled cargo tanks. Sloshing transfers kinetic energy from the waves into cargo tanks, causing friction and heating effect. This additional heating effect produces BOG.

During a ship's voyage BOG can be utilized as fuel, re-liquefied or burned in a gasification unit. Since BOG mostly consist of methane, it is lighter than air in ambient temperature. This allows the safe handling and utilization of BOG. Therefore, LNG is only liquid gas cargo allowed by IMO to be used as a fuel

for ship's propulsion and energy systems (McGuire and White, 2000). Due to the simplicity of burning BOG in boilers and high reliability of steam turbine propulsion systems, a majority of LNG tankers are powered by steam turbines.

The continuous growth of LNG marine transportation caused a rapid increase of the capacity of newly ordered LNG tankers (Dimopoulos and Frangopoulos, 2008). However, since BOG is a part of the valuable LNG product and bunker oil is more efficient, the LNG industry recently crossed over to other propulsion systems, namely dual fuel diesel or diesel-electric propulsion systems together with BOG re-liquefaction plant (Dimopoulos and Frangopoulos, 2008; MAN Diesel A/S-LNG Carriers with ME-GI Engine and High Pressure Gas Supply System, 2009). The reason is the superior efficiency of diesel engines. These systems are installed in LNG tankers intended for long distance transportation of liquefied natural gas. Since fuel oil prices are currently high, operators are considering burning boil-off gas instead of utilising 100 % HFO, DO or gas oil.

On the basis of observations of typical BOR on LNG tankers in exploitation, it is estimated that boil-off gas equals about 80-90 % of the energy needed for the LNG tanker at full power output (MAN Diesel A/S- LNG Carriers with ME-GI Engine and High Pressure Gas Supply System) in laden voyage, and 40-50% in ballast voyage. Therefore, additional fuel oil is required or alternative forced boil-off gas must be generated. Most modern LNG tankers have forcing vaporisers which vaporise additional BOG to allow the ship to run on BOG alone. The use of forcing vaporisers depends on relative fuel economics and charterer preference (MAN Diesel A/S- LNG Carriers with ME-GI Engine and High Pressure Gas Supply System, 2009). It should be noted that during the course of the ship's voyage, the ageing process increases the heat value of BOG. With the passage of time, this fact reduces the need for additional quantity of forced BOG (Sedlaczek, 2008).

For safety reasons, BOG can be released into the atmosphere or burnt in a gas combustion unit (also called thermal oxidizer). The decision on the choice of an appropriate method depends on many primarily safety, economic and legal factors.

4. LNG ENERGY CONTENT

LNG is sold depending on its energy content which is typically measured in GJ, GWh or MMBTU (British Petrol and International Gas Union, 2011; International Group of Liquefied Natural Gas Importers, 2011).

LNG is purchased by the charterer (mostly oil & gas or energy companies) at FOB price at the loading terminal and sold at a higher CIF price at the receiving terminal.

Used LNG cargo and LNG cargo lost due to boil-off reduce the amount of cargo delivered by an LNG tanker to the receiving

terminal. Furthermore, ageing decreases the percentage content of the lighter boiling point components (Methane, Nitrogen) and increases the percentage content of the higher boiling point components (heavy components) in the LNG remaining in ship's tanks (Glomski and Michalski, 2011). Therefore, the unloaded LNG has a lower percentage content of nitrogen and methane and higher content of ethane, propane and butane than the loaded LNG.

Since the composition of LNG cargo constantly changes during a ship's voyage, its quality and properties also constantly change.

The establishment and calculation of the quantity of energy of LNG transferred between LNG ships and LNG terminals is performed on both terminals. This procedure is called "*Custody transfer*" and involves the activities and measurements taken both on the LNG tanker and on the terminal jetty. Custody transfer is contractually agreed between the LNG buyer and seller.

The determination of the transferred energy is executed together with the measurement and calculation of some parameters, i.e. liquid volume, liquid density and heat value (British Petrol and International Gas Union, 2011; International Group of Liquefied Natural Gas Importers, 2011).

The transferred energy can be calculated with the following formula:

$$E = (V_{LNG} \cdot \rho_{LNG} \cdot GCV_{LNG}) - E_{GD} \pm E_{GE} \quad (2)$$

where E is total net energy transferred from loading terminal to the LNG tanker or from the LNG tanker to the receiving terminal in kJ, V_{LNG} the volume of LNG loaded or unloaded in m³, ρ_{LNG} the density of LNG loaded or unloaded in kg/m³, GCV_{LNG} gross calorific value of the LNG loaded or unloaded in J/kg, E_{GD} net energy of the displaced gas from LNG tank in J, E_{GE} energy of the gas used by LNG tanker as fuel (consumed in the engine room) at the port in J.

The volume of LNG loaded V_{LNG} can be calculated using the following expression:

$$V_{LNG} = C - V_{RH} \quad (3)$$

where C is the loading capacity of the LNG tanker in m³ and V_{RH} the remaining LNG for cargo tank cooling (heel) during ballast voyage in m³.

The volume of LNG unloaded V_{LNG} can be obtained using the following expression:

$$V_{LNG} = L_{LNG} - TL_{BOG} - V_H \quad (4)$$

where L_{LNG} is the volume of LNG loaded into the ship in m³, TL_{BOG} total used or lost LNG (BOG) during laden voyage in m³ and V_H is minimum of LNG for cargo tank cooling (heel) during laden voyage in m³.

The calculation used to determine LNG volume is based on the level, temperature and pressure measurements obtained from the ship's instruments, taking into account the calibration and correction tables to compile a report meeting the CTS (Custody Transfer Survey). Lately, the taking of volume measurements has become automated through the LNG tanker's custody transfer measurement system (Benito, 2009; British Petrol and International Gas Union, 2011; International Group of Liquefied Natural Gas Importers, 2011).

LNG density can also be determined by measuring its average value directly in the LNG tanker's tank by means of densitometers or by calculation from the measured composition of LNG transferred and the temperature of LNG measured in the LNG tanker's tanks.

The calculation is made by means of mathematical model equations of state connecting pressure, temperature and volume, widely used in the LNG industry. The most widely used method is the revised KLOSEK-MCKINLEY method according to standard ASTM D 4784-93 and ISO 6976. This method is based on empirical evaluation of molar volume of the mixture in the thermodynamic state of the LNG considered. The density of LNG is calculated as follows:

$$\rho = \frac{M_{mix}}{V_{mix}} = \frac{\sum_{i=1}^n x_i \cdot M_i}{\sum_{i=1}^n x_i \cdot V_i - [k_1 + (k_2 - k_1) \cdot (x_{N_2} / 0.0425)] \cdot x_{CH_4}} \quad (5)$$

where M_{mix} is molecular weight of the mixture in g/mol, V_{mix} molar volume of the mixture in m³/mol, x_i the molar fraction of component i in mol/mol, M_i molecular weight of component i in g/mol, V_i molar volume of the component i at the temperature of the LNG in m³/mol, k_1 and k_2 correction factors, x_{N_2} molar fraction of nitrogen in mol/mol and x_{CH_4} molar fraction of methane in mol/mol.

The calculation of volume correction factors k_1 and k_2 at a given temperature is derived by interpolation of their two known values and with respect to temperature and molecular weight.

Upper Heat value (UHV) or Gross Caloric Value (GCV) is the thermal energy produced by the complete combustion of a unit of volume or mass of the gas (vaporised LNG) in the air, at the constant absolute pressure of 1.01325 bar and at temperature T_h at which the water formed during the combustion condenses. In the case of volumetric GCV, the unit of volume of gas is considered at the gas volume metering conditions of temperature T_v and pressure p_v . The GCV can be determined by calorimeter measurements or by computation based on the composition of the gas (vaporised LNG) in the reference condition.

There are several standards that can be used to calculate GCV, such as ISO6976, ASTM 3588 GPA2145 etc. Custody transfer

should state the standards and reference conditions used, namely the combustion temperature and pressure.

According to the ISO697 standard, GCV_{LNG} is calculated with the following formula (International Group of Liquefied Natural Gas Importers, 2011):

$$GCV_{LNG} = \frac{\sum_{i=1}^n x_i \cdot GCV_i}{\sum_{i=1}^n x_i \cdot M_i} \quad (6)$$

where GCV_{LNG} is mass gross calorific value in J/kg, x_i molar fraction of component i in mol/mol, GCV_i molar gross calorific value of component i in J/mol, M_i molecular mass of component i in g/mol. The physical constants GCV_i and M_i being specified in coherent standards.

The energy of the displaced gas returned from the ship during the loading operation or transferred to the LNG tanker during the unloading operation from storage tank can be determined by the following expression at the reference conditions of 15 °C and 1.01325 bar (British Petrol and International Gas Union, 2011; International Group of Liquefied Natural Gas Importers, 2011):

$$E_{GD} = V_{LNG} \cdot \frac{273.15}{273.15 - T} \cdot \frac{p}{1.01325} GCV_{GAS} \quad (7)$$

where E_{GD} is energy of the gas displaced from the LNG tank in J, V_{LNG} volume of the LNG loaded or unloaded in m³, p absolute pressure in the tanks in bar, T mean value of the temperatures of the probes not immersed in LNG in °C, GCV_{GAS} gross caloric value of the gas in gaseous state contained in the ship's tanks in J/m³.

Since the composition of the vapour returned is not the same as that of the LNG delivered from the ship, it is common practice to assume the return gas to be 100% methane in the calculation of the energy of the gas displaced.

The quantity of gas possibly used by the LNG tanker as fuel during loading or unloading operations can be determined by:

$$E_{GE} = V_G \cdot GCV_{GAS} \quad (8)$$

where E_{GE} is the energy of the gas used by the LNG tanker (engine room) in J, V_G the total volume of gas determined by a gas flow meter on board the LNG tanker in m³.

During loading operations, E_{GE} has positive sign while for unloading operation has negative sign.

According to the ISO6976 standard, GCV_{GAS} is calculated with the following formula (International Group of Liquefied Natural Gas Importers, 2011):

$$GCV_{GAS} = \frac{\sum_{i=1}^n y_i \cdot GCV_i}{\sum_{i=1}^n y_i \cdot MV_i} \quad (9)$$

where GCV_{GAS} is the volumetric gross calorific value of the displaced gas in J/m³, y_i molar fraction of component i in the displaced gas mol/mol, GCV_i molar gross calorific value of component i in J/mol and MV_i molar volume of component i in m³.

The molar composition of the displaced gas differs from the composition of LNG and is determined either by the analysis of gas, or by calculation.

The molar composition calculation is possible with a general formula for Vapour-Liquid-Equilibria (VLE) calculation based on equilibrium ratio (Riazi, 2005; International Group of Liquefied Natural Gas Importers, 2011):

$$K_i = \frac{x_i}{y_i} \quad (10)$$

where K_i is the dimensionless equilibrium ratio, x_i molar fraction of component i in liquid in mol/mol, y_i molar fraction of component i in the displaced gas in mol/mol.

The dimensionless equilibrium ratio K_i generally varies with T , p and composition of both liquid and vapour phases. Assuming the ideal solution for hydrocarbons, K_i value at various temperatures and pressures has been calculated for n-paraffins from C1 to C10 and is presented graphically for quick estimation. For hydrocarbon systems and reservoir fluids, there are also some empirical correlations for the calculation of K_i values, such as the correlation proposed by Hoffman which is widely used in the industry (Riazi, 2005). For practical calculation of the displaced gas, K_i values are usually limited to the more volatile components, i.e. nitrogen, methane and sometimes ethane.

The energy of the gas consumed as fuel in the engine room during the loading or unloading operations of an LNG tanker with cargo capacity of 145 000 m³ and a steam turbine propulsion system, typically equals 0.05 -0.06% of the total energy of the transferred LNG (International Group of Liquefied Natural Gas Importers, 2011).

5. CONCLUSION

One of the problems in LNG transportation and storage is the generation of BOG. These vapours are created due to the heat added into the LNG during storage, transportation and loading/unloading operations.

This paper shows the causes of generation and general methods of handling and utilization of BOG at different places of the LNG supply chain.

In the LNG supply chain most BOG is generated by the LNG ships themselves. The used LNG cargo or losses of LNG cargo due to boil-off reduce the amount of cargo delivered by LNG tankers to the receiving terminal while the ageing process steadily changes the composition, quality and properties of LNG cargo during a ship's voyage. Therefore, the quantity and quality of unloaded LNG are the key factors for the economic assessment of the LNG supply chain. Consequently, this paper also describes the mathematical method for the determination and calculation of the LNG energy quantity unloaded from the ship's tanks to storage tanks in the receiving terminal. Future research will focus on simulating and computing boil-off in all parts of the LNG supply chain.

REFERENCES

- Riazi, M. R., (2005), Characterization and Properties of Petroleum Fractions, 1st Edition, Philadelphia: ASTM International.
- McGuire, J. J. and White, B., (2000), Liquefied Gas Handling Principles on Ships and in Terminals, London: Witherby & Co Ltd.
- Dimopoulos G. G. and Frangopoulos C. A., (2008), Thermoeconomic Simulation of Marine Energy Systems for a Liquefied Natural Gas Carrier, International Journal of Thermodynamics, 11(4), pp. 195-201.
- Dundović Č., Basch D. and Dobrota Đ., (2009), Simulation Method for Evaluation of LNG Receiving Terminal Capacity, Promet - Traffic & Transportation, 21(2), pp. 103-112., <http://dx.doi.org/10.7307/ptt.v21i2.216>
- Faruque Hasan M. M, Zheng Minghan A. and Karimi I. A., (2009), Minimizing Boil-Off Losses in Liquefied Natural Gas Transportation, American Chemical Society, Industrial Engineering Chemistry Research, 48(21), pp. 9571-9580., <http://dx.doi.org/10.1021/ie801975q>
- Glowski P. and Michalski R., (2011), Problems with Determination of Evaporation Rate and Properties of Boil-off Gas on Board LNG Carriers, Journal of Polish CIMAC, 6(1), pp.133-140.
- Sedlaczek R., (2008), Boil-Off in Large and Small Scale LNG Chains, Diploma Thesis, Faculty of Engineering Science and Technology, Department of Petroleum Engineering and Applied Geophysics, Trondheim, available at: <http://www.ipt.ntnu.no/~jsj/studenter/diplom/2008Sedlaczek.pdf>, [accessed 12 December 2011.].
- Benito A., (2009), Accurate determination of LNG quality unloaded in Receiving Terminals: An Innovative Approach, GERG Academic Network Event, Brussels, Belgium, pp. 1-23.
- British Petrol and International Gas Union, (2011), Guidebook to Gas Interchangeability and Gas Quality, available at: <http://www.igu.org/igu-publications/Gas%20Interchangeability%202011%20v6%20HighRes.pdf>, [accessed 17 January 2012.].
- International Group of Liquefied Natural Gas Importers, (2011), LNG Custody Transfer Handbook, 3rd Edition - version 3.01, Paris: GIIGNL.
- Natural Gas Information, (2011), Paris: International Energy Agency.
- LNG Carriers with ME-GI Engine and High Pressure Gas Supply System, (2009), available at: <http://www.mandieselturbo.com/files/news/files0f8121/5510-002600ppr.indd.pdf>, [accessed 15 May 2012.].

Reliability and Availability of the Vessel Traffic Management and Information Systems

Pančo Ristov, Pavao Komadina^a, Vinko Tomas^a

This paper presents an approach to the reliability and availability of Vessel Traffic Management and Information Systems through the analysis of hardware, software and human reliability. The paper analyzes the critical subsystems and modules on the basis of the reliability theory, in order to achieve and ensure the availability of systems, i.e. to increase the safety of maritime traffic and the protection of the sea and marine environment. The paper discusses some of the techniques and mechanisms of hardware and software redundancy, as well as the activities that result in increasing the reliability of man.

KEY WORDS:

- ~ Reliability
- ~ Availability
- ~ Hardware
- ~ Software
- ~ Humans
- ~ Vessel Traffic Management and Information Systems

University of Split, Faculty of Maritime Studies, Zrinsko-Frankopanska 35, HR-21000 Split, Republic of Croatia

e - mail: panco.ristov@pfst.hr

a. University of Rijeka, Faculty of Maritime Studies, Studentska 2, HR-51000 Rijeka, Republic of Croatia

e - mail: komadina@pfri.hr

e - mail: tomas@pfri.hr

1. INTRODUCTION

Computers and all their associated equipment present the technical foundation of modern information and communication systems. Computer technology is experiencing a rapid development geared towards the increasing miniaturization and mobility, increasing processing speed, increasing capacity of the main and secondary memory. This development is also geared towards the use of all media designed for receiving and storing data, greater compatibility, continuous price cuts, etc. The size and complexity of computer systems have dramatically increased in the last decade and the trend is likely to continue in the future. Contemporary examples of complex computer systems can be found in all sectors of economy, in all maritime systems, as well as onboard ships and in supervising, managing and organizing the maritime transport.

In order to improve the safety and efficiency of maritime transport and the protection of the sea and marine environment, it is inevitable to use modern information and communication technologies when collecting, storing, processing, presenting and distributing relevant data and information to the participants in maritime transport. These are the essential characteristics of the system called *Vessel Traffic Management and Information System* - VT MIS.

A common structure of the VT MIS system consists of the VT MIS functions and VT MIS subsystems. VT MIS functions are grouped into operational and complementary roles, while VT MIS subsystems include *sensors* (a marine radar subsystem and the automatic identification subsystem), *communication and computer networks*, *operator consoles*, *servers*, *databases*, *video*

walls, system software, application software and web services. VT MIS systems are flexible, open and have modular architectures that allow upgrading using standard computer and communication components. In other words, a VT MIS system is a distributed architecture which is: *distributed, decentralized, networking, multi-layered, hierarchical and open*.

A VT MIS system is based on a *client-server architecture*, where the server provides services to a client whose work at the computer is most of the time disconnected from the server. The client-server architecture provides a clear separation between the server and client processes and their autonomy.

The distributed database is a relational database that is not entirely situated on just one server (SQL Server – Structured Query Language). SQL servers are based on a client-server concept with highly standardized application interface, defined by the SQL standards and communication standards with databases known under the abbreviation ODBC (*Open Data Base Connectivity*).

VT MIS systems include hardware and software, and they include the man as an important participant. Hence, it is necessary to analyze the reliability of all these system elements.

Generally speaking, a computer system failure can be caused by *hardware failure, software failure, human error, or by variables from the environment* (fire, power failure, lightning, etc.). Unlike hardware failures that have been extensively analyzed, along with various techniques and mechanisms for their solving, software failures and failures caused by the man followed by an adequate analysis of reliability and availability, did not attract much attention during the research and development of professional systems. However, as the implementation of computer systems grew, the analysis and study of the software and man-induced failures gained impetus, especially when it became evident that the computer system failure occurs mostly due to software failure resulting from the operator's error. In addition, it was considered for a long time that the concept of reliability and failure rate can not apply to software because the latter cannot be physically degraded over time and because of stressful environmental influences. Practice has shown that such considerations were wrong. In many applications, there are serious consequences caused by errors or software failures that result in huge economic losses and/or loss of human life (e.g. sinking of the British destroyer HMS Sheffield by the Argentine Air Force in the Falklands War in 1982; the aircraft crashing into a mountain in Antarctica because of computer errors in determining flight coordinates).

The development of information technology enables the development, implementation and use of increasingly complex computer systems in off-line and on-line applications. All these applications require that the operation of hardware and software should be failure-free, i.e. that computers work without error or fault. In this regard, IT companies have begun to design,

deploy and use computer systems that are tolerant to failures. Failure tolerance is one of the techniques to achieve the target reliability of a computer system. Other techniques include: *avoiding failures* (preventing the occurrence or introduction of faults), *troubleshooting* (reducing the number or the magnitude of faults), and *dodging the issue* (predicting / estimating the malfunction and its consequences if it occurs).

The reliability theory shows that fault tolerance can be achieved by using redundancy, which can be: *hardware, software, information and time redundancy*. Hardware and software redundancy are carried out by multiplication of hardware and software at all levels of complexity. Information redundancy is adding bits to data, which enables the detection and/or correction of errors. The codes of parity represent the simplest form of information redundancy. Time redundancy implies the repetition of certain operations during program performance. In addition, the systems tolerant to failures are often designed using reconfiguration strategy. Reconfiguration strategy can be implemented in various ways, including logical or physical removal of faulty elements. The techniques that are used to identify faulty elements and methods that are used to fix the system are quite different and may lead to complex reliability models.

There are two basic strategies of reconfiguration: *degradation* and *replacement with a grain of salt*. Methods of degradation include the continuous removal of faulty elements without repair. A reconfigured system continues to operate with reduced elements. The other method implies removing faulty elements and their replacement with the correct ones, or repairing the defective element; see (Tomas, 2004; Kirrmann, 2005; Shooman, 2002).

2. AVAILABILITY OF VT MIS SYSTEMS

In the national and international scientific and technical literature there has been a growing interest of computer companies in expressing the quality of their products through their *reliability, availability, safety, integrity and functional suitability*. The number and types of quality indicators depend on the complexity of the information system.

The VT MIS system reliability is defined as the probability that the system will function without failure during a specific period of time under certain conditions. In other words, it is the probability that the failure time T will occur after the observed time t . Reliability is a complex feature and is an indicator of quality. Mean Time Between Failure (MTBF) is the most common indicator of quality.

Availability is defined as the probability that a system will be available at any point in time, i.e. that it will be able to work or to get started, provided it is used under specific conditions.

Availability may be defined in various ways: it may be defined by the manufacturer (inherent availability - A_i) and, on the other hand, as the operational availability (A_o) (Pokorni, 2002).

The inherent availability can be calculated with the aid of the relation:

$$A_i [\%] = \frac{MTBF}{MTBF + MTTR} \cdot 100 \quad (1)$$

Where: MTBF is Mean Time Between Failure and MTTR is Mean Time To Failure.

The operational availability can be calculated by using the relation:

$$A_o [\%] = \frac{t_{ur}}{t_{ur} + t_{uo}} \cdot 100 \quad (2)$$

Where: t_{ur} is the total or average time in the operational work and t_{uo} is the total or average time of failure.

The relation (1) shows that an increased availability can be achieved by higher MTBF (higher reliability) or lower MTTR.

A higher MTBF is achieved by higher reliability of the elements that are installed in the computers (servers), but also through redundancy. In computer systems, the MTTR is, in fact, the mean time to the restoration of service, rather than the mean time to repair or replace faulty modules, and the restoration of services includes the following activities: detection of failure / error, reporting the problem, communication between the operator and his own maintenance service or the technical service provided by the system manufacturer, repairing / replacement, restarting the computer system.

MTTR for critical modules of the VTMS system ranges from 2 to 4 hours, while with non-critical modules it lasts between 24 to 48 hours. Relying to our own experience and technical literature, MTTR can be reduced down to 50% if the user of a VTMS system is supported by trained and skilled personnel for maintaining computer equipment, if he/she has necessary maintenance equipment and a number of critical spare modules.

On the basis of our own data (Command, Control, Communications and Intelligence system) and data gathered from the literature (Struk, 2012), the availability of computers in different architectures is presented in Table 1.

Table 1.

Availability and the time of failure of computers in the course of one year.

Availability	Failure	Example
90 %	> 1 month	Unattended PC
99 %	~ 3 days 16 hours	Maintained PC
99,9 %	~ 9 h	Cluster
99.99 %	~ 57 min	Mainframe
99.999 %	~ 5 min	Onboard computer to the PC platform
999.999 %	~ 30 s	Installed on a dedicated PC platform

In the Resolution A.915 (220 Ref.40) the International Maritime Organization (IMO) defines the availability as "the probability that the system provides a needed service under the specified conditions. Unavailability can be caused by the planned and / or unforeseen interruption". International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) recommends three availability levels: *basic*, *standard* and *target (advanced)* (IALA Recommendation V-128 Edition 3.0: Operational and Technical Performance Requirements for VTS Equipment, 2007).

Companies that produce VTMS systems adhere to the IALA recommendations and launch into the market VTMS systems that are configured to provide availability of 99.9%, which means that a subsystem or the system as a whole is not available approximately 9 hours per year; see (Norcontrol IT AS – Vessel Traffic Management & Information System – VTMS 5060, 2006; CoastWatch VTMS, 2012).

Table 2.

Availability of radar subsystems as recommended by IALA.

Availability of radar subsystems

	Levels of availability		
	Basic	Standard	Advanced
Recommended availability for radar subsystems	99 %	99.6 %	99.9 %

In the simplest case, where a failure of any hardware, software, or man / operator leads to a system failure (block diagram of the three elements connected in series), and provided that their failures are independent, the reliability of such a system is obtained by the relation (Shooman, 2002):

$$R_S = R_H \cdot R_{SF} \cdot R_O \quad (3)$$

where:

- R_S – system reliability,
- R_H – hardware reliability,
- R_{SF} – software reliability, and
- R_O – operator reliability.

In VTMS systems using virtual private networks (VPN), based on TCP / IP technology, it should be taken into account that the system failure or system availability reduction may occur due to the channel failure, network congestion, viruses or attacks referring to rejection of services etc. According to (Hussain, 2005), there may be various reasons for communication network failure: in 32% of cases the failure is due to the connecting paths (links), 25% because of the directors, 36% resulting from maintaining and configuring the network, and 9% due to other communication problems.

In order to increase availability, almost all manufacturers of VTMS systems install self checking devices in their subsystems. Checks performed during the operation (*functional control*) continuously monitor the operation of the subsystems to detect errors in the software, hardware faults or mistakes made by the operator. Checks performed out of the operational work (*functional testing*) are done with the aim of finding the components that are broken and need to be repaired / replaced. This inspection is carried out by the maintenance personnel (own maintenance, dealers or service agents authorized by the system manufacturer).

Functional monitoring generates two types of warnings that are displayed and logged into a separate file (*log file*):

- system's response – if the operator, during normal operation, enters a wrong command or inadequate information in certain forms, the system responds by generating an adequate warning;
- technical warning – if the functional monitoring diagnoses a failure / error in a module, the subsystem's technical console receives an adequate warning.

A detailed analysis of the reliability and availability of the elements of the VTMS system is presented in the following chapters.

3. RELIABILITY OF HARDWARE IN VTMS SYSTEMS

VTMS systems feature a great variety of subsystems, consisting of a large number of hardware modules. This method of designing a system provides great advantages with regard to redundancy, maintenance and training.

Simple and complex hardware modules that are installed in all control centers and sensors feature an open architecture design in order to meet the new requirements. In control centers the main (critical) modules are VTS server (*Track Management Server*), SQL server and LAN (Local Area Network) networks. In sensor subsystems, the main modules (transmitters, radar extractor, pointing elements...) are under the direct control of the microprocessor. All modules are usually characterized by the so-called failure rate (λ), a general relation for hardware reliability $R(t)$ being:

$$R_H(t) = e^{-\int_0^t \lambda(t) dt} \quad (4)$$

Formula (4) is the first law of reliability, which is used to determine of reliability when is a known function of the failure rate. When the failure rate does not change over time, i.e. $\lambda = \text{const}$, the formula for reliability takes the form:

$$R_H(t) = e^{-\lambda t} \quad (4.1)$$

Formula (4.1) is called the exponential law of reliability. If the failure rate in the formula (4.1) is expressed in the unit (1/h), then the time should be included in hours (h). Formula (4.1) is valid for the second period (the period of normal use) as shown in Figure 1.

Figure 1 shows that there are three characteristic periods within the hardware failure rate: the early failure period, the period of normal use and the period of aging (wear).

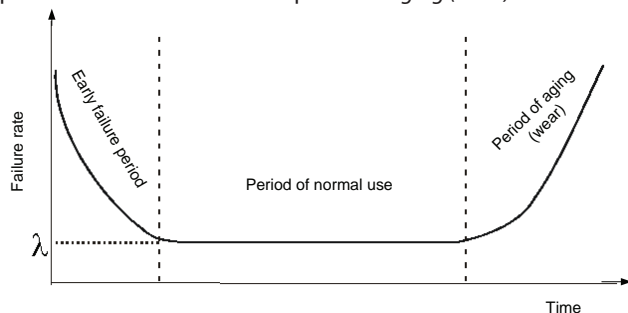


Figure 1.

Failure intensity of hardware elements

In professional systems, such as VTMS systems, the early failure period (the period of childhood diseases) is conducted by the manufacturer of the system (except for the failures that occur during transport, transfer or installation of the system). At the beginning of the third period, when components are subject to aging and wear, the systems are removed from service for safety reasons because of major material / financial losses that may result from their failure, or due to high maintenance costs.

Reliability indicators are normally used in the second period, i.e. during normal operation. This period is the longest and for personal computer systems may range from 2 to 5 years.

Computer technology provides four ways to ensure the reliability of hardware: *through installing reliable elements* (CPU, RAM, disk drives, etc.), *designing the systems* in such a way that the failure of an individual module cannot lead to the breakdown of the entire system; *purchasing the elements from multiple sources*; and *installation of redundant elements* allowing fast switching to a secondary or redundant element.

Each module whose failure may reduce the system's availability must have its redundant module. Almost all manufacturers of VTMS systems use the classical form of redundancy for critical modules. This form includes two identical components connected in parallel, where both modules perform the same functions, and each is capable of functioning independently in the system. Both modules are connected to the mechanism for automatically switching from the primary module to the secondary one in case of failure. The secondary module can function in the following conditions: *cold standby reserve*, *hot standby reserve* and *fault-tolerant operation*.

VTMS subsystems use the fault-tolerant operation which means the extension of hot reserve, since the secondary module operates as a "mirror" of the primary module. Both modules handle the same data, so that there is no loss of data or information in case of failure of the primary and switching to the secondary module. In addition, each module has a built-in ability to detect errors. Therefore, adding just one module can be sufficient to achieve the desired reliability. Additional hardware resource management allows the computer system to increase its ability to continue operating.

Figure 2 shows the schematic presentation of a redundant radar transmitter. In addition to the radar transmitter, the radar extractor and microprocessors may be duplicated in some configurations to improve reliability.

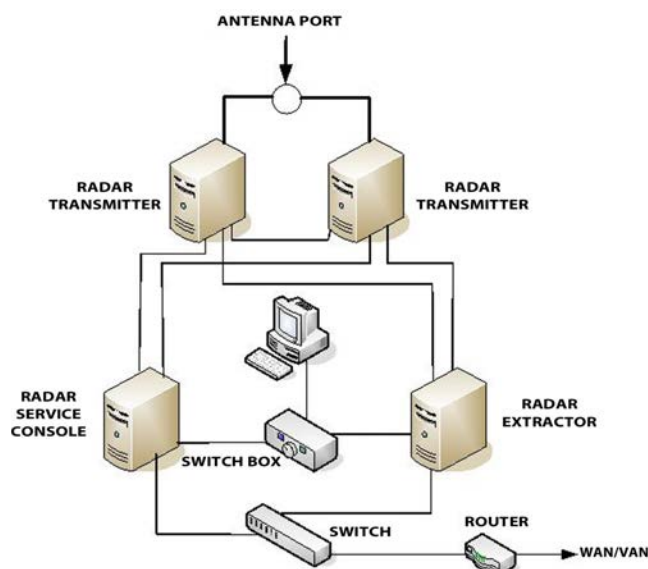


Figure 2.

Redundancy in radar subsystems.

Source: SAAB Systems - CoastWatch VTMS

In control centers of the VTMS systems, critical redundant modules include: VTS server, database server (SQL server) and LAN networks; see (Norcontrol IT AS – Vessel Traffic Management & Information System – VTMS 5060, 2006; CoastWatch VTMS, 2012).

All computer equipment in VTMS subsystems is connected to devices for uninterruptible power supply (UPS), with the provision that in the event of a prolonged interruption of power a diesel generator cuts in. This form of redundancy is ensured because power failures make 26% of total failures in computer systems.

There are several mechanisms for monitoring hardware modules. The simplest way is to monitor functional safety and it involves checking the hardware modules with the aid of other

hardware modules and using test programs. The performance of test programs does not affect normal functions of the software. When functional monitoring detects an error, a warning is sent to the technical service console and is recorded in the log file.

In order to further increase the availability of the VTMS system, i.e. the availability of control centers, the hardware and software of all consoles are configured to perform the same functions, which means that the failure of one operator console will not affect the other.

In order to increase the reliability of the VTMS system, nominal environmental conditions must be met: atmospheric pressure of 1024 hPa, relative humidity of 70%, rainfall at 5 mm/hr, air temperature 25°C, sea temperature 18°C, salinity of 35‰ and sea state up to 3.

Redundant modules have proved to be the best solution for improving the overall availability of subsystems and the VTMS system as a whole. Installing the most trusted module can be a more expensive and less reliable solution than installing the two cheaper and less reliable modules that operate in parallel with negligible time of switching and restarting.

4. RELIABILITY OF SOFTWARE IN VTMS SYSTEMS

As a result of the increasingly important role of software in professional systems, including VTMS systems, software errors have a significant share in the total number of failures. This, in turn, has forced professional system manufacturers to pay more attention to the software reliability and availability, i.e. to the overall quality of their systems.

VTMS software system is based on common modules that are harmonized with the functions. These “modules” are called systemic functions because each systemic function performs one of the many functions that the systemic software should do. The rest of the modules (programs) in the VTMS system, i.e. the utility tools, are not essential for the operational reliability of the system.

Depending on the VTMS manufacturer, the systemic functions are grouped into several categories. Here is one of the possible categorizations:

- *systemic application functions* - are functions that perform the functional requirements of operators;
- *systemic functions for sensor control* – are functions for handling the sensors for data acquisition and basic information processing;
- *systemic communication functions* – are functions ensuring the interaction with the operator, the communication within each subsystem and for communication between subsystems;
- *auxiliary systemic functions* – are used by other functions to fulfill their tasks;
- *basic systemic functions* – are functions without which the other systemic features could not work; they include the

operating system functions, data management, functional monitoring and functional verification.

Such a division of VTMS software systems into systemic functions makes the software consistent, effective, reliable, and easy to understand, maintain and upgrade.

Ensuring a high reliability of the software depends on the parameters of the software quality in each stage of the development cycle. Each stage requires parameters used to measure the quality characteristics. The IEEE 982.2. standard defines in detail the characteristics of each stage, with particular attention paid to: user requirements, design, implementation and *testing* (IEEE Std. 982.2.-1988: IEEE Guide for the Use of Standard Dictionary of Measures to Produce Reliable Software, 1988).

The assessment of the reliability of software is done using various measures (Jiantao, 1999): *the finished product value* (referring to the complexity of the software, i.e. the number of lines of the software code), *project management value* (referring to the relationship between the development process and the project feasibility in a defined period of time and at acceptable quality level), *software development process* (referring to the measures taken to produce a quality software), *error and failure ratio* (referring to the MTBF and reliability of the software calculated on the basis of information on errors obtained from users), and *reliability requirement factor* (which implies that the specification of user requirements cannot contain ambiguous phrases, requests with multiple meanings, and the like).

According to ANSI, the software reliability is defined as the probability of a successful software operation over a period of time in a particular environment. In other words, software reliability is a function of a successful software operation dependent on the time and the environment:

$$R_{sf} = f(rbo, so, ov) \quad (5)$$

where:

- *rbo* – operation without failure,
- *so* – specific environment, and
- *ov* – specified time.

The evaluation of reliability and the hardware reliability itself are based on the analysis of failure, i.e. software errors and their impact on the overall system. Software error may be the result of errors in the code, misuse, misinterpretation of specifications that the software should satisfy (incompetence of programmers), the application of inappropriate tests or other unforeseen problems.

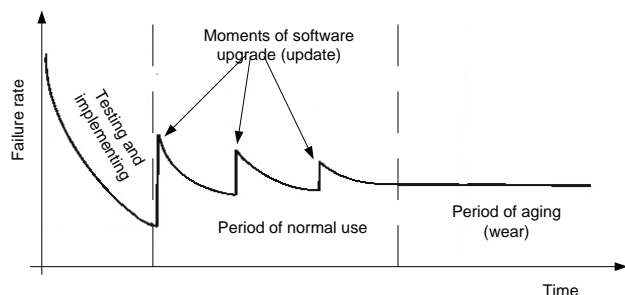


Figure 3.
The function of the failure rate of software.

Comparing the hardware failure rate curve (Figure 1) and the software failure rate (Figure 3), two main differences can be noticed:

- during aging (wear) there is no increased error intensity, nor decreased reliability, because software does not require updating;
- the software failure rate during normal use features a number of peaks indicating an increasing number of failures due to upgrades (updates) of the systemic or user software, as it is likely to make mistakes during the process.

Similar to VTMISS hardware systems, many techniques that are designed for detection and fault tolerance can be applied to the software. Redundant software can be implemented in multiple forms, and it is not necessary to replicate the entire modules to obtain redundancy. Software redundancy can be achieved by using additional parts of programs (from using several software modules to the use of programming procedures), or through additional data storage, where several software support tools may be used.

The simplest mechanism for checking software is the use of time clocks or monitoring clocks (programmable timers, counters that normally reset the programs that are being executed before reaching zero when counting backwards). If the program is terminated due to an error, the countdown timers will not be reset on time, and functional control will send a technical warning to the service console and enter it in the log file.

In order to increase the availability of software subsystems, there has been an increased use of software agents, i.e. systems for automatic installation and configuration of software support modules on remote PCs. Software agents can perform the installation of operating systems or modules of systemic functions. The RMS (Remote Maintenance Stell) is such an example. The RMS system allows fully automated remote management of software support on a large number of nodes in the IP network.

In the beginning of modern VTMISS system development, the operating systems Windows NT, Windows 2000 and

Windows XP were used. Today, Microsoft operating systems are increasingly replaced with open source solutions (UNIX, Linux, etc.), in particular for server applications.

5. RELIABILITY OF MAN

At the dawn of development of complex technical systems, the manufacturers of computer systems usually determined the reliability of their system by taking into account only the reliability of the hardware (and later, the reliability of the software). From the practical point of view, the reliability defined in such a way presents just approximate information about the reliability of the system where a man inevitably takes part. The first attempts to determine the reliability of man assumed the application of the same concepts and methods that were used by the hardware reliability theory, considering the man / operator as a separate element of the system. Thus, it was possible to form the function of operator errors analogous to the function of the hardware failure rate. When the operator starts working (not being familiar with the current state of maritime traffic), the number of errors is usually high, to be soon reduced and become relatively small and approximately constant. After a while, the number of errors increases due to fatigue. The human error rate curve is analogous to hardware failure rate (Figure 1). The only difference lies in the observation period: for the hardware it is equal to the time of use (for a PC 2 to 5 years), and for humans the observation period covers an operator's shift or working hours.

Significant factors affecting the reliability of the human being are: *stress, time, training, conditions (ergonomics), procedures, etc.*

Man, as part of the system, may take a number of roles that directly or indirectly affect the availability of the system. In VTMISS systems, man can take the role of a VTS operator, VTS supervisor, VTS instructor, VTS manager, he/she may become a service provider (maintenance) or a service user.

IALA Recommendation V-103, entitled "Standards for Training and Certification of VTS Personnel", provides a set of requirements for courses and standards for certification of VTS personnel. A VTS operator must hold a certificate that includes the provision of information services, provision of navigation assistance and traffic organization services, and – if necessary – a VTS supervisor license (Recommendation V-103 Standards for Training and Certification of VTS Personnel, 2009).

Each VTS center should ensure a detailed VTS operator's job description that is in line with the provided services, equipment and coordination with other participants in maritime traffic.

For VTS personnel educational purposes a simulation function is used. The function should be in accordance with the IALA V-103 recommendations. Simulated maritime vessels move in line with the pre-programmed trajectories that are similar to those used for showing the movement of objects. On simulated

maritime facilities an operator can use most of the functions within the VTMS system in the same way he/she uses the functions of the real-life marine facilities.

In order to increase the reliability of VTS operators, it is necessary to develop the ability of simultaneous acting which implies the human activity involving the simultaneous receiving and processing information from multiple independent sources or the simultaneous performance of two or more tasks. The term "simultaneous" should not be taken literally (parallel processing of information), but rather in a broader sense as a fast switching of focus from one task to another.

Problems that affect the reduced reliability of operators include:

- *arm muscle strain* – which largely depends on the design of the keyboard, mouse or control surface; strain of other muscles of the body (general fatigue and pain in the lower back) depends on the design of operator and service console;
- *visual comfort in using the console monitors* – is related to the features of the characters and the background on the console monitor and video terminals (size, contrast, brightness and color); in addition, the visual comfort is affected by monitor resolution, monitor size and speed of exchanging letters;
- *ergonomic design of interfaces* – the interface should allow the operator to focus on the task to be performed and be done in an intuitive way, the user's interface is actually a window providing a view into the application.

It is obvious that man as a part of the system can increase the reliability of the system, but also reduce it if his/her reliability is low. Therefore, the reliability of the man in VTMS systems should be taken into careful consideration. There are human reliability models that have been designed specifically to serve the purpose.

6. CONCLUSION

Safe navigation of vessels is increasingly required in today's global maritime transport, especially in the control and organization of maritime transport. This is achieved through reliable operation of information and communication systems that provide timely, accurate and reliable data and information to the master and other participants in the maritime traffic. Low reliability and availability result in endangered safety of the ship, master's dissatisfaction (due to undelivered goods or services) and lead to pollution of the sea and marine environment. These consequences generate considerable material and financial losses. The reliability and availability of a VTMS system must be calculated by taking into account the reliability of the hardware, the reliability of the software (as there is no component of the system which does not feature a built-in software), but also

the reliability of the man / operator, particularly in supervision systems where human component takes part in all operations.

All manufacturers of VTMS systems can achieve the availability of at least 99.9% for devices, subsystems and the system as a whole by combining hardware, software, information and time redundancy. The introduction of redundancy leads to complex and expensive configurations of the subsystems. For this reason, the designers and users of professional systems including VTMS systems introduce redundancy only into the modules that are critical for the system, i.e. into the modules that require an extremely high level of reliability and availability, such as the VTS server and SQL server.

An increased availability of VTMS systems inevitably implies investment in VTS human resources. The personnel engaged should have IT knowledge, hold VTS certificates, be able to act simultaneously, and be trained to perform all procedures and critical events with the aid of the simulator which is in compliance with the IALA V-103 recommendations.

REFERENCES

- Hussain, I., (2005), Understanding High Availability of IP and MPLS Network, Indianapolis: Cisco Press.
- IEEE Std. 982.2.-1988: IEEE Guide for the Use of Standard Dictionary of Measures to Produce Reliable Software, (1988), available at: <http://standards.ieee.org/findstds/standard/982.2-1988.html>, [accessed 07 September 2012.].
- IALA Recommendation V-128 Edition 3.0: Operational and Technical Performance Requirements for VTS Equipment, (2007), available at: <http://www.tidelandssignal.com/web/information/IALA/Recommendations/V-128-Ed2-2007.pdf>, [accessed 07 September 2012.].
- Jiantao, P., (1999), Software Reliability, Carnegie Mellon University, available at: <http://www.ece.cmu.edu>, [accessed 07 September 2012.].
- Kirmann, R., (2005), Fault Tolerant Computing in Industrial Automation, 2nd Edition, Baden: ABB Research Center.
- Norcontrol IT AS – Vessel Traffic Management & Information System – VTMS 5060, (2006), product data sheet, available at: <http://www.aatash.com/website/aatash-norcontrol/pdf/VTMS5060.pdf>, [accessed 07 September 2012.].
- Pokorni, S., (2002), Pouzdanost i održavanje tehničkih sistema, (in Serbian), Beograd: Military academy.
- IALA Recommendation V-103: Standards for Training and Certification of VTS Personnel, 2009.
- CoastWatch VTMS, User Guide, SAAB SYSTEMS, <http://www.caclase.co.uk/Products/Documents/391/CoastWatch.pdf>, [accessed 07 September 2012.].
- Shooman, M. L., (2002), Reliability of Computer Systems and Networks: Fault Tolerance, Analysis, and Design, New York: J. Wiley & Sons.
- Struk, V., Pouzdanost računalnih sustava, (in Croatian), lectures, Faculty of Electrical Engineering and Computing, University of Zagreb, available at: http://www.fer.unizg.hr/_download/repository/prs_01%5B1%5D.pdf, [accessed 07 September 2012.].
- Tomas, V., (2004), Tehnike toleriranja kvarova u dijagnostičkom sistemu, in Croatian, Pomorstvo, 18(2004), pp. 137-146.

Maritime English – What Does It Communicate?

Adelija Čulić-Viskota, Sara Kalebota^a

Maritime English is said to be a product of life on the ocean itself. It may be considered as the cradle of what is nowadays known as a type of ESP for the purposes of maritime communications. This paper presents an account of the rise of Maritime English as a type of ESP. It deals with the characteristics of ESP and how well Maritime English fits into the frame. Furthermore, the reciprocating influences of General English and Maritime English are presented and examples of both are provided to illustrate the vivid interaction between the two. Finally, an attempt is made to view the future development of Maritime English as based on the present-day conditions and future requirements.

KEY WORDS:

- ~ Maritime English
- ~ ESP
- ~ Maritime history

1. INTRODUCTION

It is definitely not by accident that English has assumed the responsibility for maritime communications, not only business but also communication among multinational, multicultural and multilingual crew members on board vessels worldwide. The communicative role of Maritime English is deeply rooted in centuries-long British seafaring tradition but it has grown eventually to become a proper jargon related to a branch of human activity. It simultaneously extends its influence to the General English while making specific use of it, and to other ESP varieties that it comes across. Crewmembers on board make varied use of it according to their specific needs, but what is common to all of them is appropriate communication, both spoken and written, that contributes to the safety of navigation.

2. THE RELATEDNESS OF THE ENGLISH MARITIME HISTORY TO LANGUAGE

What is today known as the territory of Great Britain was connected to the European continent long before the human period began, that according to the findings of the Ancient Human Occupation of Britain project (AHOB)¹ was about 500,000 years ago. The land link to the continent later widened, and climate changes forced pre-historic population out of and again

Faculty of Maritime Studies in Split, Zrinsko-Frankopanska 38, 21000 Split, Croatia,
e-mail: adelija@pfst.hr

a. Primary school Petar Berislavić, Obala bana Berislavića 16, Trogir, Croatia
e-mail: sakalebo@hotmail.com

-
1. *The Ancient Human Occupation of Britain* project whose third phase is currently under way has been funded by the Leverhulme Trust. The results have been made available through publications, conferences, databases, a television series and a website: see www.nhm.ac.uk/hosted_sites/ahob/

into what is now Britain. Thus, the inhabitants were forced to get first into contact with the sea if they wanted to make any contacts with the neighbouring areas and their inhabitants. First, they had to cross the ocean to inhabit the Islands and later they had to cross it back for various purposes.

The beginning of the maritime history of England is believed to date back to the Iron Age Phoenician traders describing the trade routes to England around 600 BC. They were succeeded by the Ancient Greeks who provided a detailed description of their sea voyages from Massilia, present-day Marseilles, along the western Mediterranean to Britain some three centuries later.² These were in fact the ancient pilot books called *peripli* from Latin singular *periplus* originating from Greek *περίπλους* meaning sailing around or circumnavigation. Eventually, the meaning broadened to include “a manuscript document that listed, in order, the ports and coastal landmarks, with approximate intervening distances, that the captain of a vessel could expect to find along a shore. ... the Greek navigators added various notes, which if they were professional geographers (as many were) became part of their own additions to Greek geography. In that sense the *periplus* was a type of log.”

The Britons inhabiting the area of the Island to the south of the Firth of Forth³ already before the Roman Iron Age⁴ are of unknown origin. They are supposed to have reached the Island from Armenia, which is thought to be a mistaken transcription of Armorica, an area in North-Western Gaul⁵. They are also known for periodically moving to continental Europe, where they founded the settlements of Brittany in France and the little-known Britonia is what is now Galicia in north-west Spain.

The first boats used by the Britons are believed to have been rafts, canoes dug out from tree trunks and coracles. They are supposed to have mainly been used for fishing and transport on rivers. According to the archaeological findings, the oldest known ocean-going boat related to the British Isles dates back

to the Bronze Age, approximately 1600 BC. It was named the Dover Bronze Age Boat after the area in which it was excavated in 1992. Its length is 9.5 m, beam 2.3 m, it is thought to have been propelled by a crew of between 4 and 16 paddlers and to have reached speed up to 5 knots. It could also carry some cargo.

During the Roman period maritime expeditions to the Island were frequent, as well as invasions and trade contacts with Britain and later from there to Europe.

In the second half of the 3rd ct. the shores of Britain were under frequent attacks by the Picts and Scots as well as the Germanic tribes of Angles, Saxons and Jutes. The latter were even recruited as mercenaries to assist the British kings. They eventually established control over the south-eastern areas of England. From the east coast of Britain many trade lines went across the North Sea while the west coast continued trade with the Mediterranean. So, the sea-borne trade stimulated migrations from southern England to Brittany and northern Spain.

As early as in 730s ships that used the port of London for trading had to pay a toll⁶ that would later become what is known as harbour dues.

From the 9th ct. the Vikings frequently attacked Britain and simultaneously traded with the help of their longships propelled by both oars and sails. A significant feature of their vessels was a steering oar (or board) at the back on the right-hand side that will later result in the term *starboard* designating the right-hand side in Maritime English and the term *port*⁷ left-hand side. Later, in 1066 the Normans conquered Britain after a sea-borne attack followed by a lot of trade across the English Channel. The British also fought against the French, Portuguese and Irish; therefore, they required naval transport for the army and its support. Another later ship design, the *cog*, is believed to have been influenced by the *longship*. The rudder was now fixed to the stern post, thus facilitating the steering. There were also more masts and a more abundant sail wardrobe to increase the ship's speed.

2. “The *Massaliote Periplus* or *Massaliot Periplus* is a now-lost merchants' handbook possibly dating to as early as the 6th century BC describing the sea routes used by traders from Phoenicia and Tartessus in their journeys around Iron Age Europe. Massalia, however, was a Greek colony. It was preserved by the Roman poet Avienus in his work *Ora Maritima* (The Maritime Shores) who wrote down parts of it much later, during the 4th century AD. It contained an account of a sea voyage from Massilia (Marseilles) along the western Mediterranean.

It describes seaways running northwards from Cadiz in Spain along the coast of Atlantic Europe to Brittany, Ireland and Britain. The *Periplus* is the earliest work to describe the trade links between northern and southern Europe. That such a manual existed indicates the importance of these trade links. The trade in tin and other raw materials from the British Isles southwards is attested by archaeological evidence from this period and earlier and the riches to be won probably attracted numerous adventurers to explore and exploit the Atlantic coasts. Pytheas of Massilia described a similar expedition in more detail a few centuries later, around 325 BC.” (retrieved from: http://en.wikipedia.org/wiki/Massaliote_Periplus)

3. Firth of Forth is the estuary or *firth* of the river Forth in the southern part of Scotland

4. Koch, pages 291-292 (Koch, 2006)

5. The Anglo-Saxon Chronicle

6. *Toll* = a charge, fee or tax for the privilege of using a structure, in this case the port

7. The explanation found at the British National Maritime Museum web page: <http://www.rmg.co.uk/explore/sea-and-ships/facts/faqs/customs-and-origins/port-and-starboard>

“If starboard is the right-hand side of the vessel, looking forward from aft, the left-hand side is port – at least, it is now! In Old English, the term was *bæcbord* (in modern German *Backbord* and French *bâbord*), perhaps because the helmsman at the *steorbord* had his back to the ship's left-hand side. This did not survive into Medieval and later English, when *larboard* was used. Possibly this term is derived from *laddebord*, meaning ‘loading side’; the side rudder (*steorbord*) would be vulnerable to damage if it went alongside a quay, so early ships would have been loaded (‘laded’) with the side against the quay. In time *laddebord* became *larboard* as *steorbord* became *starboard*. Even so, from an early date port was sometimes used as the opposite for starboard when giving steering orders, perhaps deriving from the loading port which was in the *larboard* side. However, it was only from the mid-19th century that, according to Admiral Smyth's *The Sailor's Word Book*, published in 1867, ‘the left side of the ship is called port, by Admiralty Order, in preference to *larboard*, as less mistakable in sound for *starboard*’.”

During the rise of the Hanseatic league the trading guilds extended their commerce over the Baltic and part of the North Sea in the Late Middle Ages when warehouses were established for the League in English and Scottish ports. At nearly the same time seamen's guilds, the predecessors of modern seamen's clubs were established all over Britain. Thus, the English merchant fleet started developing after the League collapsed.

From the 15th to the 17th ct. the British travelled all around the world in search of new markets and trading relations, established new trading routes contributing at the same time to the exploration of unknown lands and peoples. Once the British established their colonies worldwide, they set up trading relations supported by their emerging merchant fleet. The English ships were seaworthy, but required a lot of crew. Thus, they could not be competitive in the newly rising maritime shipping market. When they captured several Dutch merchant ships in the wars they fought, they first made them part of their own merchant fleet and subsequently applied newly-acquired techniques to building their own new ships. The results were ships with a larger stowage area due to a longer keel, but with a reduced number of crewmembers. Thus, the first part of the 17th ct. was a period in which the English maritime shipping flourished due to trading relations with the Mediterranean, East Indies⁸ and North America.

The English naval fleet established by Alfred the Great declined after defeating the Vikings but it recovered in the 10th ct. when the Norman invasion was threatening. The Normans conquered England nevertheless, as the English fleet was previously damaged in a storm and was not able to oppose the conquerors. After the Normans had become rulers of England, they established a naval fleet in the 12th and 13th ct. that made a total of some 500 ships, while in the following century the number increased to more than 700. The 15th and 16th ct. saw the beginning of building specialised warships larger than merchant ships. Their number amounted to 40 by the 1550s, and were characterized by gunports designed to carry heavy guns. For this purpose new shipyards had been founded. But the navy was not supported by appropriate funds which weakened the defence of the British coast. In the following centuries the English naval fleet was reformed and improved again, and the institution of the Admiralty was founded in 1545 as the fleet had already for two centuries been commanded by admirals. This led to establishing the post of Lord Admiral of England in 1408. The important difference lay in the fact that now the Admiralty had control of naval operations and ships' officers and that the First Lord of the Admiralty was a civilian and a member of the Government. In the 17th ct. the first Fighting Instructions were issued, and in 1673 the first Sailing Instructions appeared.

8. *East Indies* is a term used by Europeans from the 16th century onwards to identify what is now known as the Indian subcontinent, Southeastern Asia, and the islands of Oceania and Maritime Southeast Asia.
(retrieved from: http://en.wikipedia.org/wiki/East_Indies , May 6, 2013)

The oldest traces of shipbuilding in England date back to the 9th into 10th ct., i.e. to the cargo boat found in Graveney, Kent. According to Fenwick and Morley (Fenwick and Morley, 1978) the boat measuring roughly 14 per 4 metres was used for carrying the cargo of quernstones from the Middle Rhine to the Thames. Another 13th ct. boat was found on the river Severn which proves that the early British boatbuilding existed in rivers and streams close to the coast.

Ship design developed over time: ships were increasingly fitted, first with decks to obtain closed space around the 12th ct. and by the beginning of the 13th century with stern-mounted rudders. The number of masts also increased in the following centuries as well as the number and area of the sails. By the 16th ct. there were about 60 types of vessel among which the most famous was the cog and carvel developed under the Portuguese influence. They were accompanied by the English galleon featuring gunports from the mid-16th ct. This was the period in which the region of the river Thames became the leading shipbuilding area.

2.1 Privateering and piracy: robbery at sea

Along with the rise of maritime affairs in what is now Britain there appeared some other less plausible activities such as privateering and piracy. The difference between the two was in the aspect, i.e. privateers were authorized to capture enemy ships, while pirates were not. In the early 16th ct. pirates were considered as offenders of the civil law, and there are records of persons convicted and hanged for piracy.

Nevertheless, the British rulers allowed and commissioned attacks they considered favourable for their country in the current circumstances. Thus, ship captains were joined by merchants and gentlemen to fit out ships that were expected to defeat foreign fleets and take over their treasure as well as explore and plot new merchant paths. So, in this period valuable charts of the East were produced.

In the 17th ct. the pirates from North Africa used to attack British ships so that by the mid-17th ct. an expedition against them started in the Caribbean. Thus, the English now had their own pirate leaders operating in the Atlantic and Caribbean. To make this activity cease, in 1700 an Act of Parliament was passed by which pirates had to be brought before Vice Admiral's Court.

All sea-related affairs obviously required a specific jargon serving the life and activities on board as well as in the occasions of discussing them either among the educated persons (e.g. the legal aspect of a maritime venture) or laymen (e.g. describing it among the villagers). This fact definitely gave rise to a special domain of English in which general and specific meet in a friendly manner both prospering from each other's company but at the same time remaining distinct entities.

3. THE RISE OF MARITIME ENGLISH AS A TYPE OF ESP: ITS NARROWER AND BROADER SENSE

3.1 The growth of ESP

The origins of ESP are a widely discussed topic. The most plausible reasons for its appearance seem to be those noted by Hutchinson and Waters (Hutchinson and Waters, 1987): 1. the demands of a Brave New World arising with the growth of economic power of the USA in the period following World War II, as well as the prosperity of oil-rich countries during the oil crisis in the early 1970s; 2. a revolution in linguistics brought about by a change of the object of investigation that ceased to be the language itself and turned to its communicative aspect; 3. focus on the learner with specific requirements that had to be met by investigating specific contexts and designing appropriate courses. The authors provide a guideline in the title itself, i.e. "a learning-centred approach". This means firstly, that the researchers' interest is focused on the process of language acquisition including the learner, and secondly, that ESP should not be considered as the product but as a possible approach to meeting the requirements of the user (Hutchinson and Waters (Hutchinson and Waters, 1987). Some ten years later Dudley-Evans & St. John (Dudley-Evans and St. John, 1998) proposed some absolute and variable characteristics to better delineate the definition of ESP. The absolute characteristics are:

- 1) Designed to meet specific needs of the learners;
- 2) Makes use of the underlying methodology and activities of the disciplines it serves;
- 3) Centred on the language (grammar, lexis, register), skills, discourse and genres appropriate to these activities.

The variable characteristics are:

- 1) ESP may be related to or designed for specific disciplines;
- 2) ESP may use, in specific teaching situations, a different methodology from that of general English;
- 3) ESP is likely to be designed for adult learners, either at a tertiary level institution or in a professional work situation. It could, however, be used for learners at secondary school level;
- 4) ESP is generally designed for intermediate or advanced students. Most ESP courses assume basic knowledge of the language system, but it can be used with beginners.

3.2 The distinction of Maritime English as a specific jargon

According to the above mentioned characteristics Maritime English constitutes an ESP course as all of the seven features apply to it. Still, any attempt at a further delineation of Maritime English as taught at the Faculty of Maritime Studies presents new problems. It cannot be restricted to English for

Vocational Purposes (EVP) as this is only a part of its scope. In the Bachelor curriculum vocational purposes meet professional (EPP) thus fitting into both branches of English for Occupational Purposes (EOP). Furthermore, in the Master curriculum English for Academic Purposes in Science and Technology (EST) as well as Business English (BE) also have to be included. Therefore, Maritime English may be perceived as a direct proportion of the number of traits involved and the level of study. This is all due to maritime profession having become interdisciplinary up to the point of involving business, medicine, technology and science as well as their specific Englishes.

From the linguistic point of view Maritime English is a specific jargon. But, it also implies a specific style embodied in specific grammatical forms, or as in (Miller, 1981) states about his work on the jargons: *"... I started to see things differently. I found that each variation on the language, much as it might be abused, contained something fascinating that I had not expected: it revealed the basic mind-set, the underlying style of thinking and perceiving of each singular discipline and the people who inhabit it."* This is how Maritime English may be perceived in its broader sense.

It was the Resolution A.380(X) adopted by IMO General Assembly in 1977 in virtue of which English was recognized as "a common language for international communications between ships and between ships and shore services." (Bocanegra Valle, 2013) It was the official recognition of Maritime English as the workhorse in the maritime profession. It first meant a specific vocabulary (Maritime English in the narrower sense of the term), but as time went by, it began to take shape of a more complex communicative tool. Consequently, its teaching aspect has been elaborated on and its curricula standardized in the IMO Model Course 3.17 designed to meet the requirements of STCW.

4. COMPARISONS AND CONTRASTS BETWEEN GENERAL ENGLISH AND ESP

Let us first introduce different terms and acronyms related to the topic. ESP itself may either stand for English for Specific Purposes or English for Special Purposes, the latter being felt as an outdated term although it can still be found as representing a superordinate term to English for Specific Purposes in that special purposes include different specific purposes.

ESP is usually opposed to EGP standing for English for General Purposes, or as it appears in TENOR, an acronym meaning Teaching English for No Obvious Reason (Lowe, 2009). Maritime English is definitely taught for a very specific purpose. Still, this does not mean that it is a self-sustaining separate entity. It certainly makes abundant use of the general language ascribing to its lexical units new meanings, thus enriching its lexical aspect. Furthermore, ESP can often present quite unexpected uses of standard grammar in order to convey specific meanings.

4.1 Maritime English and General English on Reciprocating Courses

General English may be perceived as the starting point for different specific jargons as all of them arise on the basis of the General incorporating its lexical units and basic grammar. Here starts the process of diversification which implies a detachment from the General, but also its enrichment with new meanings ascribed to the existing body. Sometimes these diversifications become highly specific and elaborate to the point of becoming hardly understandable to the speakers of General English. Thus, Miller (Miller, 1981) observes: *"Often within a single family, between brothers and sisters, or between lovers or old friends there exists a special, secret language, unknown to the rest of the world, which carries an intimate set of meanings and associations. In my own experience I have found these to be among the most beautiful forms in which language can be used."*

4.2 General English lexical units resulting into Maritime English terms

For specific purposes Maritime English has preferences for certain lexical items rather than others with synonymous meaning so as to ensure the highest intelligibility and least possibility of misunderstanding. Thus, it prefers to *alter course* instead of *changing* it (although in the General both are acceptable) as the more out-of-the-way lexical item is certainly harder to misunderstand, especially in the shipping environment that has for some time now been made increasingly hectic and communication has turned into a babel due to a large number of world Englishes used by again increasingly multinational crews. Furthermore, there are lexical units whose basic meaning takes on jargon-specific features. Thus, e.g. the sailing manoeuvre known as *tacking* derives from the General English verb *to tack* dating back to the 14th century Middle English *takken* related to *tak* meaning *something that fastens one thing to another* and probably related to Old French *tache* for a *clasp, large nail*⁹. The noun comes in its first meaning *a small, sharp broad-headed nail*, followed by a North American meaning of *a drawing pin*, next by the meaning of *a long stitch used to fasten fabrics together temporarily, prior to permanent sewing*. After that comes the meaning which is more abstract: *a method of dealing with a situation or problem; a course of action or policy*. Finally, there comes the meaning characteristic of sailing: *to make a series of changes of course while sailing; to alter course by turning a boat's head into and through the wind*, which of course denotes the steps taken to perform the alteration of course during sailing, but it nevertheless implies the above mentioned

change of tactic as proposed in the *meaning to modify one's policy or attitude abruptly*¹⁰. Likewise, the verb *to gybe*, alternatively spelt *to jibe*, deriving possibly from the late 17th century obsolete Dutch verb *gijben*, present-day *gijpen*, is used with the General English meaning *to make a sailing manoeuvre shifting a fore-and-aft sail from one side of a vessel to the other while sailing before the wind so as to sail on the opposite tack* or from the Middle French *giber*, meaning *to shake or handle with force*¹¹. *Jibe*, as a noun, is a versatile word with several meanings, including *to be in harmony or in agreement* (e.g. *let's see if our calculations jibe*)¹². There is of course a rich array of terms arisen from the General language which have gone through different processes of specification of meaning to become proper Maritime English terms.

4.3 Influences of Maritime English on General English

As seafarers and sailing enthusiasts take their experiences along even after disembarking and their activities while on board have significant effect on the formation of their worldview, the influences of Maritime English on General English are numerous. To illustrate this there are examples such as:

all at sea (Br.E.) / *at sea* (Am.E.) meaning *completely confused, lost and bewildered*¹³ as in:

It was his first day at the University, so he felt *all at sea* / *completely at sea*.

Sea legs meaning first the *ability to keep one's balance when walking on a moving ship and not feel ill* as in:

It took me a while to get my *sea legs*, but I feel fine now. (ibid.)

A second meaning can be *to get used to a new situation* as in: After graduating from college he went to Chicago to get his *sea legs* by working in radio.

To batten down the hatches deriving from a nautical expression meaning *to seal the hatches against the arrival of a storm* (ibid.) but having also a figurative meaning *to prepare for difficult times* as in:

When you're coming down with a cold, all you can do is *batten down the hatches* and wait for the body to fight it off.

Feeling blue or *feeling sad* also derives from the age of deepwater sailing ships, which on e.g. losing their Captains or Officers during a voyage would fly a blue flag and have a blue

9. <http://oxforddictionaries.com/definition/english/tack> (April 12, 2013)

10. <http://www.merriam-webster.com/dictionary/tack> (April 12, 2013)

11. <http://owad.de/check.php4?wordid=1630&choice=3&PHPSESSID=710dd862e74e02dec17e6476cb68780b> (April 12, 2013)

12. Ibid.

13. Sources: http://www.englishclub.com/ref/esl/Idioms/A/at_sea_all_at_sea_140.htm (April 19, 2013); <http://idioms.thefreedictionary.com/sea> (April 19, 2013); Cambridge Idioms Dictionary, 2nd edition, CUP 2006; McGraw-Hill Dictionary of American Idioms and Phrasal Verbs. © 2002 by The McGraw-Hill Companies, Inc.

band painted along the entire hull when returning to home port. (ibid.)

To know/learn/show/teach the ropes deriving from the early days of sailing when the phrase *He knows the ropes*. written on seafarer's discharge meant that he was still a novice and all he knew about the job was theory, or the names and uses of the principal ropes or lines. But the phrase has changed meaning and at present it means that *the person fully knows and understands the operation*, as in:

It'll take some time for the new receptionist to *learn the ropes*.

or in:

The new secretary started today so I spent most of the morning *showing her the ropes*.

The above mentioned idioms and phrases are just the tip of the iceberg. Fortunately, further discussion of the kind could only be enlightening.

5. CONCLUSION

With its centuries-long maritime history the English language has become *the language of the seven seas*. Influences of General English and Maritime English can be perceived as mutual or reciprocal. General English definitely represents the basis from which a rich array of the jargons actually in use have stemmed. On the other hand, the vividness of jargon stylistic means fostered by its deep rootedness in specific situations contributes significantly to the semantic abundance and versatility of General English. Regarding the status of Maritime English it can rightfully be emphasized that due to its standardization referring to the existing and new areas of interest in shipping, and increasing efforts at teaching Maritime English at maritime colleges and universities worldwide, it has contributed to preventing maritime accidents. A possible future development might also include ship's rating ranks as it would definitely ease both their lateral/horizontal and hierarchical/top-down, bottom-up communication.

REFERENCES

- Anglo-Saxon Chronicle, available at: <http://avalon.law.yale.edu/medieval/ang01.asp>, [accessed 9 December 2012.].
- Bocanegra Valle, A., (2013), Maritime English. In Chappelle, C. A. (ed.), The Encyclopedia of Applied Linguistics, West Sussex: Wiley-Blackwell.
- Born, J., (2012), The Norseman. CreateSpace Independent Publishing Platform.
- Britannia History, available at: <http://www.britannia.com/history/docs>, [accessed 17 January 2013.].
- Britannia History, available at: <http://www.britannia.com/history/docs>, [accessed 17 January 2013.].
- Chartrand R., Durham, K., Harrison, M. and Heath I., (2006), The Vikings, Voyagers of Discovery and Plunder. Oxford: Osprey Publishing Ltd.
- Cunliffe, B., (2001), Facing the Ocean. The Atlantic and its peoples, Oxford: OUP.
- Cunliffe, B., (2001), The extraordinary voyage of Pytheas the Greek, Harmondsworth: Penguin.
- Davis, R., (1962), The Rise of the English Shipping Industry in the 17th and 18th Centuries. Newton Abbot: David & Charles.
- Dudley-Evans, T., & St. John, M. J., (1998), Developments in English for specific purposes: A multi-disciplinary approach. Cambridge: Cambridge University Press.
- Enhanced Language Training Initiative: Formative Evaluation, <http://www.cic.gc.ca/english/department/partner/elt-spo.asp>, [accessed 17 January 2013.].
- Fenwick, V. & A. Morley, (1978), The Graveney boat: a tenth century find: excavation and recording; interpretation of the boat remains and the environment; reconstruction and other research conservation and display. Oxford: British Archeological Reports.
- Harrison, M., (2006), The Vikings: Voyagers of Discovery and Plunder. New York: Osprey Publishing.
- Hutchinson, T. & Waters, A., (1987), English for Specific Purposes: A learning-centred approach. Cambridge: CUP.
- Koch, John T., (2006), Celtic Culture: A Historical Encyclopaedia. Santa Barbara: ABC-CLIO.
- Lowe, I., (2009), Principles of ESP course design, available at: <http://www.scientificlanguage.com/swp/coursedesign.pdf>, [accessed 11 March 2013.].
- Miller, D.E., (1981), The Book of Jargon. New York: McMillan Publishing Co.
- Port-and-starboard, available at: <http://www.rmg.co.uk/explore/sea-and-ships/facts/faqs/customs-and-origins/port-and-starboard>, [accessed March 20, 2013.].
- Snyder, C. A., (2003), The Britons. Padstow: Blackwell Publishing.

Concerning Web-based e-learning at a Maritime Higher Education Institution: Case Study

Sanja Bauk, Roland Radlinger^a

The purpose of this article is threefold. Firstly, it considers the real needs which led to the idea of conceiving and developing new study program supported by web-based e-learning system (WELS) at the Faculty of Maritime Studies (University of Montenegro) as maritime higher education and training institution. In this part of the article the collaborative projects which enhanced this idea and its implementation are described briefly, as well. Secondly, the results of the polls realized among certain number of involved students, teachers, and experts in related activities, are presented and discussed in order to identify main features along with pros and cons of the WELS being here examined. And, thirdly, some empirically based suggestions when it comes to choose the appropriate software tools for creating more interesting, engaging, inciting, and thus of higher quality instructional materials being available through WELS, are given.

KEY WORDS:

- ~ Web-based e-learning system (WELS)
- ~ Maritime higher education
- ~ Audio, video and screen recording software tools selection

Faculty of Maritime Studies - Kotor, University of Montenegro, Montenegro
e-mail: bsanjaster@gmail.com

a. Academy of New Media & Knowledge Transfer, University of Graz, Austria

1. INTRODUCTION

Nowadays, numerous recognized and respectful maritime educational and/or training institutions and companies offer e-learning courses, like: Lloyd's Maritime Academy, Maritime and Coastguard Agency, MPI Group, USCG Maritime Institute, etc. Of, course the list is long and should not be limited to the above given one. Also, there are a considerable number of scholars' analyses that support the concept of web based e-learning as additional mode of acquiring/transferring knowledge and skills, not only in maritime education, but in general (Ng et al., 2009; Bauk et al., 2012; Buzadija, 2011; Flatcher and Dodds, 2003; Hanzu-Pazaraet al., 2010; Kadioglu, 2008). However, like in the previous case, the readers should not be limited to these quotations. What supports additionally using WELS at maritime higher educational institutions is the document "The Manila Amendments to the Standards of Training, Certification and Watch-keeping for Seafarers Convention and Code" (Philippines, 21-25 June 2010), which concerns, among other numerous issues: <<the introduction of modern training methodology including distance learning and web-based learning into maritime education and training>>. This strongly supports the efforts of conceiving, implementing and developing WELS at maritime higher educational and/or training institutions.

2. BACKGROUND

The Faculty of Maritime Studies of Kotor (FMS) has long lasting tradition being founded even in the medieval times, when captain Marko Martinović had his own nautical school for

Russian feudal lords (in 17th century) in Perast, a little seaside town near Kotor (today Montenegro). Later on, this nautical school continues to exist in Kotor, and it still works as FMS, educating students and seamen for a variety of both ship and port vacancies. Also, graduated students can find employment in the agencies and companies which are focused on different maritime affairs. Although the tradition of nautical and maritime studies in general is a long-lasting and rich one in Kotor, and along the whole Montenegrin littoral zone, the awareness of the existing new and demanding requirements of the actual global living and working flows is necessary. Above all, this awareness is unavoidable since the situation in Montenegro, in the sphere of maritime affairs, is not a flourishing one. Accordingly, the management of the FMS has recently come up to the idea of introducing web-based e-learning environment for the needs of the students, especially seamen among them, and all other persons being interested in this mode of education and knowledge transfer. It is to be mentioned in this context that FMS several years ago, was forced in a way to adapt the curricula to the Bologna system which recommends, among other things, presence of the students at almost all classes during the semester. Thus, if the students are not present, or if they are usually absent from their classes, there is a risk that they will not pass the examinations! This is particularly the case with the students who have to sail, i.e. to work as seamen to earn their salaries, and to study simultaneously. During the past few years, there were numerous requirements from their side to the FMS's management to organize for them condensed courses several times a year, or to develop and offer them e-learning educational modules. Consequently, the FMS's management decided to meet their requirements and objective needs, and to develop and implement an appropriate web-based e-learning study program.

3. PERPETUATORS

What caused developing e-learning instructional modules at the Faculty of Maritime Studies (FMS), University of Montenegro, besides the enthusiasm of a few teachers and their desire to enrich traditional channels of knowledge transfer, are three projects briefly presented below.

Project 1: The first one is the Tempus project (2010-2013): "Enhancing the quality of distance learning at Western Balkan higher education institutions" (Enhancing the quality of distance learning at Western Balkan higher education institutions, 2013). The objectives of this project are: to improve the quality and relevance of distance education at Western Balkan higher education institutions and to enable easier inclusion of partner country institutions into European Higher Education Area. This implies the specific objectives: to improve, develop and implement accreditation standards, guidelines and procedures for quality assurance of distance education study programs

according to EU practices at national level in Western Balkan (WB) beneficiary countries; to establish the framework for improving distance learning (DL) quality assurance and e-learning methodology on higher education (HE) institutional level in WB countries; to provide training for relevant members of HE educational and public authorities responsible for accreditation and evaluation of DL programs and trainers involved in DL from each partner country, etc. The project leader is University of Kragujevac (Serbia). Owing to this large project, University of Montenegro Center of Information System "set up" Moodle (1.94) server, that creates the opportunity for FMS to use its capacities in preparing and realizing web based educational activities. Through this project a few teachers and assistants from FMS also had opportunities to attend short training courses being dedicated to e-learning several times and to participate in discussion process along with the experts from EU in this domain.

Project 2: The second is the small project of bilateral cooperation realized between FMS and the Academy for New Media and Knowledge Transfer – ANMKT (University of Graz). This project entitled "Developing an e-learning module at Faculty of Maritime Studies (Kotor, Montenegro) for the seamen educational needs" had as its main aim conceiving a new web-based educational program at FMS devoted primarily to the seamen's (among the students) needs. However, this module should be used by all other potential users besides seamen who are interested in such a kind of acquiring knowledge. The University of Graz supported the project by bringing in perennial expert knowledge in novel e-based didactical methods and techniques. In return developed e-learning methods and tools were tested on the basis of a concrete case study. Within this project (2011-2013) experts from ANMKT transferred very useful practical skills on the use of Moodle Management Learning System (MLS) in the effective implementation of e-learning to the teachers and system engineers of FMS throughout several trainings.

Project 3: The third important project within this context is a follow-up of the previously mentioned project of bilateral cooperation between FMS and ANMKT. This project entitled "Distant learning implementation at the Faculty of Maritime Studies, University of Montenegro, as an additional mode of education" aims at effective implementing and developing of web-based e-learning at the FMS as an additional mode of knowledge transfer, devoted again primarily to seamen's needs. ANMKT was the partner in conceiving this e-based instructional module and through this project it would support its effective implementation. In the mean time, this e-learning module has been accredited by the Montenegrin National Council for High Education, and the study program started officially in September, 2012. This e-learning module is still implemented by Moodle platform, and currently it is available at the FMS web portal fzp.moodle.ac.me/login/index.php. The materials for some of

the planned courses are uploaded at the platform, and they are currently available to the certain number of teachers and students who can test it on-line and suggest improvements. In this second phase of the project, possibilities of enriching on-line resources by introducing audio/video/screen-capturing records shall be considered, as well. The possibilities of extending this e-learning aid toward the mobile-learning one, by the Windows 7 Phone (Pekić, 2011) and some other similar applications for mobile devices like i-Phones, shall be considered as well. This project has been approved and it will be realized within the ongoing two years' period (2013-2014).

These three projects are in fact perpetrators of implementing and developing web based e-learning resources at the FMS as maritime higher education and training (MHET) institution.

4. SURVEY ANALYSIS

From the beginning of the WELS project implementation at FMS several surveys among the students (e-learners) have been conducted in order to examine in a way how their perceptions of the advantages and disadvantages of WELS correspond to the ideas of the creators' of this course. The total of 110 students at the postgraduate level have been involved in the survey. Specifically, the interviewed students were supposed to identify the WELS advantages and disadvantages according to their visions among the offered options (Table 1). What is indicative is that more than 50% of the respondents agreed that the suggested advantages of WELS: A1, A2, and A3, are indeed benefits of WELS, as it was predicted by the creators of this system. On the other hand, among the disadvantages of WELS more than 50% of respondents identified only the predefined disadvantage D2 as real disadvantage (Figure 1).

How can the results obtained (Figure 1) be interpreted? - Most of the surveyed students are still not convinced that the possibilities of self-controlling learning process, learning community activities, and more effective learning are the advantages of the WELS (A5 and A6 are lower than 50%). What does it imply? – It implies that students should be convinced by these WELS benefits, i.e. more intensive communication to the teachers and among the students themselves should be enabled, as well as more interesting and inciting self-evaluation tests and educational games, etc. Consequently, the learning outcomes should be obviously higher.

If we now consider the supposed disadvantages of WELS, the e-learners do not see them as big problems: on/line testing,

Table 1.

The WELS advantages and disadvantages taken into consideration.

Advantages	
A1	The possibility of learning from home and working place (during the breaks)
A2	Reducing the travelling costs and time saving
A3	Easier access to the instructional materials
A4	Possibility of self-knowledge-evaluation through on-line tests
A5	Ability to communicate via the net with teachers and other candidates
A6	More effective learning

Disadvantages	
D1	Lack of direct contact with teachers
D2	Inability to put a question, and get the answer immediately when there is some ambiguity in knowledge transfer
D3	A non-standard form of learning that requires strong will, self-discipline, and high level of concentration
D4	Some exams are taken on-line, which is sometimes stressful due to limited time and present fear if the technique will/will not function properly.

need for a strong self motivation, and lack of direct contact to the teachers, otherwise offered through the traditional classroom teaching/learning. But, what e-learners really need is undoubtedly more frequent consultations with the teachers, in accordance with one-to-one principle. This conclusion directly corresponds to the recognized disadvantage D2. On the other hand, by achieving this, the WELS will give better results due to uprising learning effectiveness. Since this is only a preliminary study, it is to be extended throughout the future research activities planned by the authors, with the aim of scanning e-learners' satisfaction, and concerning the directions toward increasing the overall effects of WELS-based learning process.

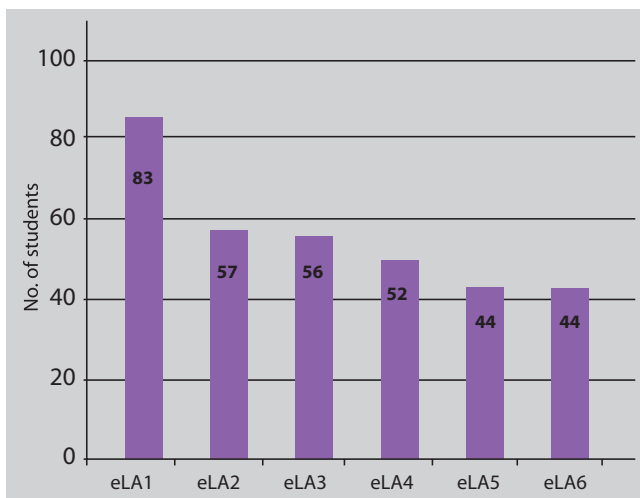


Figure 1.
Number of e-learners who opted for the offered WELS advantages (Table 1).

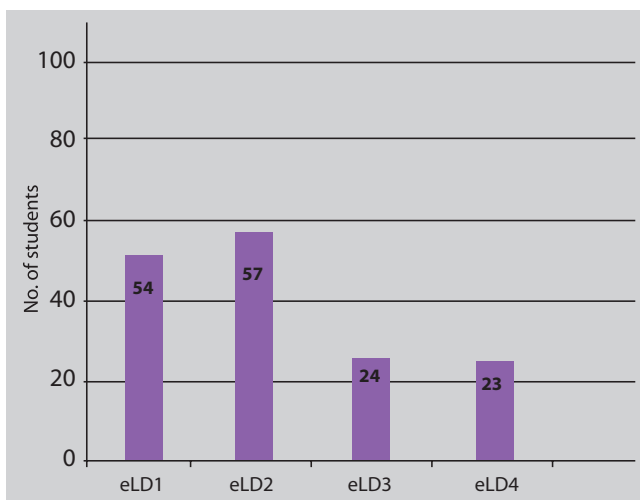


Figure 2.
Number of e-learners who opted for the offered WELS disadvantages (Table 1).

In order to obtain as complete as possible a feedback in the current moment on the realized WELS, besides the surveys among the students of the specialist studies at the FMS, one survey is conducted among teachers at the FMS and experts in developing new IT-supported didactic methods from the ANMKT. The poll conducted among the teachers and the experts has been based on the well-known and in literature extensively used Saaty's AHP

(Analytical Hierarchy Process) method and the author's previous research papers (Bauk et al., 2013a; Bauk et al, 2012). This approach enabled us to rank some WELS features, which have been in the context of this study identified as important ones (Table 2). The ranks are determined by the values of normalized average weight coefficients being previously calculated for each considered criteria, i.e. WELS feature. Certainly, the readers should not be limited by them in the sense that the need for further, more extensive and rigorous research in this area is underlined.

Table 2.

The rank of the analyzed WELS features by AHP approach on the basis of the survey among experts (ANMKT) and teachers (FMS).

Feature	Rank
Availability on-line and high quality of all necessary materials for preparing the exam in a subject	1
Stability and speed of the Internet connection (that is not always the case at sea and in some ports)	2
The existence of the tests for self-evaluation of the acquired knowledge	3
Possibility of regular communication with teachers via forum, chat and/or e-mail	4
Possibilities of doing and evaluating tests and final exam on-line	5
Conducting regular students' surveys	6

The obtained grades in the analyzed WELS features could be qualified in the following manner:

- The teachers and experts involved in this research assigned numerically the highest marks, and gave consequently the greatest importance in the qualitative sense to the availability on the web of the instructional materials (which implies their appropriateness and quality);
- In the second place they put the stability of Internet connection, which is understandable since the WELS examined here is devoted mostly to the seafarers. Namely, it is often not possible to establish Internet connection on the vast sea, or it is usually unstable. Another interpretation should be that the teachers and the experts consider a stable Internet connection fundamental prerequisite for WELS establishing;
- In the third position there is the availability of tests for students' (here mostly seafarers') self-evaluation during the process of acquiring knowledge that is also a very important segment of e-learning which indirectly should involve the existence of smart educational games as well;

- The fourth position is assigned here to the possibilities for the students to communicate to teachers via forum, chat, e-mail, etc. which is of course a very important segment of e-learning, but it is sometimes difficult to achieve this due to the previously mentioned problems with Internet connection and its stability at sea (and sometimes in ports). On the other hand, teachers are usually too busy, and they are practically sometimes physically unable to devote more time to the communication with students;
- At the lowest positions are WELS technical possibilities of doing exams on-line, and conducting regular on-line (or classical) surveys among students related to their degree of satisfaction with offered e-learning services respectively. This is understandable since the Internet as an open communication channel is not perfect for testing students on-line. In addition, even surveys conducted among students are very important. In comparison with the previously considered components of e-learning they are for sure slightly less important. However, this does not mean at all that they should be ignored.

This conducted survey reflects profoundly very subtle nuances in mutual positions of the analyzed e-learning features, and it reminds us to associate them to the high degree of expertise and sensitivity of the responders in this domain (Bauk et al., 2013a).

Further analysis should be directed toward evaluating e-learners' satisfaction with offered WELS and this will be realized by multi-criteria evaluation technique based on Saaty's AHP (Paechter et al., 2010; Shee and Wang, 2008; Wang, 2003). Since the large number of respondents is necessary for conducting such analysis, the possibility of involving some other institutions that offer WELS is in consideration. Namely, a large number of respondents is a kind of guarantee that the survey will be successful and reliable, i.e. that the largest number of respondents will be consistent in accordance to the Saay's AHP method requirements.

5. TECHNICAL SUPPORT: CHOOSING APPROPRIATE SOFTWARE TOOLS FOR CREATING INCITING INSTRUCTIONAL MATERIALS

If we look at the above presented ranking of the WELS features, it is evident that the availability and quality of the instructional materials are rated as the most important factors by teachers and experts in WELS. Undoubtedly, the quality of the instructional material is one of the key factors for successful implementation of WELS. Since the appropriate IS/IT solutions and tools are necessary in their creating, this part of the paper offers a short overview of some available up-to-date software tools for creating interesting and engaging instructional WELS materials, along with the recommendations based mostly on the authors' experience which of them is the most appropriate for certain application.

Today, there is quite a large offer of different proprietary commercial and freeware application software which can be used for producing (Table 3):

- Audio: Audacity, NCH Wave Pod, Adobe Audition, Cubase Steinberg, Logic Studio, Kristal Audio Engine, etc.;
- Video: Windows Movie Maker, Adobe Premiere, Avidemux, Magix Video, Video Spin, AVledit, etc.; and,
- Screen capturing: Adobe Captivate, Capture Fox, Camtasia Studio, Jing, ActivePresenter, BB Flashback, BB Flashback Express, ScreenPresso, VirtualDub, etc.

Web can be used as a resource for further search (Best Free Audio Editing Software, 2013; Best Free Video Editing Software, 2013).

Table 3.

List of the software tools for post-production of e-learning teaching materials.

Legend: A-audio; V-video; S-screen capturing; C-commercial; F-freeware.

Software / Feature	A	V	S	C	F
Audacity	X				X
NCH Wave Pod	X				X
Cubase Steinberg	X			X	
Logic Studio	X			X	
Kristal Audio Engine	X				X
Windows Movie Maker		X			X
Lightworks		X			X
Avidemux		X			X
Magix Video		X		X	
Adobe Premiere		X		X	
Video Spin		X			X
AVledit		X			X
Adobe Captivate			X	X	
Camtasia Studio			X	X	
Jing			X		X
CamStudio			X		X

The list above is not exhaustive as there are many more software tools on the market, proprietary commercial as well as freeware and shareware. Of course, there is also difference concerning the available functions but it is definitely possible to produce up to professional results with selected freeware software.

The following recommendations can be done according to the authors' experiences:

- The open source software Audacity is the most powerful freeware tool for audio editing. It offers various effects and analyzing tools for signal processing, e.g. powerful noise reduction (even adaptive noise reduction) and dynamic processing as well as equalizing, multi-track editing for sophisticated mixes and of course supports recording from any microphone or signal source connected to the computer. Professional commercial audio editing software mainly aims at professionals like sound engineers or sound designers. These professional tools provide further interfaces to audio hardware and various 3rd party plug-ins for high-end audio editing.
- In the field of video editing it is the freeware Lightworks that offers the most functions and editing tools. Even commercial movies have been cut and produced with that software; however it is not especially designed for beginners, so it requires time to get familiar with the production workflow. A more intuitive way and, therefore, more appropriate for beginners is the Windows Movie Maker (last built version is No. 12). It does support most of the latest video formats and has also built-in effects to make transitions and/or color effects and animated titles. It also supports most picture formats so that the producer can combine still and moving pictures in the project. Background sound or

speech can be added and mixed.

- Screen-recording tools have become very popular as it is very easy to make engaging tutorials or presentations of what is happening on the monitor. The freeware tools Camstudio, Jing and AutoScreenrecorder offer the general possibility to record the screen but do also include restrictions which can be watermarks, a limited time for recordings or not supported audio recordings along with the screen recording. Also, the choice of output formats is limited in freeware tools.
- Two market leaders offer a professional tool that combines the above mentioned types of recording: Adobe Captivate, and Camtasia Studio. Camtasia Studio lets the user create professional screen recordings; you can include other media like pictures, movies or sound. The footage can be arranged in multi-track layers, with additional zoom or pan effects as well as highlighting options you can increase the professional look of the production. Below are given some examples of employing Camtasia Studio (ver. 7) in teaching students ECDIS simulator basis. Thus, Figures 3, 4, and 5 show some examples of using call-outs and zoom or pan effects in teaching students ECDIS (Electronic Chart Display and Information System) basis using Transas NAVI Sailor 4000 demo version simulator (Bauk et al., 2013b).

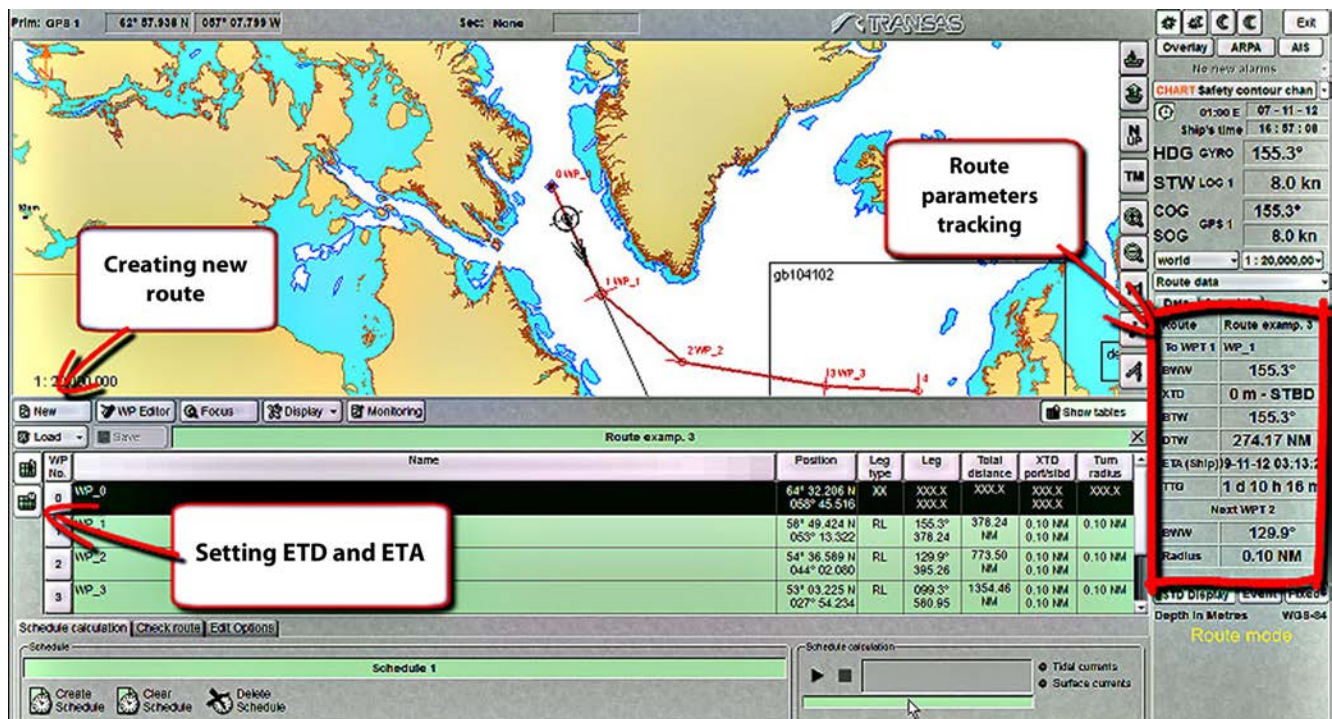


Figure 3.
Call-outs for route planning and scheduling in graphical mode.

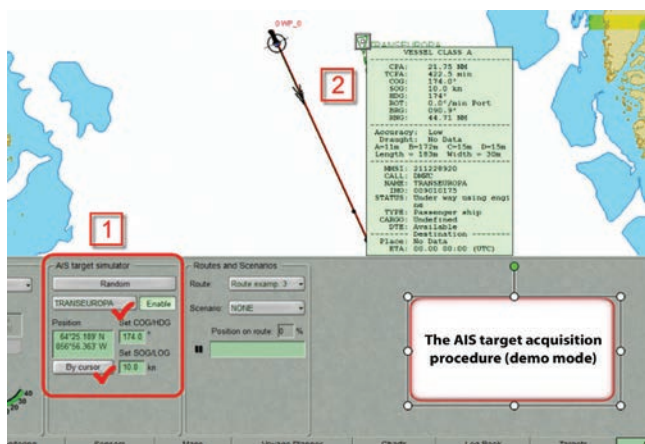


Figure 4.
Call-outs and zoom-n-pan effects for explanation of AIS target acquisition.

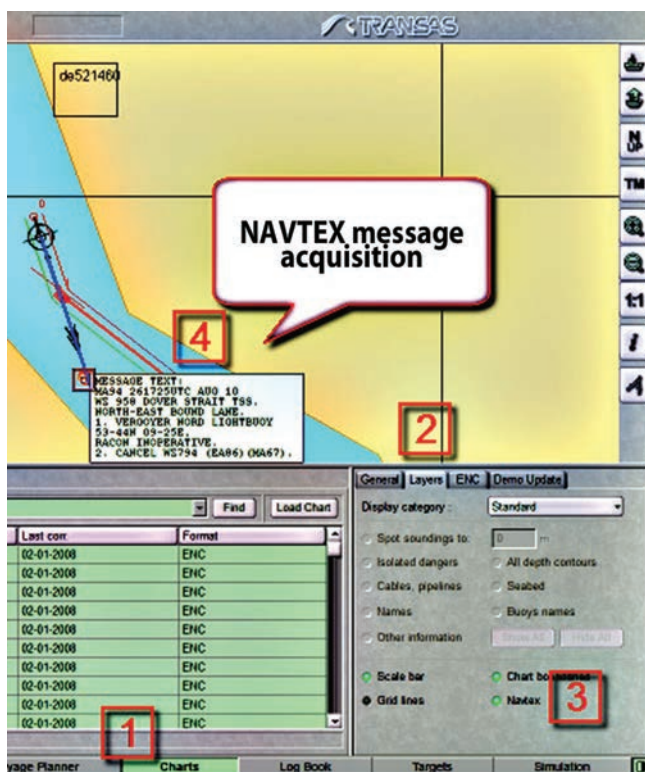


Figure 5.
Call-outs and zoom-n-pan effects for explanation of NAVTEX message acquisition.

6. CONCLUSIONS

All previously mentioned efforts in the introduction and development of e-learning resources at the FMS should improve the overall educational quality standards at MHETs in the Region. However, the need for greater investment in seafarers' higher education (HE) in terms of personnel and infrastructure is indisputable. The networking is also very important, and not "networking just for the sake of networking", but a real one is necessary, based on professional cooperation (on the EU level) among the MHET institutions through more intensive exchanges of teachers and students for the sake of mutual enrichment of knowledge and implementation of joint projects. It is necessary to establish permanent connections with the maritime industry, e.g. shipping companies interested in providing practical training on board ships as well. The national legislation has to be modernized in the sphere of higher education in terms of recognition and proper interpretation and implementation of the STCW (Standards of Training, Certification and Watch-keeping) requirements in terms of a faster deployment of virtual learning as a supplement to the traditional education and training of the seafarers. The newest STCW Code amendments concern and recommend: the introduction of modern training methodology including distance learning and web-based learning in seafarers' knowledge acquisition and upgrading. Within this context, sight should not be lost of the fact that STCW Convention itself calls for a proper education - as the foundation of successful training and acquiring competencies (see for more information "The Manila Amendments" - Chapter II, Section B-II/1, Paragraph 14, 2010). It is to be expected that at least some of these recommendations should be shortly considered and accepted by the responsible HE bodies.

REFERENCES

- Adolf K.Y. Ng, A. K. Y., Koo, A. C. and Ho, J. W. C., (2009), The motivations and added values of embarking on postgraduate professional education: Evidences from the maritime industry. *Transport Policy*, 16(5), pp. 251-258.
- Bauk S., Dlabac T. and Pekić Ž., (2012), Implementing E-learning Modes to the Students and Seafarers Education, Faculty of Maritime Studies in Kotor Case Study. *Proc. 4th International Maritime Science Conference - IMSC*, Solin, Croatia, June 16-17, Faculty of Maritime Studies in Split, pp. 247-255.
- Bauk S., Kopp M., and Avramovic Z., (2013a), A Case Study on Introducing E-learning into Seafarers' Education, *JITA – Journal of Information Technology and Applications*, 3(1), pp. 34-42.
- Bauk S. and Radlinger R., (2013b), Inciting the Development of Engaging Screencasts in Teaching ECDIS. *Proc. 10th Jubilee International Conference - TransNav - On Marine Navigation and Safety of Sea Transportation*, 19-21 June, Gdynia, Poland.

- Bauk S., Šekularac-Ivošević S. and Jolić N., (2012), Seaport positioning supported by the combination of some quantitative and qualitative approaches, accepted for publishing in Transport.
- Buzadžić, N., (2011), The Way of Students' Efficiency Improvement in Knowledge Acquisition and Transfer Knowledge Model in Clarolina CMS, JITA – Journal of Information Technology and Applications, 1(2), pp. 127-135.
- Fletcher S., Dodds W., (2003), The use of a virtual learning environment to enhance ICM capacity building, Marine Policy, 27(3), pp. 241-24.,
[http://dx.doi.org/10.1016/S0308-597X\(03\)00003-4](http://dx.doi.org/10.1016/S0308-597X(03)00003-4)
- Hanzu-Pazara R., Arsenie P. and Hanzu-Pazara L., (2010), Higher Performance in Maritime Education Through Better Trained Lecturers, TransNav – International Journal on Marine Navigation and Safety of Sea Transport, 4(1), pp. 87-93.
- Kadioglu M., (2008), Information and Communication Technology (ICT) Training Application for MET Institutions, TransNav – International Journal on Marine Navigation and Safety of Sea Transport, 2(1), pp. 111-116.
- Paechter M., Maier B. and Macher D., (2010), Students' expectations of, and experiences in e-learning: Their relation to learning achievements and course satisfaction, Computers & Education, 54(1), pp. 222-229.
- Pekić, Ž., (2011), Windows Mobile Application as Support for E-learning in Education, Proc. 6th International Symposium: Ports and Waterways (POWA), 12 October, Zagreb, Croatia (CD issue).
- Shee D.Y., Wang Y.-S., (2008), Multi-criteria evaluation of the web-based e-learning system: A methodology based on learner satisfaction and its applications, Computers & Education, 50(3), pp. 894-905.
- Wang Y.-S., (2003), Assessment of learner satisfaction with asynchronous electronic learning system, Information & Management, 41(1), pp. 75-86.,
[http://dx.doi.org/10.1016/S0378-7206\(03\)00028-4](http://dx.doi.org/10.1016/S0378-7206(03)00028-4)
- Best Free Audio Editing Software, available at: <http://www.techsupportalert.com/best-free-audio-editing-software.htm>, [accessed January 2013.].
- Best Free Video Editing Software, available at: http://webseasoning.com/technology/best-free-windows-video-editing-software/1079/#.UP_kph1bbUd, [accessed January 2013.].
- Enhancing the quality of distance learning at Western Balkan higher education institutions, Tempus project report, available at: <http://www.dlweb.kg.ac.rs>, [accessed January, 2013.].

Environmental and Economic Benefits of Slow Steaming

Marina Zanne, Milojka Počuča, Patricija Bajec

Notwithstanding the fact that maritime shipping is the most energy efficient mode of transportation for large quantities of freight, there are continues efforts to improve its performance. These efforts have become even more intensive since the beginning of global economic crisis.

Slow steaming is one of the attempts to improve both environmental and economic performance of maritime shipping.

The paper gives an overview of existing studies on slow steaming and lists other available and already applicable solutions.

KEY WORDS:

- ~ Slow steaming
- ~ Operating costs
- ~ Environmental efficiency
- ~ Maritime transport efficiency

1. INTRODUCTION

International trade largely depends on maritime transportation as around 80% of the global trade by volume and over 70% by value is carried by sea and is handled by ports worldwide (Panitchpakdi, 2013).

The world fleet consisted of more than 104 thousands of merchant ships at the beginning of January, 2012 (RMT, 2012, p. 34). These ships in general use bunkers which are, by definition, made up mostly from residual fuel oil (Drewery, 2006, p. 142). When burned, these oils produce large amounts of sulphur oxides (SO_x), nitrogen oxides (NO_x), carbon dioxide (CO_2), carbon monoxide (CO), particulate matters (PM), volatile organic compounds (VOCs), etc.

There have been many technical and operational solutions identified to reduce fuel consumption and consequently harmful emission from shipping industry, however it seems that so far slow steaming has become most widely accepted by the shipping carriers. One of the reasons for this is because fuel usage costs make up 50-70% of a ship's total operating expense, and with volatile fuel prices can represent an unpredictable expenditure to maritime companies (Emerson, 2013, p. 2).

Slow steaming indicates a reduction of operating speed of long-distance liner ships. It is mainly applied in container shipping. There are several levels of slow steaming; "slow steaming" for reduction of about 15% with regard to the normal operating speed; "extra slow steaming" for reduction of about 25%, and "super slow steaming" for even higher reductions in operating speed.

The objective of the paper is to present pros and cons of slow steaming identified by the existing studies as well as to give an overview of possible alternative approaches towards costs and emissions reduction in maritime shipping.

University of Ljubljana, Faculty of Maritime Studies and Transport

e-mail: marina.zanne@fpp.uni-lj.si

milojka.pocuca@fpp.uni-lj.si

patricija.bajec@fpp.uni-lj.si

2. TWO ASPECTS OF ONE PROBLEM – THE INCREASING FUEL CONSUMPTION IN INTERNATIONAL SHIPPING

Maritime transportation is supporting international trade for thousands of years. The trade has in general a growing trend, and maritime industry responds with the increasing ordering of ever larger ships; in January 2012 the merchant fleet of almost than 105 thousands of ships had more than 1.5 billion deadweight (DWT) tonnage, and these ships transported 8,748 million tons of cargo in 2011.

However, international trade is growing slower than the DWT capacity, in particular since the pre-crisis year 2007, and this is resulting in oversupply of capacity and consequently in lower utilization of individual ship in average as can be seen from Table 1.

Table 1.

Tons of cargo carried per deadweight ton.

Source: Authors, based on RMT, 2012, p. 6, p. 34, RMT, 2009, p. 38 and RMT, 2001, p. 25

	Trade (million tons)	DWT (million tons)	Coefficient
2011	8,748	1,534	5.70
2010	8,409	1,396	6.02
2009	7,858	1,276	6.16
2008	8,229	1,192	6.90
2007	8,034	1,118	7.19
2006	7,700	1,043	7.38
2005	7,109	960	7.41
2000	5,984	799	7.49

The demand for fuel is increasing in international shipping as it can be seen in Table 2.

Table 2.

Fuel consumption (million tons) in international shipping.

Source: IMO, 2009, p. 37

	Low bound	Consensus	High bound
1990	120	149	185
1995	141	176	218
2000	166	206	256
2005	204	253	314
2006	215	267	331
2007	223	277	344

Fuel consumption and, consequently, bunker costs depend mainly on ship's speed, but also on ship's design and hull condition as well as bunker fuel grade, weather conditions, etc. But, bunker costs significantly depend also on bunker price, which is an external factor and out of control for ship operators. In ocean shipping, bunker fuel prices have more than quadrupled in the last decade, from about \$170/metric ton in 2000 (Ballou, 2013). In fact, according to the latest data from Bunkerworld (2013), the fuel prices range from around \$600 for IFO 380 to more than \$1,000 for MGO at main bunker points.

Slow steaming can help economic performance of shipping carrier in two ways: it can artificially decrease the supply in maritime transportation, so shipping carriers can benefit from lower fuel consumption as well as from higher freight rates due to better relation between supply and demand.

Fuel consumption is closely related to the harmful emissions. Although maritime transportation is clean and energy efficient mode of transportation (see Figure 1), emissions from the growing maritime transport sector represent a significant and increasing air pollution source (Miola et al., 2009, p. 25).

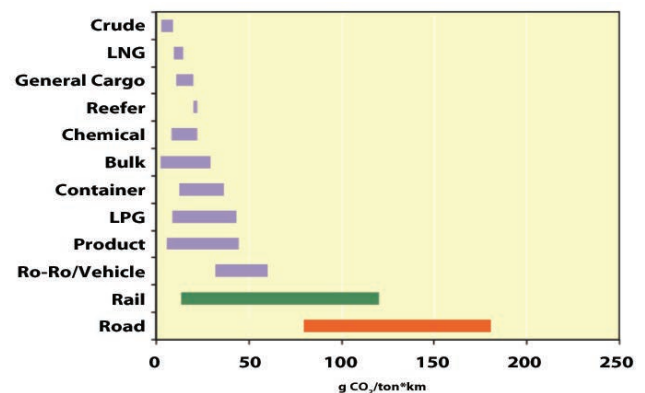


Figure 1.

CO₂ efficiencies of ships compared with rail and road transport.

Source: (IMO, 2009, p. 9)

There's an estimation that international shipping emitted 870 million tons of CO₂ in 2007, which was around 2.7% of the global total of that year, but mid-range scenarios show that by 2050 those emissions could grow by a factor of 2 to 3 if no regulations to stem them are enacted (IMO, 2009, p.1). In addition exhaust emissions from international shipping included also 20 million tons of NO_x, 12 million tons of SO_x, 1.5 million tons of PM and 2 million tons of CO (IMO, 2009, p. 28).

By averaging the air pollution cost factors obtainable from the study on External Costs of Transport in Europe (CD Delft, 2011, p. 38, p. 45) we can estimate the external costs of international shipping to be around 330 billion EUR in 2007^{1,2}.

Corbett and others point towards the dangers arising from maritime transportation that affect human population. They say that shipping related particulate matters (PM) emissions are responsible for approximately 60,000 cardiopulmonary and lung cancer deaths worldwide annually, with most deaths occurring near coastlines in Europe, East Asia and South Asia. Under current regulation and with the expected growth in shipping activity, they estimated that annual mortalities could increase by 40% by 2012 (Corbett et al., 2007, p. 8512).

This is because (IMO, 2009, p. 12):

- 70% of maritime traffic occurs within 200 nautical miles from shore,
- 44% of maritime traffic occurs within 50 nautical miles from shore and
- 36% of maritime traffic occurs within 25 nautical miles from shore.

With respect to GHG, substantial efforts were taken to develop technical (mainly applicable to new ships, e.g. Energy Efficiency Design Index – EEDI), operational (applicable to all ships, e.g. Ship Energy Efficiency Management Plan – SEEMP and Energy Efficiency Operational Indicator – EEOI) and financial measures (e.g. carbon price for shipping) to regulate GHGs, in particular CO₂, emissions from shipping. Consequently, in July 2011 all these measures were adopted into a new chapter in MARPOL Annex VI.

3. PAST STUDIES

Slow steaming is not a new approach to reduce fuel costs; in fact, it was for the first time in use in 1970s during the first oil crisis. However, slow steaming has now a double effect: cutting costs and cutting harmful emissions from maritime transportation. Studies show that when a ship reduces its speed by 10%, its engine power is reduced by 27% (Faber et al., 2012, p. 7). A 10% reduction in fleet average speed results in a 19% reduction of CO₂

emissions even after accounting for the emissions of additional ships needed to deliver the same amount of transport work and the emissions associated with building the necessary additional ships. Emissions of SO_x, NO_x and probably black carbon will decrease in line with fuel use and CO₂ emissions (Dings, 2012, p. 6). According to previously given estimation of external costs of ships' emissions, the reduction of speed by 10% would result in around \$63 billion decrease of these costs on yearly basis.

Maersk alone saved around 2 million tons of CO₂ in 2010 thanks to slow steaming (Jorgensen, 2012) and turned to a \$639 million profit in the first three months of 2010 from a \$373 million loss in the same period of 2009 (Tidetch news, 2012). For example: *Running a 10,000 TEU containership at 18-20 knots instead of the optimal cruising speed of 20-25 knots, can deliver daily savings of 175 tonnes of bunkers. Moreover, super-slow steaming at 15-18 knots improves the picture even further, saving an additional 100 tonnes per day* (Wackett, 2013).

The survey carried out by MAN PrimeServ in late 2011 revealed that engine retrofit, derating and propeller upgrade measures delivered fuel savings either as expected or higher than expected (MAN, 2012, p. 4).

From the economic point of view of a shipping carrier, it is thus necessary to find an optimal speed to have total costs reduced to minimum. But this is feasible in economic sense only when maritime market is in depression. There is, hence, an expectation that, as the economy and markets pick up and excess capacity is brought back into service, speeds will increase again to meet the growing demand (Dings, 2012, p. 4).

There are other entities besides shipping carriers involved in the supply chain, and the question is how they accept the slow steaming. Longer transit times can actually increase shippers' costs because they need more inventory to feed this longer supply chain. Longer ocean transit times can also impact shippers' cash flow as the time from production to sale is extended (Kloch, 2013).

But, the MAN PrimeServ survey documented a positive reaction to slow steaming by a large majority of the global shipping community (Table 3).

1, 2 The first IMO study on greenhouse gas (GHG) provided estimation that ships engaged in international trade contributed about 1.8 per cent of the world total anthropogenic CO₂ emissions in 1996.

Expressed in prices of 2008, and excluding cost estimation for CO and VOC emissions.

3. Those measures are needed to make slow steaming technically impeccable.

Table 3.

Customer reactions to slow steaming [%].

Source: MAN, 2012, Slow Steaming Practices in the Global Shipping Industry, p. 7

	Considerers	Implementers
Positive, without reservation	18.0	32.4
Positive, as long as schedule reliability is not impacted	35.1	29.7
Positive, as long as it means lower rates	15.3	10.8
Indifferent, as long as schedule reliability is not impacted	5.4	8.1
Negative, because of destination logistics planning	3.6	2.7
Negative, because of sensitive or perishable cargo	0	0
Do not know	22.5	13.5

For many manufacturers, retailers, importers and exporters, supply chain reliability is, thus, more important than transit time or rates (Kloch, 2013), and slow steaming gives better time flexibility than regular steaming as there is still space for speed increase if the ship is in delay.

Similar confirmation to slow steaming is given by the study *Smarter Steaming Ahead* which states that if the direct costs (fuel use, crew, capital costs of ships), indirect costs (additional inventory costs, adjustment of logistic chains) and external costs (impacts of emissions on human health and ecosystems, climate impacts) are taken into account, the benefits of slow steaming outweigh the costs (Dings, 2012, p. 6).

However, it is very difficult to predict the effect of slow steaming on individual shipper as it depends on many factors (Kloch, 2013): from product type and volumes to credit facilities and insurance terms, as well as destination and customer expectations.

4. ALTERNATIVE APPROACHES

There are many other ways, besides slow steaming to reduce fuel consumption, such as (Hochkirch & Bertram, 2010):

- Reduce required power for propulsion,
- Reduce required power for equipment on board,
- Substitute fuel power (partially) by renewable energies like wind and solar energy.

Waste heat recovery systems are already in use on merchant ships, and alternative operating systems have recently started being installed and tested.

The kite ship or the skysail technology has been proved to reduce fuel consumption of ships when the kite is used in strong winds. *Aghina Marina* – the largest bulk carrier ship to use skysail technology and *Beluga Skysail* are some examples wherein the kite technology has been used successfully (Kantharia, 2013).

Nichioh Maru Car Carrier is an eco-friendly ship partially fuelled by solar power. This unique engineering system helps the vessel to reduce nearly 1,400 tonnes of exhaust discharges. This accounts for an estimated reduction in carbon dioxide discharges by over 4,000 tonnes yearly (Sharda, 2013).

MV Hallaig is the first passenger/vehicle Ro-Ro ferry in the world to be equipped with a multi-fuelling system using diesel-electricity and lithium ionized battery systems. This also makes it the world's first hybrid ferry (Wankhede, 2013).

In future, ships might be fuelled by Liquefied Natural Gas (LNG), an environmentally friendly, safe, and widely available and thus low-cost alternative to current heavy oil fuels.

5. CONCLUSIONS

Slow steaming is not the only way of reducing fuel consumption and, therefore, fuel costs and harmful emissions, but it seems to be the least time and money consuming and, thus, widely accepted by shipping carriers around the world. In fact, this approach has many advantages as it can be seen in Table 4. This has been recongnized both from the shipping carriers that have already implemented the necessary technology and from those still considering that option.

Table 4.

Main advantages of slow steaming as perceived by considerers and implementers [%].

Source: MAN, 2012, Slow Steaming Practices in the Global Shipping Industry, p. 5

	Considerers [%]	Implementers [%]
Fuel cost savings	93.7	94.7
Greater utilisation of existing capacity	22.5	34.2
Avoidance of idling costs	29.7	28.9
Schedule reliability	10.0	15.8
Service and maintenance savings	17.1	18.4
Lower emissions	36.0	42.1

As different studies show, majority of customers have positively accepted slow steaming, although some individual customers might lose their market position due to longer delivery times and costs connected to this.

Alternative approaches do not affect the operating speed of the ship as slow steaming does, and many believe that slow steaming could be refused as soon as maritime market recovers, or can become regulated if external benefits are recognized in their entirety.

The future of slow steaming will mostly rely on market situation, fuel prices as well as on the supply chain requirements and the oscillations in vessel's operating cost. Considering the fact that the environmental concerns will not vanish, but instead might then become even more emphasized, slow steaming will probably not be an optimal solution when global economy revives.

REFERENCES

- Ballou, P. J., (2013), Ship Energy Efficiency Management Requires a Total Solution Approach, *Marine Technology Society Journal*, 47(1), pp. 83-95., <http://dx.doi.org/10.4031/MTSJ.47.1.5>
- Corbett, J. J., Winebrake, J. J., Green, E. H., Kasibhatla, P., Eyring, V. and Lauer, A., (2007), Mortality from ship emissions: a global assessment, *Environmental Science & Technology*, 41(24), pp. 8512-8518., <http://dx.doi.org/10.1021/es071686z>
- Dings, J., (2012), *Smarter Steaming Ahead*. Brussels: Seas At Risk and Transport & Environment.
- Faber, J., Nelissen, D., Hon, G., Wang, H. and Tsimplis, M., (2012), *Regulated Slow Steaming in Maritime Transport: An Assessment of Options, Costs and Benefits*. Delft: CE Delft.
- Group of authors, (2011), *External Costs of Transport in Europe (Update Study for 2008)*. Delft: CE Delft.
- Group of authors, (2009), *Second IMO GHG Study 2009*. London: International Maritime Organization.
- Hochkirch, K. and Bertram, V., (2010), *Options for Fuel Saving for Ships*. Mare Forum USA 2010: Maritime Transportation of Energy. Houston, USA, February 19, available at: http://www.mareforum.com/ENERGY_TRANSPORTATION_USA_2010_PAPERS/HOCHKIRCH_paper.pdf, [accessed 1 August 2013].
- Jorgensen, R., (2012), *Slow Steaming: The Full Story*. Copenhagen: Maersk.
- Kantharia, R., (2013), *Top 7 Green Ship Concepts Using Wind Energy*, available at: <http://www.marineinsight.com/marine/marine-news/headline/top-7-green-ship-concepts-using-wind-energy/>, [accessed 5 August 2013].
- Kloch, L., (2013), *Is Slow Steaming Good for the Supply Chain?*, available at: <http://www.inboundlogistics.com/cms/article/is-slow-steaming-good-for-the-supply-chain/>, [accessed 3 August 2013].
- Miola, A. et al., (2009), *External costs of transportation - Case study: Maritime transport*. Ispra: JRC.
- Panitchpakdi, S., (2013), *Review of Maritime Transport 2012*, available at: <http://unctad.org/en/pages/PublicationWebflyer.aspx?publicationid=380>, [accessed 1 August 2013].
- RMT, (2008), *Review of Maritime Transport 2008*. Division on Technology and Logistics, New York and Geneva: UNCTAD.
- RMT, (2008), *Review of Maritime Transport 2008*. Division on Technology and Logistics, New York and Geneva: UNCTAD.
- RMT, (2012), *Review of Maritime Transport 2012*. Division on Technology and Logistics, New York and Geneva: UNCTAD.
- Sharda, (2013), *Nichioh Maru – The First Car Carrier with Solar Power System*, available at: <http://www.marineinsight.com/marine/marine-news/headline/nichioh-maru-the-first-car-carrier-with-solar-power-system/>, [accessed 5 August 2013].
- Unknown, (2012), *Slow steaming speeds up*, available at: http://www.tidetech.org/news/Slow_steaming_speeds_up.html, [accessed 4 August 2013].
- Unknown author, (2006), *Ship management*. London: Drewery Shipping Consultants Ltd.
- Unknown, (2013), *Marine Fuel Measurement - Superior measurement for outstanding results*. Boulder: Micro Motion.
- Unknown author, (2012), *Slow Steaming Practices in the Global Shipping Industry*. Copenhagen: MAN PrimeServ.
- Unknown, (2013), *Bunker prices*, available at: <http://www.bunkerworld.com/prices/>, [accessed 11 August 2013].
- Wackett, M., (2013), *Lower speeds boost box schedule reliability, say top European customers*. Lloyd's List.
- Wankhede, A., (2013), *The World's First Hybrid Ferry – MV Hallaig*, available at: <http://www.marineinsight.com/marine/marine-news/headline/the-worlds-first-hybrid-ferry-mv-hallaig/>, [accessed 5 August 2013].

CONTRIBUTION

News from IMO
Maritime heritage
News
Pjesma / Poem
Guidelines

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

INTRODUCTION

Since the last issue of ToMS, the Maritime Environment Protection Committee (MEPC) met at the Organization's London Headquarters for its 65th session from 13 to 17 May 2013, and the Maritime Safety Committee (MSC) held its 92nd session from 12 to 21 June 2013. 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/>).

65TH SESSION OF THE MARINE ENVIRONMENT PROTECTION COMMITTEE (MEPC 65)

Resolution on technical cooperation for energy efficiency measures adopted

The MEPC adopted an MEPC Resolution on Promotion of Technical Co-operation and Transfer of Technology relating to the Improvement of Energy Efficiency of Ships, which, among other things, requests the Organization, through its various programmes, to provide technical assistance to Member States to enable cooperation in the transfer of energy efficient technologies to developing countries.

Update of GHG emissions estimate gets go-ahead

The MEPC approved the terms of reference and agreed to initiate a study for an updated greenhouse gas (GHG) emissions' estimate for international shipping. The new study will focus on

updating key figures in the current (second) IMO GHG Study (2009), which estimated that international shipping emitted 870 million tonnes, or about 2.7%, of the global man-made emissions of carbon dioxide (CO₂) in 2007.

Development of energy-efficiency measures for ships continued

The MEPC continued its work on further developing technical and operational measures relating to energy-efficiency measures for ships, following the entry into force, on 1 January 2013, of the new chapter 4 of MARPOL Annex VI, which includes requirements mandating the Energy Efficiency Design Index (EEDI), for new ships, and the Ship Energy Efficiency Management Plan (SEEMP), for all ships.

The Committee adopted, inter alia:

- amendments to update resolution MEPC.215(63) Guidelines for calculation of reference lines for use with the Energy Efficiency Design Index (EEDI), including the addition of ro-ro cargo ships (vehicle carrier), ro-ro cargo ships and ro-ro passenger ships, and LNG Carriers;
- the 2013 Interim Guidelines for determining minimum propulsion power to maintain the manoeuvrability of ships in adverse conditions, which are intended to assist Administrations and recognized organizations in verifying that ships, complying with the EEDI requirements set out in regulation 21.5 of MARPOL Annex VI, have sufficient installed propulsion power to maintain the manoeuvrability in adverse conditions; and
- amendments to resolution MEPC.214(63) 2012 Guidelines on survey and certification of the energy efficiency design index (EEDI), to add references to measuring sea conditions in accordance with an ITTC Recommended Procedure or ISO 15016:2002.

The MEPC also approved a number of related guidance and interpretations and continues the work on development of the EEDI framework for ship types and sizes, and propulsion systems not covered by the current EEDI requirements.

Draft Assembly resolution agreed and ballast water management systems approved

The MEPC approved a draft IMO Assembly resolution on the application of regulation B-3 of the BWM Convention to ease and facilitate the smooth implementation of the Convention, for submission to the 28th session of the IMO Assembly (25 November to 4 December 2013). The draft resolution recommends that ships constructed before the entry into force of the Convention will not be required to comply with regulation D-2 until their first renewal survey following the date of entry into force of the Convention.

The MEPC also granted approvals to ballast water management systems that make use of Active Substances; approved BWM-related guidance, including Guidance concerning ballast water sampling and analysis for trial use; and adopted a revised MEPC resolution regarding information reporting on type-approved ballast water management systems.

Guidelines for implementation of MARPOL Annex VI regulation 13 agreed

The MEPC adopted guidelines, as required by regulation 13.2.2 of MARPOL Annex VI, in respect of non-identical replacement engines not required to meet the Tier III limit; and a unified interpretation on the “time of the replacement or addition” of an engine for the applicable NO_x Tier standard for the supplement to the IAPP Certificate.

MARPOL amendments to make RO Code mandatory adopted

The MEPC adopted amendments to MARPOL Annexes I and II to make mandatory the Code for Recognized Organizations (ROs). The Code will provide a consolidated text containing criteria against which ROs (which may be authorized by flag States to carry out surveys and issue certificates on their behalf) are assessed and authorized/recognized, and give guidance for subsequent monitoring of ROs by Administrations.

Implementation of MARPOL Annex V – guidance agreed

The MEPC adopted amendments to the 2012 Guidelines for the implementation of MARPOL Annex V, to add references to E-waste generated on board such as electronic cards, gadgets, equipment, computers, printer cartridges, etc.

The MEPC also approved an MEPC circular on adequate port reception facilities for cargoes declared as harmful to the marine environment (HME) under MARPOL Annex V, which agrees that, until 31 December 2015, cargo hold washwater from holds previously containing solid bulk cargoes classified as HME, may be discharged outside special areas under specific conditions.

92ND SESSION OF THE MARITIME SAFETY COMMITTEE (MSC 91)

Passenger drill amendments adopted

The MSC adopted amendments to SOLAS regulation III/19 to require musters of newly embarked passengers prior to or immediately upon departure, instead of “within 24 hours”, as stated in the current regulations. The amendments are expected to enter into force on 1 January 2015.

Interim measures for passenger ships updated in wake of Costa Concordia recommendations

Following discussion in an MSC working group on passenger ships safety, the Committee approved revised Recommended interim measures for passenger ship companies to enhance the safety of passenger ships (to be issued as MSC.1/Circ.1446/Rev.2), to include new recommendations relating to harmonization of bridge navigational procedures across a fleet or fleets; securing of heavy objects (procedures to ensure securing of heavy objects to be incorporated into the safety management system); stowage of life-jackets (including stowage of additional life jackets near muster stations); extending the use of video for passenger emergency instruction notices; and following voyage planning guidance in the case of any deviation.

On specific matters relating to the recommendations arising from the investigation into the Costa Concordia, the MSC, among other things, endorsed the view that the role of shoreside management is critical to the proper development and function of an effective Safety Management System; and invited Member States to consider the mandatory application of evacuation analysis to non ro-ro passenger ships.

Adoption of other amendments

The MSC, *inter alia*, also adopted:

- Amendments to SOLAS regulation III/19, on emergency training and drills, to mandate enclosed-space entry and rescue drills, which will require crew members with enclosed-space entry or rescue responsibilities to participate in an enclosed-space entry and rescue drill at least once every two months. Related amendments were adopted to the International Code of Safety for High-Speed Craft (HSC Code), the Code for the Construction and Equipment of Mobile Offshore Drilling Units (MODU Code) and the Code of Safety for Dynamically Supported Craft (DSC Code) (the amendments are expected to enter into force on 1 January 2015);
- Amendments to SOLAS regulation XI-1/1 to make mandatory the Code for recognized organizations (RO Code), with an expected entry into force date of 1 January 2015. The RO Code was also adopted;
- Amendments to the Protocol of 1988 relating to the International Convention on Load Lines, 1966 (1988 Load Lines Protocol) to make the RO Code mandatory, with entry into force expected on 1 January 2015;
- Amendments to the International Management Code for the Safe Operation of Ships and for Pollution Prevention (International Safety Management (ISM) Code), including a new requirement

for the Company to ensure that the ship is appropriately manned; and

- Amendments to the International Maritime Solid Bulk Cargoes Code (IMSBC Code) (amendment 02-13)), including a new nickel ore schedule, and various related guidance.

Concern over piracy and armed robbery off west and central Africa expressed

The Committee expressed its clear concern over the level of piracy and armed robbery against ships off the coast of West and Central Africa and endorsed the actions of the Secretariat over the last few years to address this. It was noted that the maritime safety, security and law enforcement challenges in the region, all have broadly similar solutions, including: comprehensive legal frameworks; maritime situational awareness; maritime law enforcement capability; and inter agency cooperation on both the national and regional levels, thus the MSC welcomed the development of the new Code of Conduct concerning the prevention of piracy, armed robbery against ships and illicit maritime activity in West and Central Africa, which was adopted recently, at a Ministerial meeting in Benin.

The Secretary-General announced the establishment of a new multi-donor trust fund to support an expanded programme of capacity-building activities in west and central Africa and urged Member States, and the industry to contribute to this fund.

Future of Ship Safety recommendations to be considered at future session

The MSC was preceded by the IMO Symposium on the Future of Ship Safety on 10 and 11 June, which agreed a statement recommending a review of safety measures. The MSC agreed to consider the recommendations emanating from the Symposium at a future session.

AMENDMENTS TO IMO INSTRUMENTS THAT HAVE ENTERED INTO FORCE ON 1 AUGUST 2013

- MARPOL amendments on regional arrangements for port reception facilities under MARPOL Annexes I, II, IV and V (resolution MEPC.216(63)).
- MARPOL amendments on regional arrangements for port reception facilities under MARPOL Annex VI and Certification of marine diesel engines fitted with Selective Catalytic Reduction systems under the NOx Technical Code 2008 (resolution MEPC.217(63)).

The Story of the Liberty Ships

Marijan Žuvić

THEY MARK OUR PASSAGE AS A RACE OF MEN, EARTH WILL NOT SEE SUCH SHIPS AS THOSE AGAIN

Although John Edward Masefield wrote his poem 'Ships' back in 1917, these verses are the best homage to the Liberty ships built a quarter of a century later, describing their very special place in history, not only in the chronicles of shipbuilding and shipping but in the history of mankind. Today it's not easy to describe the enormous effort and achievement it took to build 18 new shipyards on the fields and marshes across America and then construct 2711 ocean-going steamers. Believe it or not, this gigantic fleet was built in only four years, between December 1941 and October 1945!

Seven decades later, the story of the Liberty ships has long been forgotten. The new generations of shipbuilders and seafarers are completely unaware of the ships that saved the world. Since back in 1978 this author was the youngest ever contributor to the eight-volume Croatian Maritime Encyclopaedia with the article on the Liberty ships, it is a great pleasure to introduce these glorious steamers to the readership of ToMS.

Although the best proof of the American industrial might, Liberty ships in fact have deep British roots, with their origin dating back to the 19th century. By American standards they were completely obsolete. Even so, the Liberties became not only a mighty weapon, but a crucial factor in the Battle of the Atlantic. German Blitzkrieg proved disastrous to the Allies not only on the battlefields throughout Europe but also on the sea routes. From the very beginning of World War II Admiral Dönitz's submarines were destroying Allied merchant ships in horrifying numbers. Sailing without escort, these poor merchantmen were just sitting ducks for the U-boats. The most disastrous month in the Battle of the Atlantic was May 1941 when U-boats sunk 125 merchant ships.

For British shipyards naval vessels were of the highest



Figure 1.
The first Liberty 'Patrick Henry' on trials in December 1941.

importance and cargo ships were built at such a low rate that their losses by the hundreds couldn't be replaced. In September 1940, the United Kingdom asked for American assistance in building replacements. The British mission arrived to Washington with the blueprints of general cargo vessel 'Dorington Court' built a year earlier by the Sunderland shipyard of J.L. Thompson & Sons Ltd. It was a standard British steamer, based on a design dating back to 1879, 134.5 meters in length overall, 17.4 meters in breadth, with cargo capacity of 10,500 tons and powered by a triple-expansion steam reciprocating coal-fired engine of only 2500 HP. So her maximum speed was under 11 knots.

The Chairman of the United States Maritime Commission, Admiral Emory Scott Land, was disappointed with British proposal: 'Dorington Court' was just a ship of a bygone era. Reciprocating steam engines, coal firing, extremely slow ship... All long forgotten in America. But that was only part of the problem. A much bigger headache was the fact that America had no shipyards in 1940! After the mass production of emergency cargo ships during World War I, mainly the Hog Island type standard

Maritime journalist and publicist

E mail: marijan.zuvic@st.t-com.hr

freighters, the United States abruptly ceased building its cargo fleet and closed its shipyards. Over an incredibly long period of 15 years, between 1922 and 1937, only two general cargo ships were built in America!?

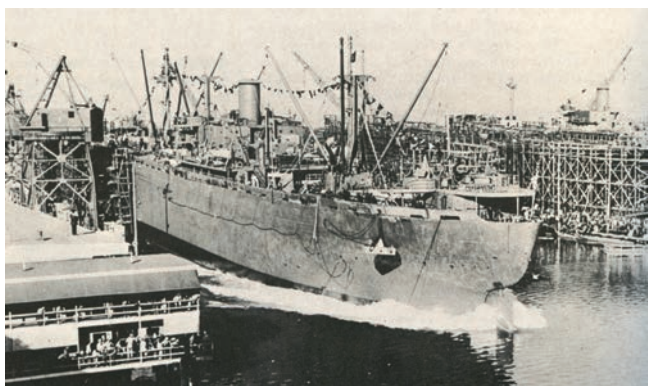


Figure 2.
Record breaker – launching of 'Robert E. Peary' at Richmond.

Nevertheless, willing to help Britain, the Americans accepted an order for 32 vessels based on the 'Dorington Court' design and named Ocean type. But first they had to build two 'green field' shipyards: Todd-Bath Iron Shipbuilding Corp. at Portland, Maine and Todd California Shipbuilding Corp. at Richmond, California. The first of these vessels, 'Ocean Vanguard' was launched on October 15, 1941 at Richmond. After accepting additional orders, the Americans finally built 60 ships.

The escalating war impelled the United States to prepare its own merchant ships for the upcoming hostilities. Since this emergency fleet required urgent action, the Americans reluctantly accepted Ocean type as the basic design for their own mass production, making many significant changes and modifications along the way. The split superstructure was replaced by a compact one, making space for additional cargo hold and the second mast in the forward section. Antique steam reciprocating engine of only 2500 HP remained, but coal was replaced with oil. The choice of an old but simple engine proved to be the best! During the war, the severe shortage of skilled engineers became an enormous problem but steam engines of 2700 Liberty ships could be easily maintained by hastily trained crews.

At 18 locations in the United States brand new shipyards were built. All in all, 210 building berths emerged on the Pacific coast from Oregon and Washington to southern California, Atlantic coast from Maryland to Georgia and the Deep South, in the Gulf at Alabama, Louisiana, Texas and Florida. In inland America, hundreds of miles from the coasts, the

complete industry was prepared for the enormous needs of mass production. Simplicity and adaptability were the motto of the Emergency Fleet Program.

All ship's sections, parts and equipment, over 30 thousand components, were adapted to prefabrication, transported by railroad to the yards and assembled in the shortest possible time. It was said that these new shipyards were merely assembly plants for ships. So it was noted that these revolutionary new shipyards lacked the regular shipbuilding tools and equipment! Furthermore, all parts of the future ships were adapted to welding. All European and Japanese shipyards relied on riveting and welding was rarely used, especially on ocean-going ships. The American experience with welding was likewise scarce, but it was the only way to build such a huge fleet in an extremely short time.

The shipbuilding stage was ready for the grand opening! The keel for the very first of the new emergency ships was laid on April 30, 1941 at Bethlehem-Fairfield Shipyards Inc. in Baltimore, Maryland. Five months later, on September 27, the vessel named 'Patrick Henry' was launched. Admiral Emory Scott Land announced the formation of the Liberty Fleet and that date was declared Liberty Fleet Day. It is generally accepted that they were nicknamed 'The ugly ducklings' by the late US president Franklin Delano Roosevelt. The truth is that Roosevelt was so disappointed with the ship's appearance that he called Liberty 'A dreadful looking object', and the Time magazine introduced the less scary nickname - 'The ugly ducklings'.

'Patrick Henry' was under sea trials for only 245 days after



Figure 3.
Sideways launching of 'William Crompton' at New Orleans.

keel laying, an incredibly short time, especially having in mind that Liberties were among the biggest general cargo ships of their time. Their dimensions were: length overall 134.6 meters



Figure 4.

Wartime scene: 'Hoke Smith' carrying supplies.

(441 feet), length between perpendiculars 417 feet, breadth 17.4 meters, depth 11.38 and draught 8.46 meters. Liberties were measured at 7.176 gross register tons, 4.380 net register tons and 10.865 tons deadweight. The total capacity of three forward and two aft holds was 562.608 cubic feet of wheat or 499.573 cubic feet of cargo in bales. On the main forward mast there were four 5-tons derricks and a 30- or 50-ton boom. Second forward mast had two or four 5-ton derricks. The aft mast was equipped with four derricks and a 15- or 30-ton boom.

Almost unbelievable building records were set and surpassed again and again. On November 12, 1942 at Yard No.2 of Permanente Metals Corp. at Richmond, California a modest ceremony marked the launching of the Liberty ship 'Robert E. Peary'. But it was the greatest shipbuilding achievement in history: she was launched only four days, 15 hours and 29 minutes after her keel had been laid! Being fully completed, 'Peary' left shipyard three days later. Even without such records, the average time of construction for all 2.711 Liberties was the incredible 62 days.

The construction of the Liberties peaked in 1943 and 1944. Victory against the German submarines and the significant reduction of the number of lost merchant ships allowed the American shipyards to turn to sophisticated cargo vessels. The best known of these are the fast turbine-powered ships type Victory.

Even so, the construction of the Liberties continued. The very last vessel, 'Albert M. Boe', was delivered in October 1945 by Permanente Shipyard at Portland.

A total of 2711 Liberty ships were built. The overwhelming majority were ordinary Liberties type EC2-S-C1. But what does this cryptic writing mean? That was the United States Maritime Commission's official mark in accordance with the Classification system introduced in 1936 under the Merchant Marine Act. The letter E was allocated exclusively to the Liberties, meaning Emergency. C2 is a mark for Cargo ship of length between 400 and 450 feet, while letter S represents steam propulsion. C1 is a designation of a particular type of modification.



Figure 5.
Standard Liberty: Croatian owned 'Cavtat' in the dry dock.



Figure 6.
Liberty collier ship 'Hajduk' of Croatian company Jadroslobodna.

During the last months of 1942, the demand for tanker tonnage raised dramatically and the United States merchant fleet was unable to keep up. The mass production of Liberties and all kinds of naval vessels left no space for tankers in the American shipyards for a long period of time. So an emergency solution appeared: the Maritime Commission approved the construction of 62 Liberty tankers type Z-ET1-S-C3. Nine tanks were installed in cargo holds and five ballast tanks in the double-bottom were also used for oil transportation. Cargo pumps and other loading/unloading equipment were of the 19th century design. In spite of being quite primitive by the tanker standards of the time, these vessels were a great relief.

As the German submarines had orders to sink tankers first, the emergency tankers kept the original appearance of the standard Liberty cargo ships. Masts, derricks, winches and other equipment successfully fooled U-boats and not a single tanker was lost. After the war, the entire fleet proved antiquated and Liberty tankers were converted into general cargo ships, mainly by the Japanese yards. The new 51-meter forward cargo sections were inserted so that deadweight capacity was increased to 12.000 tons. A part of the rebuilt Liberties received a third forward mast.

In the spring of 1945, the Delta Shipbuilding Corp. of New Orleans received an order for two dozen completely different

ships - a Collier type Liberty. Officially marked EC2-S-AW1, these vessels were intended for the American coastal coal trade from Hampton Roads, Virginia to Boston, Massachusetts. Only the bare hull preserved the original dimensions and appearance. The bridge was located amidships and the engine-room far aft. Its cargo capacity was 11.047 tons.

Liberty ships proved suitable for all kinds of rebuilding, especially for military transport. 36 ZEC-S-C5 type ships were designed for the shipments of boxed aircrafts. Other Liberties included six hospital ships, eight specialized tank carriers, 13 animal transport vessels for Army horses and mules... The most numerous were the Liberties used to carry troops: 37 were built as genuine troopships and 195 were only temporary and primitively equipped for the transportation of soldiers.

The largest number of the Liberties came from the Bethlehem-Fairfield Shipyards Inc., the builder of the 'Patrick Henry'. 385 vessels were built by the end of 1944, when the Baltimore yard focused on the mass production of the Victories. California Shipbuilding Corp. of Los Angeles had the second largest output with 366 Liberties built. Top builders were also Permanente Metal Corp. - Yard No.2 of Richmond, California (351), Oregon Shipbuilding Corp. of Portland (322), New England Shipbuilding Corp. of Portland, Maine (244), Todd Houston Shipbuilding Corp

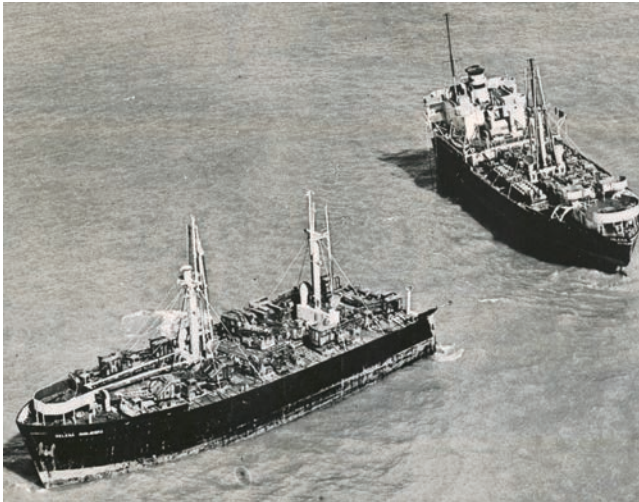


Figure 7.
Troubles with welding: 'Helena Modjeska' split in two.

of Houston, Texas (208) and Delta Shipbuilding Corp. of New Orleans, Louisiana with 188 Liberty ships delivered.

From the very beginning of the Emergency Fleet Program, Admiral Land and his associates considered the Liberty ships weapons, just like the Sherman tanks or B-17 bombers. Their purpose would be fulfilled by a single voyage with 10,000 tons of military supplies. But the Liberties proved very tough and only 155 were lost to enemy actions. The loss rate of 5.7 percent exceeded the most optimistic expectations by far.

The majority of the Liberties were armed with one or two 4-inch guns (102 mm), mainly obsolete and rarely used in actions. But 'Stephen Hopkins', with a single aft gun, entered the history on September 27, 1942 in the battle with the German commerce raider 'Stier'. The Liberty was sailing from Cape Town to Suriname in the dense fog of the Atlantic when she encountered the German ship. 'Hopkins' was disastrously over-gunned, as 'Stier' was armed with six 5.9 inch guns and numerous small weaponry. Even so, in a fierce close range battle, a single-gun freighter damaged the German auxiliary cruiser so heavily that it was abandoned by its crew shortly after 'Stephen Hopkins' sunk.



Figure 8.
'Hellenic Star': One of 106 Liberties sold to Greeks.



Figure 9.

The last years: standard Liberty 'Edenbank' battered by sea.

Under wartime conditions, the Liberties were endangered not only by the enemy but also by their poor welding. The extremely short construction time, the lack of experience with welding, the absence of proper quality control prior to delivery due to the urgent need for new ships proved to be a dangerous combination. The brand new Liberties met with all the temptations of gales and storms and freezing waters of the Atlantic. The problem of poor welding emerged and the Liberties fell apart at open seas by the dozens. After urgent improvements were made, the falling apart of the ships became a rarity.

At the end of World War II, there were more than 2500 Liberties in service. Being absolutely obsolete for American peacetime needs, these ships were warmly welcomed by the merchant fleets of the Allied countries that suffered heavy war losses. During the war, 198 Liberties were allocated to the United Kingdom under the Lend-lease Act. Under the same Act, 39 ships were allocated to the Soviet Union. In 1945 these ships were offered for sale and Britain purchased 106 Liberties. The Soviet

Union didn't react to the offer: lend-leased ships were neither purchased nor returned to America!

One hundred and six Liberties were sold to Greece, as its cargo fleet was devastated during the war. France was allowed to buy 75 ships, Norway 24 and China 18. Italy, a former foe and now a friend, purchased exactly 100 ships. In the first post-war years, the American companies used a large number of the Liberties to ship relief cargoes to Europe, but in the end, the majority of these ships were returned to the US Government. Hundreds of Liberties became part of the United States Reserve Fleet, being mothballed in the anchorages all across America. Some were reactivated to serve in the Korean and later the Vietnam War.

Having such an enormous fleet available, the Americans used the Liberties for all kinds of duties and experiments. 'John Sergeant' entered the history of shipping in October 1956 as the first gas-turbine powered ship to cross the Atlantic. Liberty ship 'Charles H. Cugle' was converted into the first floating nuclear power plant in the world named 'Sturgis'.



Figure 10.
Liberties at Sveti Kajo scrapyard near Split.

But the late 1960s marked the end of the era of the Liberty ships. Hundreds were stricken from the US Reserve Fleet and sent to the scrapyards. Exactly the same happened to the Liberties serving on worldwide merchant routes. Being created for wartime needs, they had no chance in the competition against a vast fleet of modern ships from the Japanese and European shipyards. As many as 42 Liberties met their end at the Brodospas shipbreaking yard at Sveti Kajo in the vicinity of Split. Greek steamers 'Alexandros Koryzis' and 'Georgios F. Andreadis' arrived there in the summer of 1985 as the last Liberty ships to be broken up in Europe.

The story of the Liberties didn't end with their disappearance from the sea routes. Their role in shipping was so strong and important that shipbuilders around the world raced to offer ships called Liberty Replacements. Japanese shipbuilders were pioneers in the development of standard ships designed for mass production, being easier and cheaper to build and use.

The most successful was type Freedom built by Ishikawajima Harima Heavy Industries (IHI), but a brainchild of Canadian ship designer G.T.E. Campbell from Montreal. The very first of these new Liberties, the 'Khian Captain', was delivered to the Greek ship-owner Carras on July 21, 1967. IHI yards built 176 ships, but the Freedoms were also built in Spain as Freedom Hispania. Also for IHI, the Canadians later designed a Liberty Replacement called type Fortune, 62 of which were constructed. Standard ships were designed and built by many other Japanese yards, including Hitachi, Mitsui, Mitsubishi and NKK.

At the same time, the British developed a highly successful type SD 14 Liberty Replacement. The great majority of the 211 of these ships were built by the two neighbouring shipyards at Sunderland: Austin & Pickersgill and Bartram & Son. It is interesting that 'Nicole', the first ship from A&P, was delivered on February 14, 1968 and 'Mimis N. Papalios', the first from Bartram, on the following day. SD 14 type ships were also built under licence in Greece, Brazil and Argentina.



Figure 11.
'Khian Captain' – the very first of Liberty Replacement ships.



Figure 12.
The deck of a museum ship 'Hellas Liberty'.

The German shipbuilders had an important role in the creation of the Liberty Replacement fleet. The best known German Liberty was built by Flensburger Schiffbau, Bremer Vulkan and Rickmers Werft. The first of the 52 ships, 'Dirk Mittmann', was delivered in Flensburg in May 1968. A.G. Weser Company designed and built 61 standard ships of the Seebeck 36 type. Belgian shipyard Cockerill offered type Unity, but only eight ships were built, including six for the Croatian owners.

Today, 70 years after the Emergency Fleet Program, only three Liberty ships survive. Fully restored and still sailing are 'Jeremiah O'Brien' and 'John W. Brown', both under the US flag. 'Jeremiah O'Brien' is stationed in San Francisco, California and 'John W. Brown' in Baltimore, Maryland, not far from the location of the shipyard in which she was built in 1942. The third vessel afloat is not sailing. To commemorate the importance of Liberty ships to the national merchant fleet, the Greek shipping community purchased Liberty ship 'Arthur M. Huddel' in 2008. Being abandoned for years and in a derelict condition, she was completely refitted, christened 'Hellas Liberty' and has been moored at the Piraeus old port as a floating museum since June 2010.



Figure 13.
Still sailing: 'Jeremiah O'Brien'.

Notable books on the Liberties:

L.A. Sawyer, L.A., Mitchell, W.H., (1970), *The Liberty Ships – The History of the Emergency Type Cargo Ships Constructed in the United States During World War II*, 1st edition, Newton Abbot: David & Charles Ltd.

L.A. Sawyer, L.A., Mitchell, W.H., (1973), *The Liberty Ships – The History of the Emergency Type Cargo Ships Constructed in the United States During World War II*, 2nd edition, Newton Abbot: David & Charles Ltd.

Bunker, J.G., (1972), *Liberty Ships – The Ugly Ducklings of WW II*, Annapolis, US Naval Institute Press

Elphick, P., (2001), *Liberty – The Ships that Won the War*, Rochester, Chatham Publishing Ltd.

TRANSAS CONFERENCE (Baltimore and Easton-Maryland, USA)

1. ABOUT THE CONFERENCE

Transas Conference took place from July 15 – 19, 2013 in the USA, on two locations: Baltimore- MITAGS Institute and Easton- MEBA Seafarers' Training Centre.

233 members from 43 countries took part in it. 12 sessions were held with 57 papers from different areas. The aim of the Conference was to represent the existing technologies and future technological development in the field of nautical equipment and simulators.



Figure 1.
Transas participants at MEBA School (Easton).

The first day of the Conference was held in Baltimore (Maritime Institute of Technology and Graduate Studies-MITAG). The Institute deals with the education of seafarers of different profiles – from ordinary seaman to ship's master with unlimited licence as well as harbour pilots.

The Institute organizes courses, seminars, training for coast guard. It is the leading centre for maritime simulations including the possibility of in-service training and scientific research. It is currently the leading institute in America in the field of seafarers'



Figure 2.
Simulator – MITAGS Institute.

2. CONFERENCE PROGRAMME

On the Conference programme there were the latest technological achievements in the field of nautical simulators as well as guidelines and planned future development of new maritime systems in which such equipment would be the key to success of system sustainability.

training and practical exercises on simulator. The main simulator consists of the bridge with the turn radius of 360° and height of 10m.

The remaining four days of the Conference were held in the small town of Easton, at the distance of two-hour ride from Baltimore in Calhoun MEBA School Engineering- MEBA (Marine Engineers Beneficial Association).

MEBA is a private institution for education of marine engineers.



Figure 3.
MITAGS Institute.

The Conference programme referred to the following topics:

1. STCW latest amendments, requests for amendments, assessment of amendments and simulator application
2. Application in the power engineering sector
3. Research and development, special application of simulations obtained
4. Hydrodynamic modelling and visualization obtained
5. Engineering training
6. The Navy, defence and security elements
7. Services and maintenance, simulator maintenance expenses
8. E-learning and distance learning
9. ECDIS training
10. E-Navigation

News

INNOVATION OF AZIPOD MARINE PROPULSION

ABB, the leading power and automation technology group, has got prestigious Red Dot Award 2013 for product design in recognition of its innovative Azimuth lever that steers its Azipod XO marine propulsion unit.

This was the decision of board of 37 experts who assessed products submitted by more than 1,800 manufacturers, designers and architects from 54 countries, evaluating the degree of innovation, functionality, quality, ergonomics, durability and ecological compatibility.



Figure 1.

Source: [//www.abb.com/cawp/seitp202/3e03600fe25129f0c1257b86002aac68.aspx](http://www.abb.com/cawp/seitp202/3e03600fe25129f0c1257b86002aac68.aspx).

The Azimuth lever is the key part used in Azipod-powered ships to control propulsion speed and steering angle and forms part of the ABB Intelligent Maneuvering Interface (IMI) system. Propeller speed is controlled by moving the horizontal axis of the lever while the steering angle is controlled by rotating the lever around its vertical axis. The Azimuth lever can easily steer mega large vessels which is more than 200,000 GRT(gross register tonnage) and over 300 meters long, and it will be an important feature of the steering equipment in the future cruise vessels.

One of the features of the latest Azimuth lever is the use of programmable detents – or “feeling” points – in the lever. The shape of the Azimuth lever is designed to fit easily into the hand and the lever direction can always be determined by its shape, providing tactile feedback. The award-winning design also features scale lamps that can be adjusted to maximize visibility during the night or in bright sunshine.

The product design competition has existed since 1955. Its award is an internationally recognized quality seal.



Figure 2.

Source: [//www.abb.com/cawp/seitp202/3e03600fe25129f0c1257b86002aac68.aspx](http://www.abb.com/cawp/seitp202/3e03600fe25129f0c1257b86002aac68.aspx).

ROBOT BECOMING NEW FIRE DEVICE

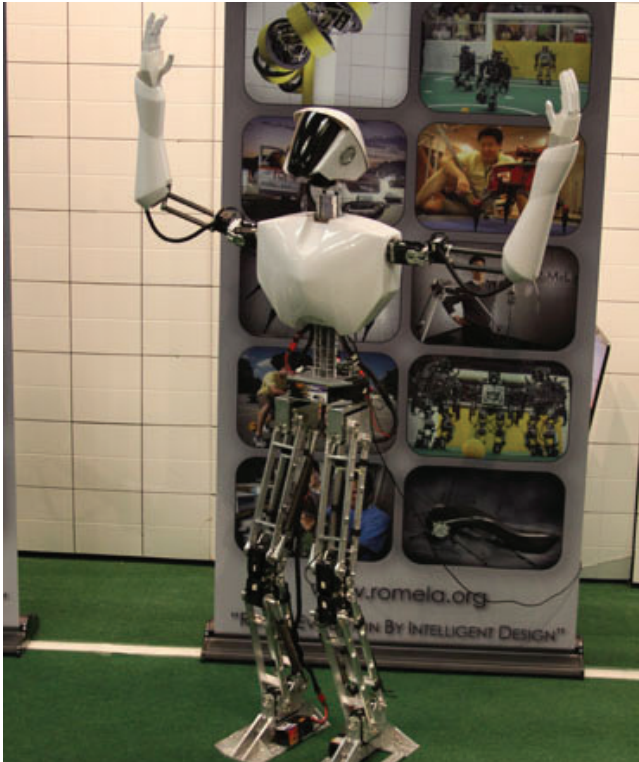


Figure 3.

Source: <http://www.nrl.navy.mil/media/news-releases/2012/nrl-designs-robot-for-shipboard-firefighting>

The U.S. Navy reports it is developing an autonomous, humanoid robot for fighting fires aboard ships.

Shipboard Autonomous Firefighting Robot will be able to maneuver within the vessel's confined spaces as well as on ladder ways and interact with personnel.

An interdisciplinary team from the U.S. Naval Research Laboratory is in charge of the device's development. The robot is designed with enhanced multi-modal sensor technology for advanced navigation and a sensor suite that includes a camera, gas sensor and stereo IR camera to enable it to see through smoke.

It is battery-powered that holds enough energy for 30 minutes of firefighting. Like a sure-footed sailor, the robot will also be capable of walking in all directions, balancing in sea conditions and traversing obstacles.

The laboratory said algorithms are being developed to give SAFFiR autonomous mobility and decision-making capability as a "team member." Capabilities will include the ability to understand and respond to human gestures.

Language may also be incorporated as well as other modes of communication and supervision.

Working with the NRL on the robot's development are researchers from Virginia Tech University and the University of Pennsylvania.

A test of the firefighting robot in a realistic firefighting environment onboard the ex-USS Shadwell is slated for September of next year.

MHI BUILD RAMFORM VESSELS CAPABLE OF HIGH-ACCURACY, WIDE-RANGE 3D SEISMIC DATA ACQUISITION

Mitsubishi Heavy Industries, Ltd. (MHI) has received an order for two vessels capable of three-dimensional (3D) seismic data acquisition for sea bottom resource exploration from Petroleum Geo-Services ASA (PGS), a leading company in marine seismic and reservoir data acquisition, processing and analysis/interpretation services in Norway.

The vessels ordered are the "Ramform Titan-class", the newest generation in the Ramform series featuring today's most advanced 3D seismic-data acquisition/analysis capability. The 104 meter-long vessel has a very wide breadth of 70m. For quiet operation, the vessel adopts diesel electric for the main propulsion system. The vessel is capable of receiving supply at sea to enable a long-term exploration over an expansive area.

The Ramform vessel tows multiple streamer cables from the vessel's stern. The cables contain sensors which detect echoes of sound waves emitted from sound sources and bounced back from the sea bottom and stratum boundaries. The detected

echoes are used for 3D seismic analysis. The Ramform Titan-class vessels ordered by PGS have a wider stern compared with existing vessels; this feature permits deployment of a greater number



Figure 4.

Source: <http://www.pgs.com/en/Pressroom/News/Ramform-Titan/>

of streamer cables—up to 24 lines—enabling exploration of a wider area at one time.

MHI has a track record in building exploration vessels for deep earth, sea-bottom and ocean applications. The company also instituted a policy to expand its business in high-value-added vessels and marine structures as part of a new strategy for its Shipbuilding & Ocean Development business segment. By further refining its capability to build specialized vessels through construction of the vessels for 3D seismic data acquisition for sea bottom resource exploration for PGS, going forward MHI intends to further strengthen its aggressive activities to attract demand for special ships in Japan and other countries.

“SAYAENDO” NEW-GENERATION LNG CARRIER

Mitsubishi Heavy Industries, Ltd. (MHI) signed an agreement with Mitsui O.S.K. Lines, Ltd. to build a Sayaendo series new-generation liquefied natural gas (LNG) carrier. Sayaendo-series ships feature a unique structure that integrates the LNG tank cover with the ship's hull, resulting in significantly improved fuel consumption and maintainability. From 2020 the new ship will be used mainly for transportation of LNG produced by the Ichthys LNG Project* in Australia for Osaka Gas Co., Ltd. and Kyushu Electric Power Co., Inc.

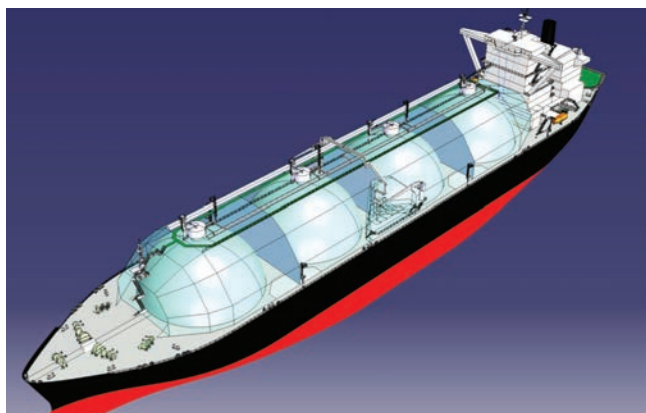


Figure 5.

Source: http://www.mhi.co.jp/en/products/detail/lng_carrier_sayaendo.html

The new LNG carrier will measure 288.0m in length overall (LOA), 48.94m in width, and 11.55m in draft. The 138,000 gross tonnage (75,000 deadweight tonnage) ship will be capable of carrying up to 153,000 m³ of LNG (cargo tank total volume: 155,000m³) in four Moss-type tanks at a service speed of 19.5 knots per hour. The ship will be built at the MHI Nagasaki Shipyard and Machinery Works.

To protect its four Moss spherical tanks, the Sayaendo features a peapod-shaped continuous cover integrated with

the ship's hull in lieu of conventional hemispherical covers. This innovative configuration enables reductions in size and weight while maintaining the ship's overall structural rigidity. The continuous cover over the tanks also improves aerodynamics by substantially reducing air resistance that acts as drag on ship propulsion. For its main power plant the Sayaendo adopts MHI's Ultra Steam Turbine Plant (UST), a new turbine that provides higher thermal efficiency through effective use of thermal energy by reheating steam. Through downsizing, weight reduction and hull line improvement, Sayaendo ships achieve a substantial 20% reduction in fuel consumption compared to conventional ships.

With a conventional cover configuration, pipes, wires and catwalks atop the tanks are supported by complex structures. By covering the tanks with an integrated cover and making those supporting structures unnecessary, the new design also improves maintainability. In addition, CO₂ emissions are reduced as a result of decreased fuel consumption, and response to environmental issues is further enhanced with installation of a ballast water treatment system, which addresses impact on the marine ecosystem.

Owing to the suspended operation of nuclear power plants in Japan in the wake of the Great East Japan Earthquake, as well as an expanded shale gas production in the U.S., demand for LNG and LNG carriers has been expanding not only in Japan but globally. As such, MHI will continue to expand its efforts to secure new orders for Sayaendo and other types of LNG carriers.

Note: The Ichthys LNG Project is a joint venture between INPEX Corporation of Japan (lead partner) and Total S.A. of France, with participation by various other international corporations and Japanese gas and electric power companies. The project aims to build a major facility in Darwin to liquefy gas extracted from the Ichthys Field located approximately 200 kilometers off the coast of Western Australia. Gas production is scheduled to begin by the end of 2016.

BALLAST-WATER-TREATMENT SYSTEM ENGINEERING

Ballast water is sea water drawn into ships' ballast tanks to stabilize and balance the ship. However, the marine organisms it contains may damage the local ecosystem when transported to and propagated in sea areas that are not their natural habitat. In response, an international convention was adopted, imposing requirements on ships newly built and those already in service to equip ballast water treatment systems. MHI has offered total services, ranging from engineering for installation to the actual installation of ballast water treatment systems.

COSTA CONCORDIA SALVAGE OPERATION MAKES PROGRESS

Another important step towards the parbuckling operation has been successfully completed. The Salvors finished the



Figure 4.

Source: <http://www.pgs.com/en/Pressroom/News/Ramform-Titan/>

process of positioning and installment of the two blister tanks on the wreck's bow.

The two blister tanks are special sponsors that provide a net buoyancy of about 4,000 tons and will support the bow during the next three phases of the process: the rotation of the wreck into a vertical position (the so-called parbuckling); the resting of the wreck on the artificial seabed and the refloating.

The two blister tanks are made of steel and were built at Fincantieri shipyards, respectively in Palermo and in Ancona and, consequently, assembled with tubular frame in Palermo.

They are fixed to the hull by means of three anchor pipes installed in the thruster tunnels. The whole structure (the two blister tanks, the tubular frame and the three anchor pipes) weighs about 1,700 tons. The two blister tanks measure 23 meters in length, 20 meters in height and have a breadth of about 15 meters.



Figure 7.

Source: <http://www.noaanews.noaa.gov/stories2013/images/qo478-walker.jpg>

NOAA CONFIRMS IDENTITY OF HISTORIC WRECK

More than 153 years after it was lost in a violent collision at sea, government and university maritime archaeologists have identified the wreck of the ship Robert J. Walker, a steamer that served in the U.S. Coast Survey, a predecessor agency of NOAA.

NOAA notes that the Walker, while now largely forgotten, served a vital role as a survey ship, charting the Gulf Coast including Mobile Bay and the Florida Keys in the decade before the Civil War. It also conducted early work plotting the movement of the Gulf Stream along the Atlantic Coast.

Twenty sailors died when the Walker sank in rough seas in the early morning hours of June 21, 1860, ten miles off Absecon Inlet on the New Jersey coast. The crew had finished its latest surveys in the Gulf of Mexico and was sailing to New York when the Walker was hit by a commercial schooner off New Jersey. The side-wheel steamer, carrying 66 crewmembers, sank within 30 minutes. The sinking was the largest single loss of life in the history of the Coast Survey and its successor agency, NOAA.

NOAA was able to confirm the identity of the Walker using various criteria, including the ship's unique paddlewheel flanges.

Built in 1847, the Walker was one of the U.S. government's first iron-hulled steamers, and was intended for the U.S. Revenue Service, the predecessor of the United States Coast Guard. Instead, the Walker and some of its sister steamers were sent to the U.S. Coast Survey.

The U.S. Coast Survey is NOAA's oldest predecessor organization, established by President Thomas Jefferson in 1807 to survey the coast and produce the nation's nautical charts. In 1860, as the Civil War approached, the Coast Survey redoubled efforts to produce surveys of harbors strategically important to the war effort along the Gulf and Atlantic coasts.

The New York Herald, in reporting the Walker's loss on June 23, 1860, noted that a "heavy sea was running, and many of the men were doubtless washed off the spars and drowned from the mere exhaustion of holding on, while others were killed or stunned on rising to the surface by concussion with spars and other parts of the wreck."

The Walker wreck site initially was discovered in the 1970s by a commercial fisherman. The wreck's identity has been a mystery despite being regularly explored by divers. Resting 85 feet underwater, the vessel's identity was confirmed in June as part of a private-public collaboration that included research provided by New Jersey wreck divers; Joyce Steinmetz, a maritime archaeology student at East Carolina University; and retired NOAA Corps Capt. Albert Theberge, chief of reference for the NOAA Central Library.

While in the area to conduct hydrographic surveys after Hurricane Sandy for navigation safety, NOAA Ship Thomas Jefferson sailed to the wreck site and deployed its multi-beam and side-scan sonar systems. Hydrographers searched likely

locations based on analysis of historical research by Vitad Pradith, a physical scientist with NOAA's Office of Coast Survey.

A NOAA Maritime Heritage diving team, on a separate Hurricane Sandy-related mission in the area, was able to positively identify the Walker. Key clues were the size and layout of the iron-hulled wreck, and its unique engines, rectangular portholes, and the location of the ship, which was found still pointing toward the Absecon lighthouse, the final destination of a desperate crew on a sinking vessel.

NOAA's intent is not to make the wreck a sanctuary or limit diving, but to work with New Jersey's wreck diving community to better understand the wreck and the stories it can tell.

JAN DE NUL ORDERS MULTIPURPOSE VESSEL AT CROATIAN SHIPYARD

Belgium's Jan De Nul Group has ordered a 10,500 dwt, 138 m long multipurpose vessel at the Uljanik Shipyard in Pula, Croatia. It will be a trenching and offshore support vessel, a subsea rock installation vessel and a cable laying vessel.

In the cable laying mode, the vessel will be able to install up to 10,000 tons of cable and will be equipped with a 5,500 tons capacity turntable above deck and a 4,500 tons capacity turntable below deck along with tensioners as required by the project, chute and auxiliary equipment.



Figure 8.
Multipurpose Vessel

In the subsea rock installation mode, the vessel will be able to install up to 10,000 tons of rock in a single load by using the aft stone hopper with a capacity of 3,000 tons and the midship hopper with a capacity of 7,000 tons along with the two excavators and the fall pipe for accurate rock installation at up to 200m water depth.

In the combination mode any combination of the above will be possible, up to the carrying capacity of the vessel. The vessel will be delivered in 2015 and will be the 76th vessel in the Jan De Nul Group fleet.

SWEDISH ICEBREAKER TESTS NEW ARCTIC MONITORING SYSTEM

The Arctic is one of the world's most environmentally sensitive areas, while also being one of the most difficult to protect against accidents. The Swedish Maritime Administration is now testing a new system for monitoring maritime traffic that will improve the potential for Arctic sea rescue, icebreaker assistance and environmental protection.

Oden is owned by the SMA and manned by Viking Supply Ships AB. She was delivered by the Götaverken Arendal shipyard in 1989.

The new tracking system will be tested during an Arctic expedition by the Swedish Maritime Administration icebreaker Oden as part of the MICE (MONALISA Ice) research and development project, which is being conducted in cooperation between the Swedish Maritime Administration and the Chalmers University of Technology in Gothenburg. MICE aims to capitalize on the more wide-ranging MONALISA project, which the Swedish Maritime Administration leads, and which permits the global monitoring of maritime traffic without the need for shore-based



Figure 9.

Source: http://marinelog.com/index.php?option=com_content&view=article&id=4480:swedish-icebreaker-tests-new-arctic-monitoring-system&catid=1:latest-news&Itemid=195

infrastructure, such as AIS base stations or radio communications

The solution is based on using vessels as base stations to communicate information regarding the surrounding traffic and the vessel's own course, speed position and other relevant data. The information is interchanged with a shore-based coordination centre via a satellite link. The same satellite link is used for the interchange of navigation routes and other necessary communications between the vessel and the shore-based centre

FOSEN SHIPYARD DELIVERS LNG-FUELLED CRUISE FERRY



Figure 10.

Source: <https://fjordline.com/en/About-Fjord-Line/Media/Press-releases/Fjord-Lines-cruise-ferry-MS-Stavangerfjord-ready-for-service/>

Norway's Bergen Group Fosen shipyard has today completed the successful delivery of MV Stavangerfjord to Fjord Line.

The 170 m vessel can carry 1,500 passengers and 600 cars and is the first large cruise ferry to be fuelled only by LNG, rather than being dual-fuelled. The Stavangerfjord and her sister were originally ordered with dual-fuel engines. However, Bergen Group received a contract modification last July that specified single-fuel LNG engines. (See earlier story) and each ship is fitted with four Bergen gas engines, powering a highly efficient Promas integrated rudder and propeller propulsion system.

The switch from dual fuel to single fuel contributed to some delays in Stavangerfjord's delivery the handover was in line with a revised schedule announced in May.

The hull for the next cruise ferry arrived in Fosen from Poland's Stocznia Gdansk shipyard in late March for outfitting and completion. Bergen Group and Fjord Line say they will clarify the final delivery of this sister ship "in the near future."

BERGEN ENGINES NOW A UNIT OF TOGNUM AG

Norwegian engine manufacturer Bergen Engines AS have become part of the Tognum Group. Bergen Engines was formerly a Rolls-Royce subsidiary and the switch to the new ownership follows the acquisition of MTU-parent Tognum by a joint venture of Rolls-Royce plc. and Daimler AG.

The acquisition adds medium-speed diesel and gas engines with power outputs up to 10 MW to Tognum's engine portfolio.

This is an important milestone and positive for both customers and employees as this enables us to combine the medium- and high-speed portfolios under one roof.

Tognum's MTU brand supplies high-speed diesel and gas engines with power ranges of 75 to 10,000kW and 100 to 2,150kW respectively. The Bergen engine portfolio comprises medium-speed units for marine and power generation applications. The diesel engines deliver 1,800 to 8,000 kW and the gas engines are built for 1,400 to 9,700kW output.



Figure 11.

Source: <http://www.4-traders.com/TOGNUM-AG-619494/news/Tognum-AG--Bergen-Engines--the-new-Tognum-subsiary-17058542/>

STUDENT PROJECT GENERATES NEW ARCTIC VESSEL DESIGN

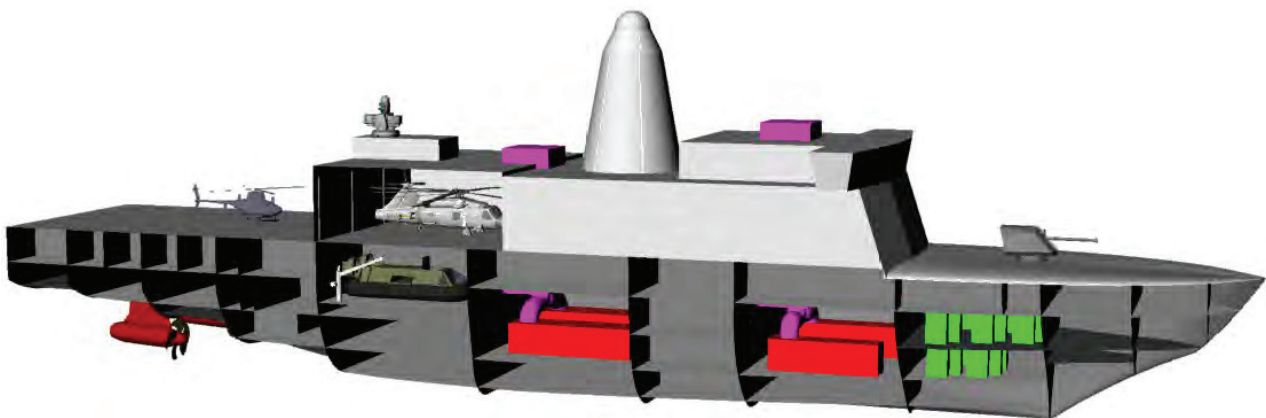


Figure 12.

Source: <http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA558375>

Five maritime engineering bachelor students at the Delft University of Technology in the Netherlands) finished their minor in Arctic Engineering last February. Now, in cooperation with Damen Shipyards Group and other partners, their project has resulted in a new Arctic vessel design: the Damen AMTSV (Arctic Modular Towing Supply Vessel).

The 100 m double-acting supply ship is capable of operating in the Barents Sea year round and in the Baffin Bay and Beaufort Sea for eight months. The AMTSV has the ability to sail through 1.6 m of level ice at 3 knots.

The Toptrack program at Delft University of Technology offers students the opportunity to organize their own Minor and fill it up with master courses.

In this particular case students Reiner Bos, John Huisman, Martijn Obers, Tobias Schaap and Max van der Zalm organized their own Arctic Minor. As the Aalto University in Helsinki, Finland, offered several courses on ice, they were included in the project.

The project began with a literature study to get an overview of the environment, the market and the geography in the Arctic and to create an operational profile for the vessel.

Second, a comparison study was held, testing three existing Damen vessels on their Arctic capabilities. The third stage consisted of a ship design, combining the experiences of the Arctic Minor Team into one innovative concept.

The resulting Arctic Modular Towing Supply Vessel (AMTSV) is capable of operating in Arctic waters for 8 to 12 months, depending on the specific region. The vessel actually has two bows; when she sails through open water the accommodations will be in the front. Through ice however, she will sail with her thrusters first. The “stern first” concept is not new in arctic shipping. However, in this case it’s a veritable “double-bow” vessel, a concept which is incorporated in the structural lay-out of the ship.

The AMTSV can handle up to 1.6 m of level ice at a speed of 3 knots. The research showed this to be an optimal solution, because the shape of an ice bow is completely different compared to an open water bow. When using two bows no compromises have to be made. Another argument for this concept is that, while sailing through ice, the thrusters will create a flow around the hull which decreases friction.

Because the vessel can sail in both directions, she also has to be capable of towing in both directions. Hence, a double-acting winch of 300 tons is installed. This winch is installed inside the accommodations so the harsh weather will not affect it.

No compromises on crew conditions are made, by allowing the crew to work in the Enclosed Superstructure (ESS) located behind the conventional superstructure. This superstructure can be kept up above zero degrees with an outside temperature of -55 degrees. The ESS is not only useful for the crew, but temperature-sensitive cargo can also be kept in this area.

This Arctic concept vessel will be running on Liquid Natural Gas (LNG), with dual fuel engines, in an effort to make it more environmentally friendly. The main disadvantage of LNG is that it requires a lot of storage capacity. However, ice strengthened vessels have a lot of steel weight in the hull compared to open water vessels and this means that the centre of gravity is relatively low. Therefore, the disadvantage is negated by placing the LNG tanks on top of the ESS.

The project shows that the motivation of students, supported by open-minded universities and partnering companies, can lead to the creation of a substantial and innovative project. The Arctic Minor project taught the team about cooperation, working in a foreign environment and most of all Arctic shipbuilding. For its part, Damen will incorporate the research into its own, ongoing Arctic research program.

LNG-FUELLED FERRY NOW WORLD’S FASTEST SHIP

Australian ferry builder Incat Tasmania’s world first high-speed dual-fuel vehicle and passenger ferry is now officially fast

with a lightship speed of 58.1 knots - (107.6 kilometres an hour) and a thrill for the designers of the 99-metre-high speed vessel Francisco (Incat hull 069).

This is certainly the fastest ship in the world.....of course there are a few speed boats that could surpass 58 knots but nothing that could carry 1,000 passengers and 150 cars, and with an enormous duty-free shop on board.

Last week at 1,516-ton displacement trial she achieved 51.8 knots at 100% MCR operating with one turbine on LNG and one on marine distillate, exceeding the results achieved on 1st June when Francisco was sea trialled with full ballast comfortably exceeding 50 knots at full power and maintaining a steady 49 knots at 90 per cent power while operating on marine distillate.

On Saturday, 15th June, with the water ballast removed, and with both Port and Starboard Gas Turbines operating on LNG, Francisco achieved 58.1 knots at 100% MCR.

The vessel’s high speed can be attributed to the combination of Incat wave-piercing catamaran design, the use of lightweight, strong marine grade aluminum, and the power produced by the two 22MW GE LM2500 gas turbines driving Wartsila LXX 1720 SR waterjets. The extensive and luxurious interior made significant increases to the weight of the interior fit-out, however the Incat team worked diligently to maximize weight savings during construction wherever possible.

Francisco has been constructed for South American company Buquebus, for service on the River Plate, between Buenos Aires Argentina and Montevideo, Uruguay.

Incat is still not claiming 58.1 as the end point of lightship trials as there was a full load of LNG on board (two 40-cubic-meter tanks) in addition to about 35 tons of marine distillate, with Incat Chairman Robert Clifford, saying “When we have less fuel on board, and delivery spares removed, we will see that speed go higher still in the shallow waters of the River Plate (Rio Plata). We are delighted with the efficiency of the design and sure that our customer, Buquebus, will be pleased with the results, enabling the ferry to compete with airline traffic on the River Plate route.”

Buquebus Chairman Juan Carlos Lopez Mena recently announced that the vessel will be named Francisco, in honour of the Argentinean-born Pope Francis. “Godmother” to the ship will be the President of Argentina, Christina Fernandez de Kirchner, who will christen Francisco following the ship’s arrival in Argentina.

Francisco has capacity for 1,000 persons and 150 cars. A luxurious fit-out has been incorporated, including a 1,100-square-metre duty-free shop.

Buquebus has clearly demonstrated their preference for Incat technology over a twenty-year period and Francisco (hull 069) is the eighth Incat vessel to be operated by Buquebus and their associated companies. It will be the largest catamaran they have operated, the world’s first dual-fuel high-speed

ferry to operate on LNG as its primary fuel, and the fastest, environmentally cleanest, most efficient, high-speed ferry in the world.

Incat's High Speed Record

The fastest previous vessel built by Incat was Juan Patricio, delivered also to Buquebus, with a top speed at 53.8 knots. Juan Patricio was delivered in 1996 and remains in commercial service.

Francisco is the fourth Incat-built vessel with service speed over 50 knots.

The past three consecutive winners of the Hales Trophy, the Transatlantic Blue Riband record for commercial passenger ships, were all built by Incat. The average speed over the 3-day (unrefuelled) voyage of Incat hull 049 was 41.284 knots.

Incat has built 25 High Speed Craft over 5,000 gross tons with a top speed in excess of 45 knots.

COSTA CONCORDIA INVESTIGATION REPORT AVAILABLE

The Italian Ministry of Infrastructure and Transport (MIT) released the long-awaited English translation of its report on the safety technical investigation into the marine casualty on January 13, 2012 involving the cruise ship Costa Concordia.

The ship capsized as a result of large-scale internal flooding from a 53-meter long breach of its hull involving five watertight compartments. The breach occurred when the ship allided at a speed of 16 knots with the Scole Rocks off Giglio Island in the Tyrrhenian sea at 21: 45: 07 local time.

The main cause of the casualty is attributed to "the Master's unconventional behavior". The incident resulted in the death of 32 persons and the injury of 157 others, as well as the loss of the ship and significant environmental damage.

Initial findings of the report include the following:

- Poor route planning and navigation direction;
- BTW management shortcomings;
- Poor management of emergency evacuation procedures;
- EDG functionality criticalities

Actions to be taken as reported include the following :

- More detailed passengers info;
- Voyage plan requested by Solas R V/34 should be made available by the Master to the Company prior ship's departure;
- Instructions to passengers to be implemented;
- Muster of passengers to be performed in each port for embarking passengers;
- Company Audit follow up as a consequence of the casualty;
- Amending procedures (Emergency instructions / Decision support system for Master);

- Creation of a new Maritime Development & Company Dept by the Company;
- Implementation of "High Tech Safety Monitoring System";
- Dedicated Fleet Operations Center in Genoa;
- Deck Officers training implementation.

Finally, the report indicates that there are the following findings affecting international regulations :

1. Double-skin for protecting the WTCs containing equipment vital for the propulsion and electrical production;
2. Limiting of the downflooding points on the bulkhead deck;
3. Provision of a computerized stability support for the master in case of flooding;
4. Interface between the flooding detection and monitoring system and the on-board stability computer;
5. Discontinuity between compartments containing ship's essential systems;
6. More detailed criteria for the distribution, along the length of the ship, of bilge pumps and requirement for the availability of at least one pump having the capacity to drain huge quantities of water;
7. Relocation of the main switchboard rooms above the bulkhead;
8. Relocation of the UHF radio switchboard above the bulkhead deck;
9. Increasing the emergency generator capacity to feed also the high capacity pump(s);
10. Provision of a second emergency diesel generator located in another main vertical zone in respect to the first emergency generator and above the most continuous deck;
11. Provision of an emergency light (both by UPS and emergency generator) in all cabins in order to directly highlight the life jacket location;
12. Bridge management, considering aspects such as the definition of a more flexible use of the resources;
13. Bridge Team Management course for certifications renewal should be mandatory by the 1st January 2015;
14. Principles of Minimum Safe Manning (resolution A.1047(27) as amended by resolution A.955(23)) that should be updated to better suit to large passenger ships;
15. Muster list, showing the proper certification/documentary evidence necessary for crew members having safety tasks;
16. Inclusion of the inclinometer measurements in the VDR;
17. SAR patrol boat supplied with fix fenders, blocked in the upper side of the hull, to approach safe other ships/boats in case of extraordinary evacuation of persons. This should be able to load at list 100 passengers in their deck;
18. Divers speleologists, able to rescue, even in dark condition, persons standing into the ravines of ships/wrecks.

SEAFARERS' BILL OF RIGHTS IN FORCE FROM AUGUST 2013

The Maritime Labour Convention (MLC) – the seafarers' bill of rights – comes into force. The MLC is a far-reaching, groundbreaking international convention which establishes an international minimum standard that has the potential to make a real difference to seafarers. The ITF was in at its birth and has supported it all the way. Now it becomes a reality.

The ITF is committed to supporting the MLC's effective and full implementation and ensuring that as many countries as possible ratify it.

The ITF is supporting the MLC's launch with a range of advice and materials designed to help seafarers understand and apply it. These include a dedicated web area complete with advice and Q&As at www.itfmlc.org; a new leaflet for all those working on cruise ships, The Maritime Labour Convention 2006 – what does it mean for cruise crews, which can be downloaded here; and more, including the previously published, in-depth guide A seafarers' bill of rights, available here. The ITF is also collaborating fully with the ILO's welcoming publicity around the MLC, which can be seen at www.ilo.org/global/standards/maritime-labour-convention, http://www.itfseafarers.org/maritime_news.cfm/newsdetail/9418/region/6/section/0/order/1.

NORWAY BACKS FISHERS' SAFETY

Norway has become the first state to sign up to a convention to improve safety on fishing vessels. The 'Cape Town Agreement 2012' updates an earlier international convention for the safety of fishing vessels. The International Maritime Organization (IMO) says the aim of this agreement is to bring into force a "binding international safety regime" to help improve safety standards and reduce the loss of life in the hazardous occupation of fishing at sea.

To come into force, the Cape Town Agreement will need to be signed by at least 22 states with an aggregate of at least 3,600 vessels that are 24m and longer operating on the high seas. Norway has 242 such fishing vessels.

http://www.itfseafarers.org/maritime_news.cfm/newsdetail/9330/region/6/section/0/order/1.

IMSC 2014: Upcoming Conference on Maritime Science



Topics of interest

- ~ Marine Engineering,
- ~ Navigation,
- ~ Safety Systems
- ~ Marine Ecology,
- ~ Hydrography,
- ~ Marine Automation and Electronics,
- ~ Transportation and Modes of Transport,
- ~ Marine Information Systems,
- ~ Maritime Law,
- ~ Management of Marine Systems,
- ~ Maritime Health,
- ~ Marine Finance,
- ~ Up-To-Date Technologies,
- ~ Safety and Security,
- ~ Ecology and Sea,
- ~ Intelligent Transport Systems,
- ~ Human Resources in Transport,
- ~ Education in Transport.

Conference Proceedings

Authors are invited to submit abstracts on e-mail imsc@pfst.hr. Abstracts should be text only up to 250 words long, and should

be written in English and Croatian language. Immediately after abstract, please provide at least 4 keywords. Single author may participate in up to two papers, irrespectively of number of co-authors per paper. The abstracts should be sent until 1st December 2012. The authors will be informed about acceptance no later than 18th December 2012. All accepted abstracts will be published in the Book of Abstracts.

Official Language of the Conference

Papers should be submitted in English. Presentation slides should be given in English, and oral presentation can be made in either English or Croatian.

Contact

University of Split

Faculty of Maritime Studies

INTERNATIONAL MARITIME SCIENCE CONFERENCE

Zrinsko-Frankopanska 38, 21000 Split, Croatia

Tel: +385 (0)21 380-762;

Fax: +385 (0)21 380-759

E-mail: imsc@pfst.hr

www.pfst.hr/imsc

Naša Harvoska

Tin Kolumbić

Our Croatia

trans. by Mirna Čudić

Nāša Harvōska
nī sōmo ime
i pūsta lipotà.
Onà je i tēško
māterino brīme
i svēto sime
nāšega životà.

Līpa nāša
nī sōmo sōn
ča su ga nāši stōri
godīšćima snili.
Onà je i čōrna nōć
i bīli dōn
i svi krīžni pūti
kojīma smo hodili.

Nāša didina
nī sōmo zemjā,
mōre i kāmik.
Onà je i plāmik
jubāvi ča nīkad
u nāšen sārцу
gorit ne pristāje.
Onà je i mlāдост
i nāša dicà
na kojīma svīt ostāje.

Our Croatia
is not merely a name
or sheer beauty.
She is also Mother's
heavy burden
and the sacred seed
of our life.

Our beautiful homeland
is not just the dream
for long centuries
nourished by our forefathers.

She is also the darkest of nights
and the brightest of days
as well as all the Ways of the Cross
we had to tread on.

Our ancestral legacy
is not merely soil,
sea and rock.
It is also the flame
of love which never
ceases to burn in our hearts.
She is also our youth
and our children
who will inherit the earth.

Nāša bāščina
nīsù sômo libri
jazikon harvōskin
i latīnskin slōženi.
Onà je i mùka
i svi životi
za bāščinu polòženi.

Nāša Harvōska
nī sômo daržava.
Onà je i nāša kùća,
stōl i postèja,
susidi, prijateji
i drōga famèja.
Onà liči nāše rāne
i sùze otire.
Uz njù se lāšnje
rōjo, živè
i umire.

Our patrimony does not
only comprise books,
composed in both the Croatian
and Latin tongues.
It is all the suffering endured
and all the lives laid down
for the sake of our heritage.

Our Croatia
is much more than a country.
She is also our home,
our table, and our bed,
our neighbours, our friends
and the beloved family.
She heals our wounds
and wipes our tears.
Birth, living, and dying
are thereby blessed
and rendered sweeter.

RJEČNIK

Harvoska	Hrvatska
brime	breme, teret
son	san
stori	stari
godišća	godine
čoran	crn, taman
don	dan
didina	djedovina
kamik	kamen, stijena
plamik	plamen
ča	što
sarce	srce
baščina	baština, nasljeđe
libri	knjige
jazik	jezik
harvoski	hrvatski
ni	nije
somo	samo
daržava	država
postēja	postelja, krevet
drog	drag
fameja	obitelj
lašnje	lakše
rojo	rađa
žive	živi

Guidelines for Authors: Scope of Transactions on Maritime Science

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. GUIDELINES FOR AUTHORS: MANUSCRIPT PREPARATION AND SUBMISSION

1.1. 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.

1.2. Text organization and style

1.2.1. 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.

1.2.2. 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!

1.2.3. 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.

1.2.4. Figures

Figures should be numbered in sequence with Arabic numerals. Legends to figures should be listed on a separate page, in consecutive order. 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 labelled with a description of the variable it represents.

Only the first letter of the first word should be capitalized. The labelling 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 colour of your original files. Note that we will still need to convert all RGB files to CMYK for printing on paper and colour 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®.

1.2.5. 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.

1.2.6. 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.

1.2.7. References

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

Examples of citation in text:

It is well known fact (Strang and Nguen, 1997; Antoniou, 2006) that FT is not an appropriate tool for analyzing non-stationary 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

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.stat.stanford.edu/_wavelab/, [accessed 12 August 2011.].

Books

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

Conference proceedings

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, Birkhäuser, 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).

1.2.8. 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).

1.2.9. 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 the abbreviation is used in the text. This applies separately to the Abstract and the rest of the text.

1.3. Submission of manuscripts

All manuscripts should 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

2. 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://www.aspb.org/newsletter/ethicalstandards.cfm>]

2.1. 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.

2.2. 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.

2.2.1. 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.