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17th Annual General Assembly

International Association of Maritime Universities

IAMU AGA 17

Working together:

the key way to enhance the quality of maritime education, training and research

Vietnam Maritime University

26 – 29 October 2016

Welcome

The Vietnam Maritime University (VMU) is honored to host the 17th Annual General Assembly (AGA17) of the International Association of Maritime Universities (IAMU) in Haiphong City, Vietnam in the period from October 26-29, 2016.

After taking the role of the representative of Region 2 (Asia, Pacific and Oceania) of the IAMU in two continuous terms from 2012 to 2015, we are very proud to be elected for the host university of AGA17 where the Presidents, experts and scientists of more than 60 member universities from all over the world to discuss recent progress and future trends in maritime education, training, research and other matters within the scope of IAMU. The year of 2016 is really a milestone for VMU marking the 60th anniversary of its foundation and receiving honor awards from the government.

The theme of AGA17 is **"Working together: the key way to enhance the quality of maritime education, training and research"**, including following sub-themes:

1. Standardization of maritime education, training and technical research;
2. Strengthening cooperation for maritime safety and security;
3. Strengthening cooperation for protection of ocean environment.

Many IAMU members are involved in researches on such sub-themes and the best will be explored at the AGA17. We have finally over 50 scientific papers, 8 research/ development projects as well as an excited program for IAMU students (IAMUS) including technical seminars with 31 student presentations. We sincerely hope that AGA17 will provide the opportunity to share and discuss issues of mutual concern as well as a catalyst to enhance networking between member institutions.

Once again, on behalf of VMU's staff, lecturers and students, I would like to welcome all delegations to AGA17. Please enjoy its activities and take the opportunity to stay longer at our flamboyance flower city as well as to spend your time on visiting the neighbor landscapes.

Finally, I would like to acknowledge and express my sincere thanks to all involved in ensuring the success of AGA17, including representatives, speakers, students, participants, the Local Executive Committee and particularly the IAMU Secretariat and the Nippon Foundation for their continuing and valuable supports.

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Working together:

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Vietnam Maritime University

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Working together: the key way to enhance the quality of maritime education, training and research

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Session 1A

MARITIME EDUCATION AND TRAINING

(No. 1)

International Standardization of Maritime Education, Training, Scientific Research and Technological Advances related to Development of e-Navigation Strategy in Order to Enhance the Cooperation for Maritime Safety and Security and Protection of Ocean Environment

Prof. Dr. Capt. Adam Weintrit, FRIN, FNI

Gdynia Maritime University, Department of Navigation, Gdynia, Poland; weintrit@am.gdynia.pl

Abstract: The advantage of the latest technical development in the field of nautical sciences, automation, electronics, telecommunications, informatics, telematics, geomatics and global position fixing techniques, achievement in data storing, processing, analysing, transferring and visualisation should be taken into account and applied to the maritime technology. In the paper the author tries to discuss a strategic vision of development e-Navigation concept using those new technologies and the main tasks of the maritime community for the near future in international standardization of maritime education, training, scientific research and technological advances related to development of e-Navigation strategy in order to enhance the cooperation for maritime safety and security and protection of ocean environment. The author believes it is now appropriate time to develop a broad strategic vision for incorporating the use of new technologies in a structured way and ensuring that their use is compliant with the various electronic navigational and communication technologies and services that are already available. The author tries to present the background to „Why e-Navigation" and its definition, the key elements which in the vision for e-Navigation were covered and the IMO's strength as the co-ordinator of e-Navigation development, including strategy implementation plan. The underlying important principles were stated, together with the need to take user needs into account. Later presentations and comments showed just how ambiguous the term „users" can be in the context of e-Navigation. This led to a more in depth review of the components of the IMO strategy implementation plan. The author tries to answer the question of whether these assumptions, decisions and actions taken were appropriate and sufficient. Implementing technology is like a three-legged stool: if any one leg is inadequate, the whole system fails. Here, one leg is the technology itself; another is the procedure for how to use the technology (gained through testing and experience) and the final one is maritime education and training, both in the operation of the technology itself but most importantly in using the technology with agreed, standardized procedures to make good decisions. The development of well-balanced and highly qualified seafarers is possible. It should be one of most important objectives for IAMU members.

Keywords: Navigation, Communications, Marine Transportation, Safety at Sea, Maritime Education and Training (MET), e-Navigation

1. Introduction. Development of e-Navigation Concept

The last decades have seen huge developments in technology within navigation and communication systems. Sophisticated and advanced technology is developing rapidly. Seafarers have never had more technological support systems than today and therefore there is a need to coordinate systems and more use of harmonized standards. Although ships now carry Global Satellite Navigation Systems (GNSS) and will soon all have reliable Electronic Chart Displays and Information Systems (ECDIS) [9], their use on board is not fully integrated and harmonized with other existing systems and those of other ships and ashore. At the same time it has been identified that the human element, including training, competency, language skills, workload and motivation are essential in today's world. Administrative burden, information overload and ergonomics are prominent concerns. A clear need has been identified for the application of good ergonomic principles in a well-structured human machine interface as part of the e-Navigation strategy [7],[10]. The combination of navigational errors and human failure indicate a potential failure of the larger system in which ships are navigated and controlled. Maritime accidents related to navigation continue to occur despite the development and availability of a number of ship- and shore-based technologies that promise to improve situational awareness and decision-making. These include radio navigation systems, including Global Navigation Satellite Systems (GNSS), Automatic Identification Systems (AIS), Electronic Chart Display and Information Systems (ECDIS), Integrated Bridge Systems (IBS), Integrated Navigation Systems (INS), Long Range Identification and Tracking (LRIT) systems, sophisticated maritime radars, Automatic Radar Plotting Aids (ARPA), Vessel Traffic Services (VTS) and Global Maritime Distress Safety Systems (GMDSS) [8].

The e-Navigation is a major IMO (International Maritime Organization) initiative to harmonise and enhance navigation systems and is expected to have a significant impact on the future of marine navigation. The IMO has mandated that this initiative be led by ‘user needs’. It is believed that these technologies can reduce navigational errors and failures, and deliver benefits in areas like search and rescue, pollution incident response, security and the protection of critical marine resources, such as fishing grounds. They may also contribute to efficiencies in the planning and operation of cargo logistics, by providing information about sea, port and forwarder conditions [8].

1.1 Definition of e-Navigation

e-Navigation is a current international initiative that is intended to facilitate the transition of maritime navigation into the digital era, is a vision for the integration of existing and new navigational tools, in a holistic and systematic manner that will enable the transmission, manipulation and display of navigational information in electronic format [12]. The IMO has defined e-Navigation as "the harmonized collection, integration, exchange, presentation and analysis of marine information on board and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment". e-Navigation would help reduce navigational accidents, errors and failures by developing standards for an accurate and cost effective shipping. e-Navigation is intended to meet present and future user needs through harmonisation of marine navigation systems and supporting shore services.

The IMO further describes the compelling need for e-Navigation as a clear and compelling need to equip the master of a vessel and those ashore responsible for the safety of shipping with modern, proven tools to make maritime navigation and communications more reliable and user friendly and thereby reducing errors. However, if current technological advances continue without proper coordination there is a risk that the future development of marine navigation systems will be hampered through a lack of standardisation onboard and ashore, incompatibility between vessels and an increased and unnecessary level of complexity.

1.2 Electronic Navigation versus e-Navigation

The strength of the IMO’s e-Navigation initiative is that it should lead to greater harmonization of navigation information and communication on an international basis. This will be essential for safety and international trade. The weakness, however, is the time it will take to obtain agreement by all nations and stakeholders, particularly in a time of such rapid technology advancement. Electronic navigation is with us now and is epitomized by ECDIS with GNSS. We recognize that this is widely relied upon, or even over-relied upon. The training requirements for ECDIS came into force in January 2012 as per the Manila amendment to STCW [4], and the first phase of ECDIS carriage requirements commenced in July 2012. The phased carriage requirement of Electronic Chart Display and Information System (ECDIS) is underway and is scheduled to be completed by 2018. ECDIS is a complex system and will be one of the most essential tools for supporting mariners in their efforts to ensure the safety of navigation and protection of the marine environment’. The ability to harness the power of ECDIS and to avoid catastrophe due to incompetence is largely down to training and familiarisation.

1.3 ECDIS Guidance for Good Practice

All Comprehensive guidance is available in the IMO Circular MSC.1/Circ.1503 ECDIS Guidance for Good Practice [6]. All ships masters, navigating officers and operators of ships fitted with ECDIS are encouraged to use this guidance to facilitate the safe and effective use of ECDIS.

Ship owners and operators need to ensure careful management and regular maintenance of both ECDIS hardware and software. MSC.1/Circ.1503 contains guidance on maintenance of ECDIS software and identifies the need to keep ECDIS updated to meet the current International Hydrographic Organization (IHO) standards.

A list of known ECDIS anomalies is included in MSC.1/Circ.1503. Due to the complex nature of ECDIS, and because it involves a mix of hardware, software and data, it is possible (but considered not likely) that further undetected anomalies may exist. The existence of anomalies highlights the importance of maintaining ECDIS software to ensure the correct display of up-to-date electronic navigational charts. To help understand the extent of these anomalies, navigating officers are encouraged to report any such anomalies, including specific details regarding fitted equipment, to their flag State authority.

The IHO has produced an ECDIS Data Presentation and Performance Check dataset that allows mariners to check some important aspects of the operation of their ECDIS. This dataset contains two fictitious ENC cells which can be loaded into an ECDIS to assess operating performance. The test will check whether there are any display anomalies that need to be remedied or otherwise managed. If the check highlights a problem, guidance notes in the check dataset offer suggested courses of action.

2. The IMO e-Navigation Strategy

It should be noted that the term e-Navigation is often used in a generic sense by equipment and service providers. This claim should be seen as an aspiration, rather than an indication of compliance. The e- Navigation is a concept to support and improve decision-making through maritime information management and it aims to [7]:

- facilitate the safe and secure navigation of vessels by improved traffic management, and through the promotion of better standards for safe navigation;
- improve the protection of the marine and coastal environment from pollution;
- enable higher efficiency and reduced costs in transport and logistics;
- improve contingency response, and search and rescue services;
- enhance management and usability of information onboard and ashore to support effective decision making, and to optimize the level of administrative workload for the mariner.

The e-Navigation aims to provide digital information for the benefit of maritime safety, security and protection of the environment, reducing the administrative burden and increasing the efficiency of maritime trade and transport. The work conducted by the IMO during the last years lead to the identification of specific user needs and potential e-Navigation solutions. The e-Navigation Strategy Implementation Plan (SIP), which was approved in 2014, contains a list of tasks required to be conducted in order to address 5 prioritized e-Navigation solutions, namely [10]:

- improved, harmonized and user-friendly bridge design;
- means for standardized and automated reporting;
- improved reliability, resilience and integrity of bridge equipment and navigation information;
- integration and presentation of available information in graphical displays received via communication equipment; and
- improved Communication of VTS Service Portfolio (not limited to VTS stations).

It is expected that these tasks, when completed during the period 2015–2020, should provide the industry with harmonized information in order to start designing products and services to meet the e-Navigation solutions. The ultimate goal of e-Navigation is to integrate ship borne and land based technology on a so far unseen level. e-Navigation is meant to integrate existing and new electronic navigational tools (ship and shore based) into one comprehensive system that will contribute to enhanced navigational safety and security while reducing the workload of the mariner (navigator) [3]. The bridge between those two domains will be broadband communication technology which is about to arrive in regular commercial shipping within the next years to come. The constituting element of this integration, however, is a common maritime data model. The existing concept of the Geospatial Information Registry can be adapted to the enhanced scope of a future Marine Information Registry covering additional maritime domains by expansion, amendment and moderate rearrangement. Though the basic philosophy of the IHO S-100 Registry prevails, virtual barriers for maritime stakeholders to associate with the Registry concept must be lowered by all means. This includes options to adopt existing register-ike structures including identifier systems and stewardship for selected areas and elements of additional maritime domains in contrast to the possibly daunting overall third party ownership for a wide scientific field by potential contributors. Besides the recognized international organizations like, IMO, IHO and IALA who are currently discussing the further steps in e-Navigation, a grass root movement may take place with several stakeholders involved populating the Marine Information Registry. Such a grass root movement would truly demonstrate that e-Navigation has been understood and accepted. To allow for the orderly development of that stage of e-Navigation in accordance with the IMO defined goals and aspirations of e-Navigation, it would be required to activate the appropriate IMO instruments already in place to define the fundamental principles and structure of the Marine Information Registry, to assign roles and responsibilities amongst international organizations and stakeholders, and thereby facilitate the seventh pillar of e-Navigation, its “cement”, namely the Common Maritime Data Structure (CDMS) [11].

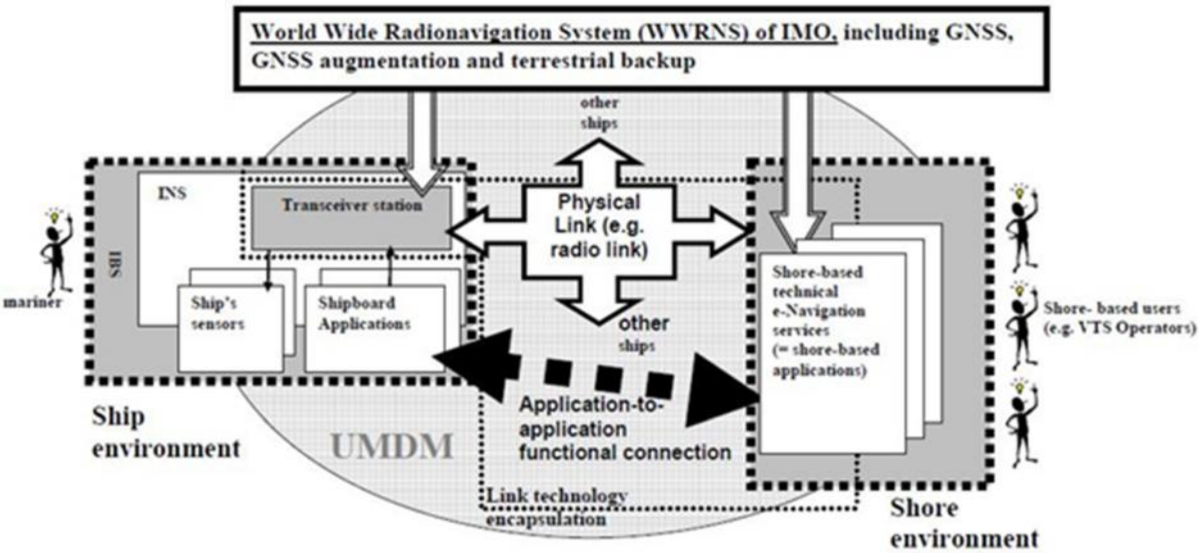

Figure 1 Conceptual, e-Navigation Compliant Architecture Overview

For ships’ navigating officers, masters and pilots to make the very best decisions concerning the safe navigation of a vessel, they need quality tools, good procedures and training that addresses how to use such tools within the context of making good decisions. Users need to be competent and confident when using information from navigation equipment such as ECDIS, Radar, ARPA, AIS, and electronic position fixing systems, in order to use them as effective tools.

3. Maritime Education and Training

Extensive and detailed requirements of training and assessment for the ship-side users of navigational systems, the seafarers, are determined in the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) 1978 [4]. In 2010 the Manila amendments were adopted (STCW 2010). The members of IMO recognized e.g.:

“*the need to allow for the timely amendment of such mandatory standards and provisions in order to effectively respond to changes in technology, operations, practices and procedures used on board ships” and*

“that a large percentage of maritime casualties and pollution incidents are caused by human error”.

Such changes generate new demands on training institutions and on instructors working within them. The implementation of the e-Navigation concept on board and ashore requires a further adaption related to new training concepts and new instructional media to changed standards. Complementary it must be ensured that instructors and assessors are appropriately trained and experienced. Trainers must be qualified in the task for which training is being conducted.

3.1. Training and Assessment On-line Introducing New Technology

During the last decades a lot of new navigational systems were installed on ships' bridges. Responding to that development the Maritime Safety Committee (MSC) published already in June 2003 the MSC/Circ. 1091 "Issues to be considered when introducing new technology on board ship" [5]. The introduction describes the way of looking at the problem in summary:

"*The effectiveness of crews to use the technology safely and to best effect requires familiarity with the equipment and training as recognized in the STCW Convention. There are a number of aspects to be considered with respect to how seafarers interact with the technology and also some issues to be considered when assessing the training needs for the seafarers who use such technology"* [5].

Furthermore document [5] stipulates issues to consider for the training of seafarers when introducing new technology:

a) Standardization: Although performance standards exist, the controls and displays are not standardized. The result is an increase in the amount of training needed to make a seafarer familiar with and effective in the use of the equipment. There are some causes which make increased training impossible e.g. a seafarer joins the vessel just prior to departure or the system aboard the vessel is very different from those on which the seafarer has received training ashore.

   "One solution is to familiarise seafarers with equipment by training them using simulators (either desktop or full mission) prior to them joining their ships. This is made far more efficient when manufacturer provide assistance in developing the training tools" [5].

   This solution can be improved by developing a common interface with standard symbology for common operations. Seafarers should be trained to use the standard dis-play whenever possible, preconditioned the "standard operation" includes all functionalities for safe navigation.

b) Training for technology based systems: There are a lot of challenges to be managed when training seafarers for using technology-based systems on board. E.g. different cultural and practical behaviour patterns. It was ascertained that many young watchkeepers have a culture of using in-formation technology (home computers, Internet, video games etc.) and that during times of stress revert to electronic displays for their primary decision support systems. "*Inexperienced seafarer may seek more data and information in stressful situations, often confusing themselves further. Problems can also develop when novice navigators are trained on desktop simulators which do not have the advantage of a simulated 'window' for visual observation. This may reinforce the habit of constant reliance on a digital display for situational awareness during actual operations*" [5]. One quintessence concluding this section is that only well-trained officers understand to manage and prioritise ECDIS and AIS information. The same information provided to an officer without ECDIS and AIS training can lead to information overload and poor decision making.

c) Introducing new technology regarding the human element: The results of research referenced to automation are:
   - automation has qualitative consequences for human work and safety,
   - automation does not simply replace human work with machine work,
   - automation changes the task it was meant to support,
   - automation creates new error pathways,

- automation shifts the consequences of error further into the future and may delay opportunities for error detection and recovery,
- when automation is installed operators will monitor less effectively,
- automation creates new kinds of knowledge demands.

"*Watchkeepers must have a working knowledge of the functions of the automation in different situations, and know how to co-ordinate their activities with the automated system's activities. This manifests itself in situations whereby officers do not understand weakness or limitations of systems they rely on. Training in this respect will become more important, as systems become more integrated and sophisticated"* [5].

d) Summary: New technology installed on board can improve the efficiency and effectiveness of watchkeeping and consequential improve the safety of operations. However, this technology brings with it the inherent training requirement needed to operate the new systems physically, and also the training need to use the system to make better decisions. The positive effects of new technology will increase with degree of standardization of designs.

3.2 E-Navigation Specific Training

The IMO's Strategy Implementation Plan (SIP) describes the further development of e-Navigation and contains a plan for enhancing public awareness of e-Navigation. The SIP focuses on five prioritized solutions, as follows [10]:

S1: improved, harmonized and user-friendly design;
S2: means for standardized and automated reporting;
S3: improved reliability, resilience and integrity of bridge equipment and navigation information; S4: integration and presentation of available information in graphical displays received via communications equipment; and
S9: improved communication of VTS Service Portfolio.

The implementation of all prioritized solutions require specific training referred to the used technical methods and new operational procedures to comply with the key messages for all stakeholders listed in the table "*Examples of key messages to promote the benefits of e-Navigation*". A detailed description and a table presenting the structure of the SIP are included in [10]. Scrutinizing the solutions in detail it becomes clear that the solutions S1and S4 address the equipment and its use on a ship only, while S2 and S9 address improved communications between ships, ship to shore and shore to ship. Solution S3 addresses both bridge equipment and e.g. shore-ship information as part of the PNT system. Consequently training courses which must developed for the solutions S2 and S9 must include new technical and operational competencies for both users groups, the seafarers and the shore side users. With regard to S9 the STCW requirements and the "IALA Model Course V-103/1 – Vessel Traffic Services Operator Training" must be revised. A possible solution could be an IMO Model Course: "Operational use of VTS Services" [1].

3.3 The Evolution of Using Simulators in Maritime Education and Training

By 1967 first ship simulators came into use for the maritime education of seafarers at merchant marine academies. In the 1990ies, along with the increasing capabilities of computers the simulators developed from pure radar simulators to full mission simulators with more and more sophisticated visualisation. The modern ship handling simulator provides the new students of the naval academies and universities with the opportunity to sample ship handling, without hazard. Simulators also allow working bridge personnel to learn the techniques of Bridge Team Management (BTM), working through a variety of potential problems that might never be encountered, but would be life-threatening should they occur.

The simulator allows mariners access to a real time simulation of the conditions aboard ship-on the bridge, in engineering spaces or in specialized spaces such as cargo handling at a lower cost than teaching classes aboard a training ship. Ship handling simulators are used to train mariners to handle ships in a variety of situations, from docking and undocking, to navigating various approaches in a variety of conditions using actual ship performance data in real time. The key features to a ship simulator are real operational controls and a system that allows the instructors operating the simulator to put the simulator students into realistic situations. All simulators are designed to provide an experience as close as possible to the real world. Bridge simulators provide accurate visual representations through the "bridge windows" and some are even mounting on hydraulic platforms to mimic movement. The speed controls, steering, radar and charting systems are the same found on the bridge of modern ships.

Today marine simulators take over an increasing part in maritime training to raise safety standards. STCW 2010 [4], section A-I/12, contains the standards governing the use of simulators for maritime training of seafarer:

- Part 1 deals with the general performance standards for simulators used for mandatory simulator-based training, assessment of competence and in accordance with their specific type (Radar simulation, ARPA simulation);
- Part 2 deals with the training and assessment procedures. STCW 2010 [4] section B explains the “Recommended performance standards for non-mandatory types of simulation” “Such forms of simulation include, but are not limited to, the following types:
  .1 navigation and watchkeeping;
  .2 ship handling and manoeuvring;
  .3 cargo handling and stowage;
  .4 reporting and radiocommunications; and
  .5 main and auxiliary machinery operation.

“*Navigation and watchkeeping simulation equipment should, in addition to meeting all applicable performance standards set out in section A-I/12, be capable to .4 realistic simulate VTS communication procedures between ship and shore*”.

For the shore side part of VTS communication the IALA Model course V, Part D – Guidelines for instructors, section 5, describes subjects and assessment criteria included in 100 hours simulated exercises.

3.4. E-Navigation Training Proposals

In this section the author presents the candidate solutions relating to education, training and using simulators. In the Interreg North Sea Region Programme ACCSEAS were identified in total 14 training proposals, described in the “Baseline Report” [1]. Some were portrayed in detail including technical specifications and user manuals. At the end of ACCSEAS project the solutions reached a different stage of development. For further work on training and use of simulators in e-Navigation training and demonstration it is reasonable to group them as follows:

1. Maritime Service Portfolios (MSPs),
2. Route Topology Model (RTM),
3. “Maritime Cloud” as an underlying technical framework solution,
4. Innovative Architecture for Ship Positioning:
   a) Multi Source Positioning Service,
   b) R-Mode at existing MF DGNSS and AIS Services,
5. Maritime Safety Information / Notices to Mariners (MSI/NM) Service,
6. No-Go-Area Service,
7. Tactical Route Suggestion Service (shore-ship),
8. Tactical Exchange of Intended Route (ship-ship and ship-shore),
9. Vessel Operations Coordination Tool (VOCT),
10. Dynamic Predictor (for tug boat operations),
11. Augmented Reality / Head-Up-Displays (HUDs),
12. Automated FAL Reporting,
13. Harmonized Data Exchange – Employing the Inter-VTS Exchange Format (IVEF),
14. Real Time Vessel Traffic Pattern Analysis and Warning Functionality for VTS.

The majority of mentioned solutions are thoroughly investigated and ready for developing training arrangements except the last three solutions. They are in principle recognized, but unfortunately yet not ready for developing training arrangements.
In addition, in the author opinion, we should take into account the following extra proposals:

1. Virtual Aids to Navigation (Virtual ATON) and AIS ATON (Real, Synthetic and Virtual),
2. Back-up Arrangements for ECDIS,
3. A robust electronic position-fixing system with redundancy,
4. IHO S-100 Universal Hydrographic Data Model (explanation and use).

First of all we should teach our students how to:

- avoid common-mode failures (e.g. GNSS, e-Loran, inertial systems, integrity checks),
- improve situational awareness (target matching, coherent presentation), and
- prevent information overload (alarm management, essential information only).

3.5. Training Requirements for Operating an e-Navigation ship

We must ask ourselves why we need this new concept and why we expect it to improve. From a simple look on the ships bridges we can see that the deck officer has a multitude of information presented to him at the same time on different displays (ECDIS, Radar, and GPS receiver) and the most important issue of all is that each equipment has functions/features that will distinguish itself from others that are to be found on different ships. Unfortunately, the user interface (the main menu) is not internationally standardized. Even if the information is readily available at almost any console (for example, position information provided by GPS, can be found at the radar and ECDIS displays) and operation at first glance seems simple and easy, in emergency situation, where will be required our fast response and quick decision to be made, even knowing where on the screen is presented the required information, the situation as a whole becomes very problematic [2],[7]. That means that each officer will need some time to find out how to operate the systems efficiently at the same time: there is the risk of accidents or misinterpretation of data due to fatigue or tiredness that is not all that uncommon in this line of activity. With e-Navigation we see an important step being made towards standardization while leaving with regard that sufficient room is left to equipment producers while leaving sufficient room for improvement. It is also under debate whether an S-Mode (Standard Mode) should be introduced for each equipment to be found on board a standard mode to which every officer and pilot should be familiarized, so to prevent any misinterpretation of data [7].

We must remember that e-Navigating means that the OOW has a completely autonomous and fully working system on board for a safe voyage, but also has the possibility to be fed with a wide variety of information from shore-based facilities [3]. That means e-Navigation requires a highly efficient data communication network that allows a constant flux of information between the ship and shore systems like VTS, ship to ship communication. This higher efficiency is needed because services like the VTS find themselves having to cope with a greater and greater number of ships and, as a result an increasing amount of time has to be spent on organizing the traffic flow and on security operations. Also the ships owners and charters will benefit because of improved communication with the ship allowing them to be up to date with her general operation. But the e-Navigation concept is not limited to the equipment on board a ship it also includes the officer as an integral part of the system, because based on all the information available to him, he is expected to make decisions that could make the difference between safe navigation and maritime disasters. But we must realize that every equipment has its limitations and its inherent flaws, and could fail to perform. Thus, it is a very dangerous trend that in modern days an OOW should rely only on the information provided by the GPS or RADAR or the ECDIS. Indeed, many masters consider for a good reason that on board their ships the most important equipment are the eyes, ears, and the mind of the OOW, and that the most important consoles are the windows of the ships [2].

Colreg states under Rule 5 that "*a good every vessel shall at all time maintain a proper look out by sight and hearing as well as by all available means appropriate in prevailing circumstances and conditions so as to make a full appraisal of the situation and of the risk of collision*", and under Rule number 7 it is stated: "*every vessel shall use all available means appropriate to prevailing circumstances to determine if risk of collision exists" also it warns that "assumptions shall not be made on the basis of scanty information, especially scanty radar information*". With this in mind we must realize that with the technological advancement in navigation equipment we expect the naval officers to exercise their profession in a safer manner. And indeed it should be so, but nowadays most of the naval accidents and naval disasters are due to human error [2]. However, along with the STCW convention, e-Navigation should make a great impact on safety levels and prevention of pollution. We think that it will be compulsory that upon arrival on a new ship (which has an integrated bridge system), the OOW must have special time allocated to reading the user manuals for the IBS equipment [2]. After that, a discussion and practical explanation session must be arranged under the supervision of senior officers, before the ship will leave the port.

3.6. Preparing Students for e-Navigation

At the Faculty of Navigation in Gdynia Maritime University, as in many other maritime universities [2], we are educating our students with due regard to e-Navigation concept since a few years. We believe that the maritime officer is a crucial part of this concept and the way they are educated is crucial to their future performances. In their two first years they learn how to navigate a ship without the use of modern systems. Disciplines like celestial navigation and coastal navigation emphasize the fact that a ship can be safely navigated with only a sextant, a compass, navigational charts, and a very well prepared bridge team of officers. They gain basic knowledge on theoretical and practical aspects of navigation as a whole. The program curricula includes Radar Navigation, Radar Plotting, as well as the use of ARPA. At these practical trainings our students are introduced to at least five/six different radar/ARPA display types, five/six various ECDIS simulators, five/six diverse GPS receivers, off course of different manufacturers. They learn how to make proper use of the ENCs, the GPS, AIS, ARPA, ECDIS, and the communication services on board a ship. The most important aspect of education regarding e-Navigation is represented by the skills they gain by working on simulator and how to use all the knowledge they have accumulated over the years and to experience situations that they may encounter at sea [2]. Apart from putting to practice the Colreg rules, they are accustomed to being in constant communication with VTS stations, as well as with ships in their vicinity.

4. Conclusions

The IMO as a specialized agency of the United Nations, which primary purpose is to develop and maintain a comprehensive regulatory framework for shipping and its remit includes safety, environmental concerns, legal matters, technical co-operation, maritime security and the efficiency of shipping and as the leading international body for maritime professionals will continue to use the resources of its members states to promote the effective application of the e-Navigation concept, of course including innovative methods of education and training. The maritime universities associated in the IAMU should assist in that process and therefore it is my pleasure to invite all maritime professionals to join in this critical effort.

Thanks to advances in information technology, free communication between ocean and land is now available and all maritime society carry forward the e-Navigation for maritime accident prevention, transport efficiency, energy conservation and marine environment protection purpose. A large-scale implementation of the e-Navigation features is inevitable in the near future. The impact of electronics and computers on the ships' bridges is well known for at least 20 years. Despite this, there are still a lot of debates regarding the real improvement of safety based on electronics. Because the future means e-Navigation, we have to start to prepare our students and cadets to face the challenges raised by an increasing amount of navigation information that must be selected, absorbed, processed and analysed in a proper way, in order to determine the correct actions.

In order to achieve this goal, to traditional methods to teach navigation must be added a new kind of module able to integrate the main information from all kind of navigational sources and sensors. We have to develop the students habitudes to generate their own overall image of the surrounding situation, based on as much information available as possible. We also have to develop new kind of maritime safety culture of our students for a self-learning process when confronted with new types of navigational equipment and a new layout/configuration of the integrated bridge system. They have to obtain a proper onboard training, starting with enough time to familiarize and understand the user manuals of the navigation equipment installed in the INS/IBS.

The e-Navigation is a broad concept that is aimed at enhancing navigation safety, security and the protection of the marine environment through the harmonised collection, integration, exchange, presentation and analysis of maritime information onboard and ashore by electronic means. It is envisioned that e-Navigation will be a 'living' concept that will evolve and adapt over a long time scale to support this objective. During this time information will change, technologies will change, political and commercial objectives will change, and tasks will change, and even our expectations will change. However it is unlikely that the need for safe and efficient seaborne transport will change significantly. It is also certain that the safe and efficient transport will continue to rely on good decisions being made on an increasingly constant and reliable basis. Some decisions may be made with increased dependence on technology, but at some level we will always rely on good human decisions being made and therefore every effort needs to be made to apply an understanding of the Human Element at all stages, of design, development, implementation and operation of e-Navigation. Therefore we need new, modified education and training system dedicated and targeted to e-Navigation and well standardised international procedures for marine navigation.

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Towards Dynamic Maritime Education and Training Systems

Capt. Ahmed Kassar, PhD.

Arab Academy for Science, Technology and Maritime Transport, Email: alkassar_ahmed@yahoo.com

Abstract

Despite the rushing development in shipping industry paralleled to technology acceleration, accidents and disasters still frequently happened. MET systems still relying on the minimum standards laid down by STCW convention to achieve the required standards for competency and qualification of seafarers. Furthermore, STCW convention does not designate the suitable teaching methodology for different subjects to achieve the required competencies and skills.

Maritime education and training depends mainly on providing candidates with knowledge and competencies to be able to perform certain duties and assignments, without any consideration of candidates` self-experiences, industry feedback and lesson learnt from previous accidents, incidents and near-miss reports.

Same safety training and proficiencies are provided to Master and First officers on one side,and Chief engineer and Second engineer on the other side at management level, this meana repetition of the same proficiencies whether during upgrading studies or refreshment of competences. Officers at management level can have instead more advanced management studies depending on the intellectual development, sharing of experiences and industry feedback.

It is important to have more reliable and effective MET system capable to overcome the problem of human errors and be able to keep pace with shipping industry updates. A proposed methodology for a more dynamic MET system is introduced as a new approach on how the maritime education and training can be provided to seafarers.

Key Words: Maritime Education and Training systems (MET), Dynamic Education System, STCW Convention, Experiences Exchange, shipping Industry

1. Introduction

Shipping today is a highly technical professional discipline. It requires special workforce with considerable skills, knowledge and expertise. Effective and reliable standards of training are the bases of a safe, secure and clean shipping industry. The main goal of MET standards is to providelearners with the required competences and proficiencies, yet experiences only achieved during practicing of work onboard ships along unlimited time duration, where seafarer practicing trial and error until reaching satisfied performance. However, seafarer experiences and their response to different situations always differ from one to another, despite the fact that maritime training institutions are generally implementing thestandards of STCW convention as a minimum requirements guided by IMO related model courses.

STCW convention standards still provided to student as indoctrination of subject material without any consideration paid to the role of human errors in shipping accidents and the surrounding contributing factors that affect efficiency of preforming assigned tasks.

In fact, what has been achieved in technology during the past two decades can`t be evencompared with the whole progress that has been achieved during the last century as a whole. Despite the technological development in all sorts of life,it hasn’tbeen imitated the same way with same speed in shipping industry, not only in the field of shipbuilding, management, but extends to differentother management style, whether onboard ships or in shipping companies.

Effective education deals with emotions, attitudes, and values of students through instructional design to modify thinking and behavior of the learner. Khan,(6).In order to provide ships with crews havingqualifications and experiencesalways aligned with the frequent development in shipping industry,and being able to prevent accidents in active and professional manner, MET has to be more allied to industry and representsreality of work at sea.

Moreover, to add value to MET systems, it has to rely much more onsharing experiences rather than listening to repeated knowledge and skills, especially for those at management level as Masters and Chief Engineers.In addition, shipboard staff needsto be fully conversant with supporting professional techniques such as management and intellectual sciences.

2. Shipping Accident and Human Errors

According to the annual report issued by Allianz (1), shipping losses continued their long-term downward trend with 85 total losses reported worldwide in 2015. Although the number of ships losses remained stable yearly, declining by just 3% compared with the previous year (88), which fortunately makes year 2015 the safest year in shipping for decades. Losses have declined by 45% since 2006, driven by safety environment and self-regulation.

Cargo and fishing ships accounted for over 60% of ships lost globally, with cargo ships losses up for the first time in three years. The most common cause of total losses was foundering (sinking), accounting for almost 75% of losses, also up 25% happened due to bad weather. In general, the reportdeclared 2,687 reported shipping incidents globally in 2015.

All references and statistics of shipping accidents during the last five decades have pointed to human errors as the main reason behind 85% ~ 90% of accidents at sea. EMSA, (2) declares that the main factors which have an effect on the potential for human error are education, training and working conditions. Therefore, the better the education and training received by seafarers is, the safer shipping will become.

According to TrasNav, (8) There are two factors that Human errors depend upon, the internal factors which related to the operators′ characteristics and differences such as skill, experience, task familiarity, and the external factors that related to equipment design and installation, task complexity, work environment, organizational factors and operating procedures. A proper balance between the capability and experiences of the human operator and the difficulty of the task would decrease the likelihood of human error.

As Jenni (5) explained the underlying theory of incidents reporting or what is known as iceberg model or accident pyramid, that, for every serious accident, there are 29 less serious accidents and 300 near miss cases. However, near misses and less serious accidents have the same underlying reasons as serious accidents. Incidents and near misses are usually unnoticed and unreported, and quite often seen as normal operational failure issues. As no accidents have occurred, as result of these unreported incidents and near misses, or avoided due to unintentional acts, they have remained hidden. However, the world has become more aware of major accidents that involve ships, than the initial events or faults that if the chain or the tree of faults or events is accomplished, risk might accelerate and lead to unavoidable serious accidents.

Procedia, (7) declared that learning lessons from incidents and near misses improves safety performance. The mandatory International Safety Management Code requires shipping companies to establish a reporting system in order to promote continuous learning in safety management. However, incidents and near misses still reported poorly in the shipping industry, and always limited to the level of shipping companies or certain group of fleets, but not yet broadcasted worldwide and not effectively utilized in MET.

Therefore, if incidents and near misses are frequently reported, communicated globally, and then integrated in the MET systems, serious accidents would be avoided and diminished worldwide.

Unfortunately, reasons behind several accidents onboard are relatively the same and repeated along the last nearby decades with the same way,consequences and errors. Seafarers onboard are systematically focused on performing tasks depending on theiracquired experiences and skills without any consideration or review of steps that shall be taken to start or carry out the required task. Onboard ships, seafarers at all levels, gaining experiences through their own practices or individual situational circumstances; there is no chance for them to study or upgradetheir knowledge and skills.

3. Shortcomings of the current Maritime Education and Training system

The latest major amendments to the STCW convention entered into force in 2012, the same year that has witnessed the disaster of passenger ship "Costa Concordia", just few meters from the Italian coast with the same reasons and causations of the "Herald of Free Enterprise" disaster that happened thirty-five years ago. This obviously indicates that current MET systems are still not capable enough to reach the right approach to cut the potentials of accident at sea.

STCW review reflects the same trends in the need for more specialization to address the higher-level maritime operations onboard through a wider coverage of knowledge, skills and competencies. STCW convention depends mainly on the competency-based training always targets skill gaps and focuses on performance of skills and acquisition of knowledge. STCW convention of course doesn`t contain any references to the suitable methodologies to be used to provide such competencies and skills. Using the traditional training methodology, that often generic, rather than targeted toward specific experience development.

Maritime education and training Standards are frequently amended and updated in response to proposals submitted by IMO`s parties, these always prepared according to research findings or outcomes of new technology and accident investigation reports. Proposals for change always proceed for prolonged procedures that might take four to five years duration until being completely effective. This prolonged procedures causethe graduated students become always behind industry updates and always attain obsolete knowledge.

Despite the comprehensive amendments of STCW convention, there is still a gap between the actual industry practices and the standards of training and competencies required to be addressed. There is a need to add much more proficiencies such as Port State Control procedures and Coastal State Control. In addition, special safety control and reviews carried out on tankers like; the International Tanker Owners Association review, Chemical Distribution Institute (CDI) M, (Marine), Tanker Management and Self Assessment (TMSA) inspection, and Ship Inspection Report (SIRE) Program on gas, oil, and chemical tankers have not yet covered as proficienciesin STCW convention. Seafarers only gained experiences on how to deal with such safety control systems through self-obtained experiences or by doing non-compulsory special courses.

Furthermore, practices and experiences have shown that there is a need for more proficiencies and skillsto be included in STCW such as Proficiency in ship/ Helicopter Operations, Hydrogen Sulphide - (H2S)-Safety Training, Smoke Diving training, Proficiency of Safety Officers, Helicopter Underwater Escape Training (HUET).

Despite the evolution in management techniques, especially in the field of decision-making under mental strain, emotional intelligence, creative thinking, risk assessment and root causes; there is no intention of IMO parties to introduce such new/old techniques for ships personnel at management levels instead of repetition of the same proficiency short courses.

Despite, the application of quality management systems in all sorts of operation at sea through the implementation of the International Safety Management code (ISM) and the management system required by the International Ship and Port facilities Security code (ISPS), still there isn`t any required proficiency that address the application of quality management systems in the STCW convention.

Technology in MET has not yet well utilized, the STCW is still behind the usage of remote study, distance learning and electronic learning. The usage of social web pages, if modified and adapted, it will provide seafarers with effectual knowledge and experiences with enormous outcomes. Complete lectures and the outcomes of incident and near miss reports could be instantly downloaded or remotely broadcasted for seafarers.

As STCW convention statement, *'revalidation of certificate means establishing continued professional competence',* that is obviously indicate the attainment of the same acquired proficiency and competencies IMO, (4). The proficiency short courses for officers at operation level and management level are the same. Advanced Fire Fighting, Proficiency in Survival Techniques and Personal Safety and Social Responsibilities courses are renewed or revalidated every five years, with the same competency and proficiency requirements.

4. Maritime Education and Training Styles

There are different teaching styles, lecturer can use in the classroom, such as the authority model where teacher-centered and frequently entails lengthy lecture sessions or one-way presentations where students are expected to take notes or absorb information. Some other style where lecturers demonstrate their expertise by showing students what they need to know. They combine a variety of teaching methods including lectures, multimedia presentations and demonstrations. Sometimes, lecturer promote self-learning and help students develop critical thinking skills and retain knowledge that leads to self-actualization.

Teaching style is considered effective when engages students in the learning process and helps them developing critical thinking skills and gaining experiences in the field of study. Despite, MET traditional teaching styles have evolved with the application of simulators and different multimedia applications, there still a need for new style which can make use of all available sources of information, sharing experiences and industry updates, specially accidents, incidents, near miss reports and different control regime reports. The new style of education will be adjusted toward students' learning needs, industry updates and always find solutions for the frequent developed problems and potential risks.

As MET student are unique and completely different from any sort of students in all studying fields, especially those at management level, as they have already practical experiences in the field of study, they may attend this course before and they need to hear something new much relating to the current actual working environment. The MET needs integrated approaches to new teaching methods that merges the teachers' experiences and interests with students' experiences and needs together while adhering to the subject curriculum.

Due to the unique working environment of seafarers at sea, and the successive thousands of accidents that reported every year, a dynamic style of education and training is required. Dynamic style of education and training depends mainly on the direct interaction and exchange of experiences between lecturers and learners especially for those at the higher level of responsibility (management level). In addition, frequent industry development and updates are integrated in the education processes regularly. Moreover, feedback of industry is collected, analysed and then communicated between students, lecturers and researchers.

Martinson, (3) defined Dynamic knowledgeas "*steps beyond just "know about" and steps into performance. It isactually doing something with the information, working with it, building skillsand understanding on a deeper level. Dynamic knowledge is to gain a feel for* *something, to internalize information and have it become real and active in the learner's world'*. Information provided by a lecturer will challenge participants to take action based upon their decisions, whether the decision is the result of personal or group problem solving.

The experience-based training and development is a learner-centered approach to develop students experiencesas well as updating lecturer` practices and experiences. Rather than presenting information as a lecture-expert, a lecturer using this methodology will create situations which invite participants to discover their own answers to challenging industry issues and presenting student own intelligence in solving problems.

Sources of information required to be integrated in the teaching curriculums

To deliver the dynamic style of MET, there shall be a complete information database regarding each individual subject concerning the following:

a) The latest industry updates and the future targets and intentions of the industry developments.
b) The latest Port State Control and other special control regime reports including the most common deficiencies detected.
c) Updated database of collected incident, near-misses and unsafe acts reports worldwide.
d) The impact of the concerned subject on the safety of the user and the surrounding environment.
e) The impact of the related subject on the marine environment and how to avoid and control potential risks of pollution.
f) The impact of the related subject on the security of the ship as general and the security of information and protection of the shipping company interests.
g) The latest research updates and results.
h) Database of the accumulated especial experiences collected from students during previous classes.
i) Database of lecture`s tacit experiences and cases to study.
j) Student feedback on industry updates, human element and the effectiveness of newly implemented standards and requirements.

The following figure showing the main Parameters of the dynamic style of MET

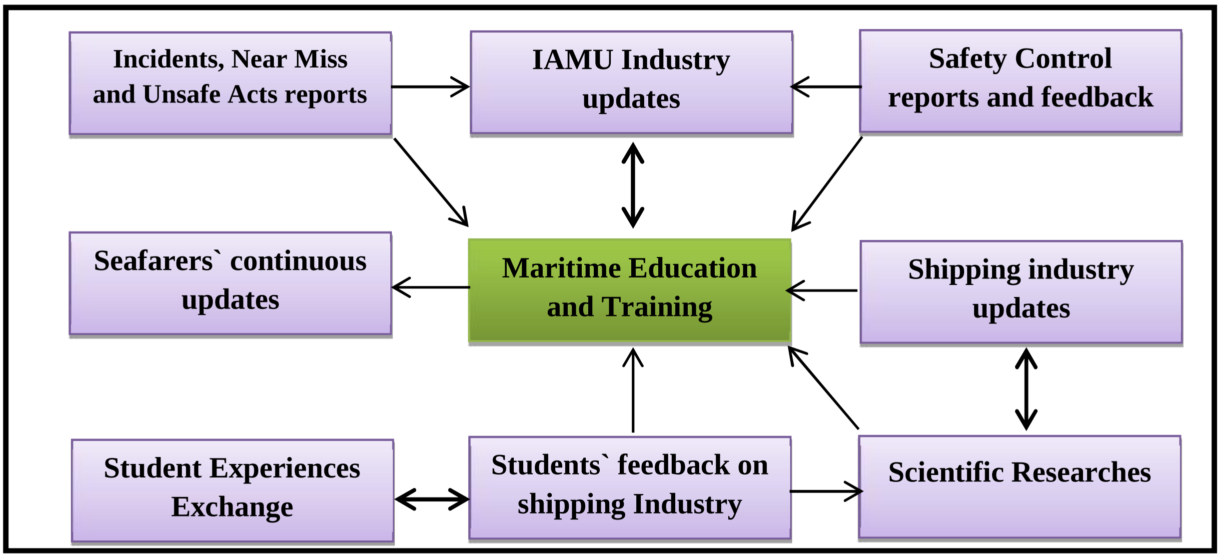

Figure 1 The main Parameters of the dynamic style of MET

Comparison between the Conventional and Dynamic Styles of MET

Table 1 Comparison between static and dynamic styles of MET

MET Conventional Style	MET Dynamic Style
Concerning with the know how	Concerning with the development of acquired capabilities and experiences.
Answering questions like; what, How and when	Answering questions like how to manage, how to utilize and how to avoid.
Concerning with how to respond to emergencies	Concerning with gaining experiences from previous accident and learn how to take proper pro-active actions.
Providing information on technologies already exist in accordance with the requirements of treaties entered into force.	Providing information on recently applied technologies and the trend of industry updates and development.
Focusing mainly on major accidents	Focusing on all levels of accidents, incidents and near misses.
Knowledge and proficiencies are provided from lecturers to students.	Knowledge and experiences are shared between lectures and students.
Not considering students experiences and their feedback on industry.	Considering students experiences and their feedback on industry.
The concept of training is to provide knowledge and skills.	Expand the concept of training to a wider integrated conceptual training system to include all contributing parameters like environment impact, security and safety.

Conclusion

Despite the obvious decrease in accident rates at sea and successive amendments to STCW convention, yet accidents still happened with the same reasons and errors. Human element remains in the forefront of errors that have led to accidents at sea.

The current maritime education and training systemsstill depend on theconventional model of education, that to provide students with knowledge and skills straightforwardjust to ensure that required proficiencies and skillsare achieved. Feedback on the present maritime education system declared that present style of education is not effective enough to provide students with sufficient experiences on how to avoid errors and in turn accidents and incidents.

Dynamic system of education relies on the exchange of experiences between students on one side and students and lecturers on the other side. The presence of experienced student is also being utilized in the purposes of scientific researches and development of the industry.

There is a gap between industry evolution and maritime education, that the later always been restricted to the requirements of STCW convention and its amendments in force. STCW convention is still in need of more improvements and updates to be much more effective and tangible. Dynamic system of education is a unique system much suitable for maritime education especially for students at management level.

Recommendations

1- It is important to expand the concept of training from just providing knowledge and skills to a wider integrated conceptual training system**.**

2- Dynamic system of education is a unique style much suitable for maritime education, the application of it, could help in reducing the rate of accidents at sea and eliminatingthe potentials of human errors.
3- Reports of different levels of accidents should be globally collected, analyzed, and investigated, then, rebroadcasted to maritime institutions as lessons to learn.
4- There should be clear identified link between MET and shipping industry. Maritime institutions shouldbe a step forward of thedate of implementation of the STCW convention updates and amendments.
5- Officers at management level should have more advanced management studies such as; decision-making under mental strain, emotional intelligence, creative thinking, risk assessment and root causes.
6- There is a need to establish channels of communication between maritime institutions and graduates to update their knowledge and awareness of the industry updates.
7- STCW convention is still in need of more proficiencies to cover such as; ship/ helicopter operations, Proficiency of Safety Officers and handling of Port State Control.
8- It is important to expand the concept of training from just providing knowledge and skills to a wider integrated conceptual training system. The core of teaching material can be considered from multifunctional approach, for example, if the teaching syllabus was regarding safety practices, there should be thoroughly considerations of the environment impact, security, personal safety and the application of good management practicing.
9- It is important to consider the standards for revalidation and updates of competency certificates and, instructors, supervisors and assessors` proficiency.

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Containerisation of MET- Moving Towards a Global Maritime Education System

<u>Mr Gamini Lokuketagoda</u>[1], DrTakashi Miwa[2], and Prof Dev Ranmuthugala[3]

1. National Centre for Ports and Shipping, Australian Maritime College, Gamini.Lokuketagoda@utas.edu.au, Locked Bag 1397, Launceston Tasmania 7250, Australia.
2. Graduate school of Maritime Sciences, Kobe University, 5-5-1 Fukaeminami, Higashinada, Kobe Japan. miwa@maritime.kobe-u.ac.jp
3. Australian Maritime College, Locked Bag 1397, Launceston Tasmania 7250, Australia D.Ranmuthugala@amc.edu.au

Abstract: In order to be relevant and efficient, Maritime Education and Training (MET) has to constantly evolve to meet changing industry and social demands that are influenced by many factors including development of technology, cost to industry and MET institutions, changes in legislation for safety, security requirements, and environmental concerns, etc.

Although International Maritime Organisation (IMO) continues to play an active role in prescribing the competencies and standards for training and certification of seafarers through various conventions and associated national legislation, the shipping world is yet to implement a comprehensive and uniform global standard for MET. There are many factors that contribute to this discrepancy in standards across the maritime world, including:

- varying education backgrounds of seafarers from different countries and regions;
- cultural, ethnic and demographical diversities of seafarers;
- affordability of MET facilities; and
- reluctance to break away from the deep rooted traditions and practices.

This paper explores the above issues across the regions and looks into strategies to standardise MET across the maritime world, with parallels drawn with the aviation industry standards and practices. Interestingly, it is noted that the maritime industry is able to standardise practices across boundaries in operations, such as the containerisation of break bulk cargo that revolutionised cargo operations, significantly improving speed, efficiency and safety.

A similar approach is discussed, referred to as the 'Containerisation of MET'in an attempt to unify the standards and processesinherent to maritime education, training and assessment to achieve one global standard. Although the proposed containerisation of MET would take a few years to achieve its goal worldwide, if properly designed and implemented will result in globalising MET, providing seafarers with the:

- ability to study modules in locations anywhere around the world;
- complete modules while sailing, without adverse downtime; and
- appear for assessments anywhere in the world.

The benefits for the respective certification authoritiesare that the results of assessments will be accessible and accepted by all participating institutions through secure web based portals and the certificates issued will be verified by each administration through Port State Control MOU's.

Keywords: Maritime Education and Training, Seafarer Training, Global Standards.

1. Introduction

To be successful and to meet the demands of a changing world, all facets of education has to evolve. It could be argued that this has never been more important than in the current environment, where rapidly changing economic and social demands and significant developments in technology heavily influence the educational outcomes and the delivery methodology. This is true irrespective of whether the education programmesare technical, non-technical, or specialised such as within themaritime discipline. A salient feature ofMaritime Education and Training (MET) is that it comprises of a broad and significantly large curriculum that has to be delivered to seafarers over a short period of time, sandwiched between periods of time at sea. The delivery of the large spectrum of knowledge and skills required is hampered by a mix ofold and traditional delivery and assessment strategies with modern concepts, exacerbated by varying standards and methods across the different nations and regions [1][2].

Today's industry finds seafarers working on vessels with diverse technology that can span from five days to five decades in age, and adhering to systems and practices that vary between operators and nations. In this back drop it is difficult to prescribe a 'one size fits all' curriculum. Over the years the International Maritime Organisation (IMO) has been very careful when prescribing the competencies inthe Standards of Training, Certification and Watchkeepingconvention (STCW 1995 and 2010) Code tables and model courses 7.01 to 7.04. The syllabi were more generic than specific and IMO was cautiousin suggesting it as a guideline rather than a prescription [3]. This position was meant to assist the administrations to adopt their own syllabi, training programmes, and assessment criteria in MET conforming to the guidelines provided. However, it also can result in the different authorities and institutions interpreting the standards and qualifications differently.

The 1995 amendments to the STCW convention (STCW, '95), brought the requirement for countries to be in the IMO 'white list'[2].At first glance it was assumed that the step taken by IMO was towards a global standard in MET. However, the countries within the white list were not required to recognise each other's Certificates of Competency (CoC's) due to the methodologies adopted by member states to conduct MET and assessment of seafarers. This further widened the gap in MET across the world, and many nations continued to conduct their education and assessment programmes with a domestic focus and in many cases with very little changes to traditional practices.

There were further factors for member states to continue their traditional MET practices with very little changes, such as:

- varying education backgrounds of seafarers from different countries and regions;
- cultural, ethnic, and demographical diversities of seafarers;
- affordability of MET facilities; and
- reluctance to break away from deep rooted traditions and practices.

2. The requirement for global standard

The requirement for unified global standard for MET stems from the requirement of shipping companies for seafarers to obtain their qualificationsthrough a flexible system that provides for shorter and cheaper training options that will produce competent seafarers at a lower cost and be more conducive to international shipping schedules. This is especially so for company sponsored seafarers, as their training costs and time is a direct expense to the company. From the view point of the self-funded seafarer, the requirements are similar although the reasons can differ as they need to spend less money and time away from their families while obtaining their qualifications and be available on the relatively competitive job market for their next opportunity.In this context a major hindrance to seafarers and shipping companies alike in achieving these objectivesis the non-recognition oftheir prior learning completed in different MET institute across different flag state administrations.

Although shipping is global in every sense, it is yet to have a global system to provide flexible and globally recognisedseafarer qualifications. The flag state administrations and MET institutions together with other stakeholders determine the standards of qualifications for seafarers, which may not necessarily be global. The differences becomes apparent whenseafarers seek to obtain their qualifications from a number countries, for example obtaining their CoCs from different countries as they progressed through their careers. This occurs when seafarers migrate between countries or are required to seek qualifications from other countries due to limitations in their own flag state qualification structure, (i.e. non-offering of management levelCoCs), location of their employers company and the rout of their vessels, or attainment of higher qualifications and pathways.

In extreme cases, some state administrations are not willing to accept any of the prior qualifications the seafarers had obtained from other jurisdictions, although they would be recognised on the IMO white list.Unfortunately, the IMO itself provides the justification for countries to adopt such a position by declaring in the regulations, that the training provided by a MET institution should be, "…approved, administered,supervised and monitored by the same administration to be accepted as valid" [4].This inference enables an administration toconsider any qualification or associated education and training done outside their jurisdiction as unacceptable, requiring the applicants to redo the qualification or the relevant components, although the training and assessment regimes in the two jurisdictions could be very similar.From the viewpoint of the administration, they are adhering to the regulation. However, this leads to many difficulties to the seafarersand their employers, who will need to spend more time and money to qualify to the level required, irrespective of the qualifications theypossess.

Coupled with the above administrative implication, the dissimilarity of the relevant MET curriculumand the delivery and assessment strategies across different countries contribute to the non-acceptance of each other's qualifications or associated learning. In most cases it is difficult to map the curriculum and syllabi of two different nations and the training programmes and qualifications themselves may have totally different structures.

Although the STCW 95 amendments clearly spelt out the levels of responsibility and associated functions for each level of responsibility, there is little information on entry requirements. Thus, MET institutions in different jurisdictions adopteddiverse entry points for school leavers embarking on seafaring careers to suit their own needs, requirements, and internal influences. In essence, the MET structures, curriculum and assessment methodologies have evolved within each jurisdiction, that many now have significantly differences between them.

Although the different jurisdictions are reluctant to recognise each other's qualifications, the shipping companies that hire multi-national crew do so very successfully with seafarers holding CoC's from different jurisdictions. This impliesthat the IMO white list is working at the exit level with regard to the competencies attained by seafarers, although the administrations may be reluctant to accept each other's training and education programmes.

A quick look at the crew list of a ship with a multi-national crew would clearly showthe diversity of the crew's background and their training, education, and qualifications. It is typical for a ship to have a mix of officers from Western and Eastern Europe, the Subcontinent, Asia, South America, and Africa, with each officer trained under their own MET system and qualified under their own state administration. Although the qualificationsmay come from different continents with different MET structures and curriculum, the final outcome is that they run the ship to the satisfaction of all stakeholders.

It can be debated that although the different administrations have adopted their own structure and curriculum, the individual processes guided by the standards outlined in the STCW code to meet the stipulated white list requirements, results in a similar end product, i.e. competent seafarers that meet the needs of the industry. This begs the question, why the global maritime industry does not adopt a unified curriculum to produce competent seafarers that are recognised across nations.

This is similar to that practised within aviation industry. It is true that the bulk of the commercial aircrafts belong to fewmakes and categories making it easier for the aviation industry to have a uniform global standard. However, even in the aviation industry, despite attempts to harmonise the requirements between nations, the differences in certification practices and standards from place to place serve to limit full international validity of the national qualifications [5]. On the other hand, ships are quite diverse in comparison with aircrafts and can be argued, that the existence of different standards as inevitable.

However, as per IMO STCW Code, all merchant ships require personnel to be qualified in the same seven functions to operate a vessel safely and efficiently. These functions are:

- Navigation
- Cargo handling and stowage
- Controlling the operation and care of the ship
- Marine Engineering
- Electrical, electronics and control engineering
- Maintenance and repair
- Radio communications [6].

When considering different types of ships, the only difference comes in the cargo handling function. The other six functions remainthe same for all ships immaterial of what they carry or where they trade except under special conditions such as operations in polar waters.This further strengthens the case to adopt a uniform global standard and a structure for MET.

3. Proposed Approach

The proposed approach is based on three main factors, which needs to be embraced worldwide:

- MET structure and curriculum is similar for all administrations
- The education and training is carried out in specific unit modules, which will be similar for all countries.
- Assessment methodology is similar for all administrations.

4. The Containerisation analogy

The strategy of this new approach can be compared with or analogues with the containerisation of cargo in the seventies. Before containers were introduced to carry cargo, break bulk cargo was loaded into and discharged out of cargo holds of ships using cargo nets, pallets, cranes and/or derricks. This necessarily required manual labour for storing and moving cargo, which took considerable amounts of time. On average a 20,000 GRTcargo ship of yesteryear would take anywhere between three to four weeks to completely discharge and then load a full load of cargo while in port, which could further extend in adverse weather conditions. Today a similar capacity container ship with around 1500 containers will take only two and half days or less to do the same cargo operation, with very little interruption due to the weather, unless encountering severe conditions [7].

Containerisation enabled the pre-stuffing of break bulk cargo into containers, speeding up the transfer of the cargo to the ship's location, easy pre-storage in close proximity to the ship, and quick loading of them into the ship, and stacking them in specified bays and tiers to enable easy and structured subsequent movement of the cargo. These ships normally berth in terminals with large gantry cranes, which can move cargo at a much faster rate than the previous cargo cranes and derricks. The movement of containers on land is also made easy with a combinations of gantries, shifters, stackers, trucks, and trains. The cargo was unpacked only when they reached their final destination.

The proposed MET unit module will be like containers, with a specific amount of material for the students to learn and be assessed on. The MET institutions can deliver these modules through face-to-face, distance, or blended delivery strategies. There are many ways in which seafarers can obtain their education, one being through e-learning using modern information and communications technology (ICT)assisted learning practised in many MET institutions [8] [9].

The assessment process will require approved centres or locations in strategic points across the world (similar to container ports with gantries) to carry out assessment when a seafarer wishes to appear for his assessment. These centres can utilise modern communication technology such as the internet, common web portals, and share points to enable consistency, validity and reliability [10] [11][12].

A seafarer should be able to get a module to study and appear for the assessment at any approved centre. The assessment does not have to be overseen by the same administration from where the study module was obtained from. The results can be handled by a worldwide data base similar to the port state control web portals for various Memorandum of Understanding's(MoU's).

Seafarers can collect the modules necessary for certification from various administrations and gradually complete the required assessments at the various portals. This will prepare them for the final assessment which canbe completed anywhere in the world. The certificate can be issued by the administrationconducting the orals, making sure that the candidate has collected all the necessary modules and completed the final assessment.

5. The challenges ahead

As this proposed maritime education, training, assessment, and certification system will operate under a single umbrella framework, it will evoke various reactions from parties to the STCW convention. Thus, these will need to be addressed through active dialogue and negotiations. The final outcome needs to satisfy all parties of its authenticity, transparency, and the fairness of the process, which will guarantee acceptance by the stakeholders and the competence of the end product.

The challenges for the proposed containerisation of MET requires:

- Universally accepted curriculum
- Development of modules with learning material for all threemajor forms of delivery
- Development of relevant, reliable, and authentic assessment tools
- Establishment of a protected web portal and share points for each administration

In such a context, anorganisation, such as the IAMU, needsto take the lead role in developing and championing this proposal. Further, the IMO or a nominee needs to play the role of the overseer and establish a process to audit the MET institutions/administrations who take part in education, training, and assessment of seafarers worldwide.

6. Conclusion

The containerisation of cargo was made possible by adopting specific sizes of containers; i.e. 20 foot and 40 foot containers, thus enabling the ease of stacking and transportation. Further they are handled by respective spreaders, gantries, and other transportation equipment, standards and practices, which are universal. The logistics involved in container movement and trans-shipment also follow the same global standards and procedures. Over the past 40 years containerisation of break bulk cargo completely transformed the world shipping into a very efficientphase with mega ships and hub ports.

A similar approach is proposed for MET, with key institutions functioning as learning providers and 'education / assessment hubs' in various parts of the world. Seafarers can then obtain their qualifications at their own pace, with a choice of different learning styles.

Assessments would be standardised and controlled through the protected web portals, ensuring consistent, reliable, and validated assessments that have been tried and tested to the satisfaction of the maritime community. This will ensure quality, accountability, and easy transferability across jurisdictions, with information stored on and accessed from a secure global database.

However, this will require a collective approach to be implemented and succeed. It will need an organisation such as the IAMU to lobby for such change and lead the development. It will need the administrations across the regions the willingness to share with and accommodate others. Once achieved, it will provide seafarers and their employers with a flexible and robust education, training, and certification framework.

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Internationalization to Improve Maritime Education and Training in Vietnam

Dr. Nguyen Thuy Hong Van[1], **MSc. Tran Thi Thuong**[2]

1. Ho Chi Minh City University of Transport, Vietnam, Email: Van.Nguyen@ut.edu.vn
2. Ho Chi Minh City University of Transport, Thuong.Tran@ut.edu.vn

Abstract Quality of maritime manpower has become increasingly important especially when this industry moves towards higher standards of safety, environmental impact and sustainability. Educating and training qualified manpower with appropriate level of competence for international standards is the key task for all maritime institutions. In Vietnam, the Resolution 09-NQ/TW by the National Assembly on the Ocean strategy for Vietnam towards 2020 and the Prime Minister decision on Vietnam's sea economy development plan towards 2020 highlighted that Vietnam would make all its efforts to rise the sea economic contribution to Vietnam's gross domestic product (GDP) up to 55%-60%. In addressing this development, improving the quality of maritime education and training is very important. However, Vietnam is currently in the shortage of seafarers (especially ship officers), both in quantity and quality. Although maritime industry is very internationalised and all MET institutions have internationalized programs with global learning outcomes regulated in the STCW Convention, not many Vietnamese seafarers were ranked qualified due to their weaknesses in English competency, skills and safety awareness. Only a small number is accepted by the international market. Why does the bespoken problem happen though Vietnam has already got a clear national strategy on sea economic development and Vietnamese maritime institutions have been delivering standard MET programs developed by IMO? Studies showed that internationalisation can improve quality of education. Internationalisation helps higher education institutions to provide graduates with inter-cultural and international skills, English competency, and confidence to compete in the global labour market. The aim of this paper is to discuss the current maritime manpower in Vietnam and explores how internationalization can help Vietnamese maritime institutions improve quality of MET.

Key words: internationalization, maritime, education, seafarers, manpower.

1. Introduction

Manpower is always the most important factor of all industries. This factor has become even more important in maritime when this industry aims at higher standards of safety, environment impact and sustainability. It is the maritime education and training institutions (METIs) responsibility to educate qualified human resource for maritime industry.

In dealing with the globalisation, internationalization becomes an inevitable trend of higher education institutions (HEIs) including METIs. Studies showed that internationalisation can improve quality of education [4, 7, 11, 17]. Internationalisation helps HEIs to provide graduates with inter-cultural and international skills, English competency, and confidence to compete in the global labour market.

In Vietnam, in addressing the Government's Ocean strategy and Vietnam's sea economy development plan towards 2020, the issue of how to improve the quality of maritime education and training is raised in any debate on maritime improvement [24]. The membership of Vietnam in the Trans-Pacific Strategic Economic Partnership Agreement (TPP) and in the Association of South East Asian Nations Economic Community (AEC) creates both benefits and challenges for Vietnamese HEIs [18]. Although maritime industry is internationalised in addition to the required global learning outcomes for every maritime graduate, Vietnamese METIs are still struggling on how to improve the MET quality and how to enhance students' capacity to work on board international ships.

2. Maritime education and training in Vietnam

2.1. Current maritime manpower in Vietnam

Maritime manpower in Vietnam is in shortage of both quantity and quality. Among 52.7 million Vietnamese people in working age, only about 0.085% is seafarers [10]. This proportion is very small compared to targeted GDP's contribution of up to 55%-60% from maritime industry. Also, this small proportion indicates the potential shortage of maritime workers in such an ocean country with more than 3,260 km of coastline as Vietnam.

In relation to the licensed seafarers, counting from the first pilot seafarer training course in 1956 up to now, the number of Vietnamese licensed seafarers has been around 45,000 [24]. Although the number of licensed seafarers in each position increased from 2010 to 2015, as can be seen in Table 1, many licensed seafarers have decided to settle their work on shore, or moved to other fields, besides those getting retired. Therefore, the actual Vietnamese seafarers currently work on Vietnamese and international vessels are only about 27,000, 40% of which is officers [27].

Table 1 Number of Vietnamese licensed seafarers

Position/ Rank	2010	2014	2015
Captains	2,382	3,827	4,045
Chief officers	1,772	1,593	1,782
Deck officers (3rd officers & 2nd officers)	4,285	4,797	4,833
Bosun & Seaman	13,820	14,809	13,994
Chief Engineers	1,880	3,272	3,506
Second Engineers	1,259	1,136	1,245
3rd Engineers & 4th Engineers	3,969	4,689	4,715
Fitters and Oilers	9,375	10,467	9,908
Electrical officers	83	69	125
Electricians	73	462	567
Total	**38,898**	**45,121**	**44,720**

Source: Vietnam Maritime Administration final report (2010, 2014, 2015)

Due to the increasing volume of global trade, there is a greater demand for seafarers now and in the future [20]. This demand is not only because of the expansion of the global shipping fleet but also the changing international regulations such as the working time and higher back up ratio. This paper discusses the maritime manpower in terms of educated seafarer resources (ie. the seafarers receiving maritime education and training in Vietnamese METIs), specifically those who are able to work in competitive global maritime labour market.

If the number of seafarers employed by foreign fleets is a criterion to evaluate education quality of a developing country, there is an evident for the shortage of Vietnamese seafarers in both quantity and quality. The number of Vietnamese seafarers contracted to work for foreign shipping companies is approximately 3,200 people [15, 24]. It is a very modest number compared to Vietnam's neighbour maritime countries, such as the Philippines. The Filipino sea-based workers employed by foreign companies was 401,826 people in 2014, of which 23% was officers [23]. The difference in the numbers of Vietnamese and Filipino seafarers working for foreign ships raises a big question for Vietnamese stakeholders on why this happens while both Vietnam and Philippine are ocean countries with long maritime tradition. The strict recruitment regulations of foreign companies limit the number of Vietnamese seafarers recruited. Studies show that the major reasons for this problem are the seafarers' incompetence in English language, especially Maritime English, health condition, lack of personal transferable skills, and working experiences [15, 20, 24]. Consequently, many Vietnamese seafarers are not selected by maritime recruiters [20, 24, 28].

In a survey conducted in 2013 on recruiters' satisfaction with maritime graduates' competence (both national and international recruiters), only 10.6% of recruiters were pleased or completely pleased with applicants' ability while the majority were not happy [28], as shown in Figure 1.

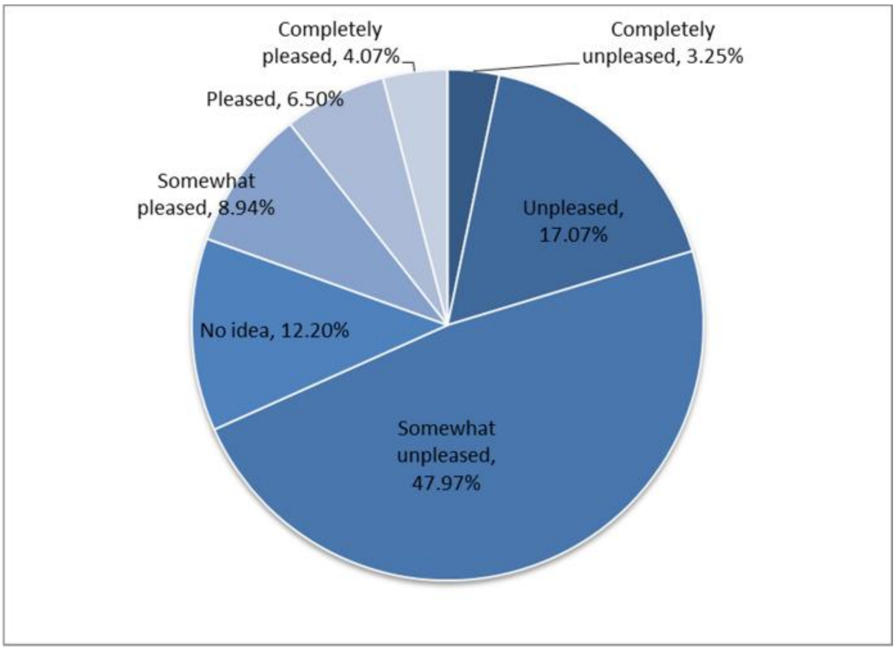

Figure 1 Distribution of recruiters' satisfaction with applicants' ability

In brief, Vietnamese seafarers are currently in shortage both in quantity and quality, especially the highly skilled ones. Improving education quality and increasing the number of well-trained seafarers are the key tasks of the Vietnamese Government, authority agencies, and METIs for the goal that maritime industry will contribute to increase Vietnam's GDP and bring other values added to social and cultural development. The next part of this paper will review the maritime education and training at Vietnamese institutions to give a picture of how a seafarer is educated and trained.

2.2. Maritime education and training institutions in Vietnam

Vietnamese seafarers are mainly educated and trained in six METIs: two universities and four colleges. All METIs have seafarer training centres [16] that provide basic safety, professional and special training. The two leading maritime universities are Vietnam Maritime University (VIMARU) in the North and Ho Chi Minh City University of Transport (UT-HCMC) in the South of Vietnam. Both of these METIs are managed by two ministries: Ministry of Education and Training (MOET) and Ministry of Transport (MOT). Therefore, the training programs of these institutions are designed to meet the regulations of International Convention on Standards of Training, Certification and Watch-keeping for seafarers (STCW 2010) and in compliance with MOET's academic requirements (Figure 2).

As can be seen in Figure 2, maritime students spend much time in their first 2 years studying foundation subjects including political and communist relating courses. Noticeably, maritime students have little sea time training, it is only a few months during their study. As a result, after graduating from universities, Bachelor degree holders are not awarded with the certificate of competency (COC) by the Vietnam Maritime Administration. They have to spend more time for sea training to become officers. In total, it takes nearly 6 years to educate a maritime officer for all ships.

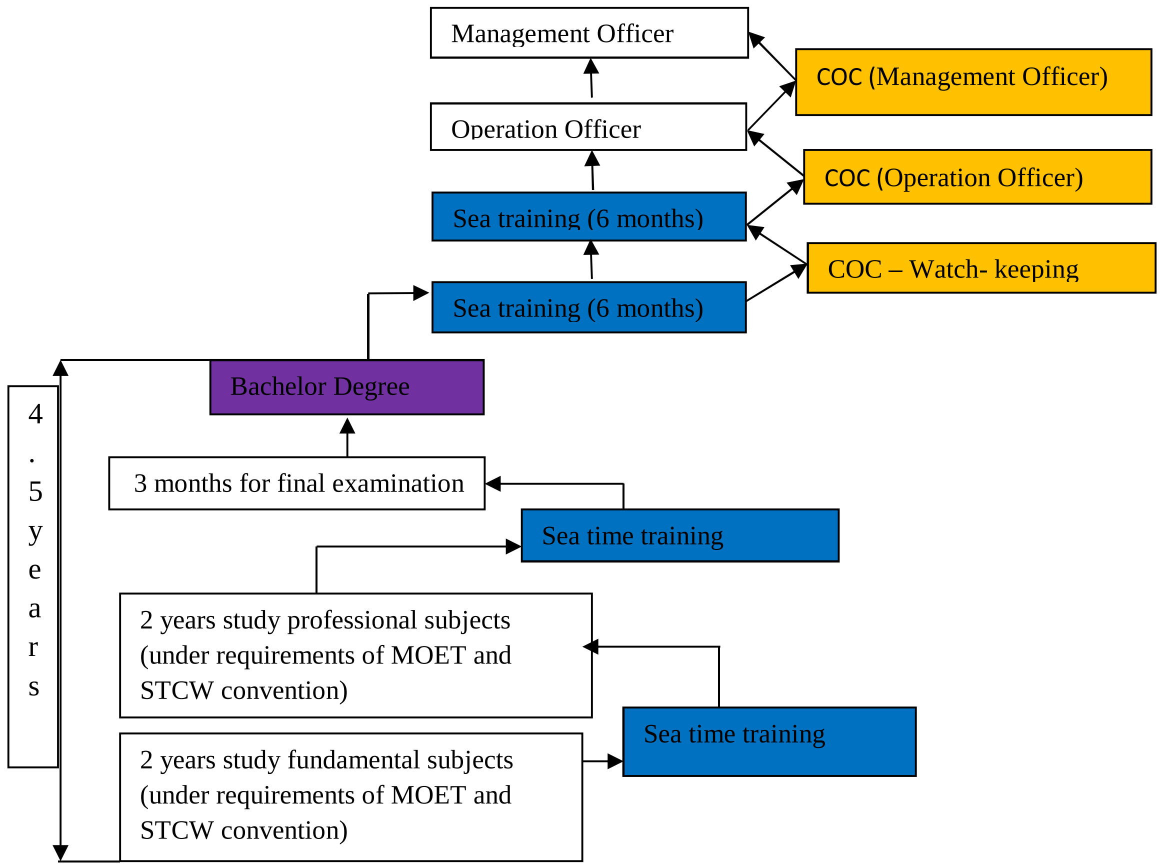

Figure 2 Maritime training program at MET universities in Vietnam

At maritime colleges, students are educated at 3 levels: primary, secondary and college. At primary level, students study 3 months for basic knowledge, 3 months internship on board ship, and another 3 months of advance training to obtain elementary certificates to work on board as ratings. It takes 2 years to complete secondary level and 3 years to complete college programs. After completing the education programs, students of college and secondary are awarded with college diploma and secondary education diploma respectively. After graduating, these students need more sea time training (normally less than 12 months) to obtain COC and become officers, as can be seen in Figure 3.

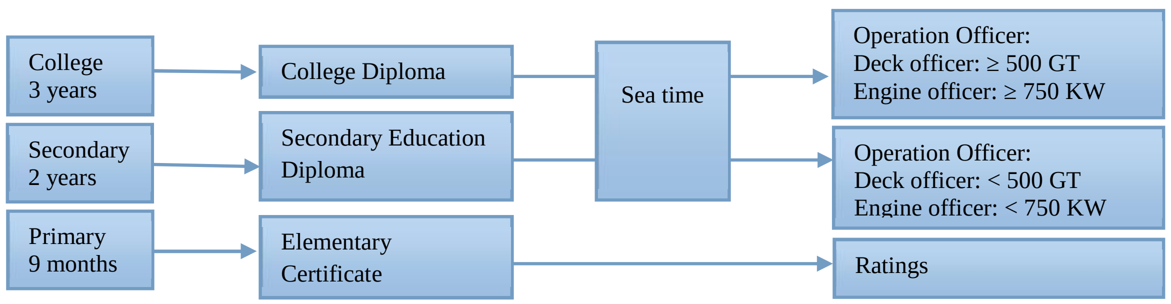

Figure 3 Training program in maritime at MET college in Vietnam

Many maritime graduates from METIs in Vietnam lack the work experience due to limited practice training [20]. In addition to the lack of sea time training and hands-on experiences, the time allocated for English and transferable skills for safety or international and intercultural skills is limited [19, 28]. A study on students with internationalisation at Ho Chi Minh City University of Transport shows that nearly three fourth of the lessons were delivered in Vietnamese language. Only 3.01 % lecturers used English in teaching [19]. Both lecturers and students are still weak in English. 80.59% of the responded students expressed their expectation of learning more English and soft skills. It can be seen that though the MET curriculum is internationalised, the course delivery methods are not internationalised. This causes challenges for graduates to compete in the global labour market. Many graduates have not been confident in applying for jobs in international maritime companies [28] because they know that they are not good at English, lack skills and good health condition, and importantly, their love to the sea is not much.

In Vietnam, METIs have limitations on institutional autonomy and have to cope with pressures from different directions, as can be seen in Figure 3 [18].

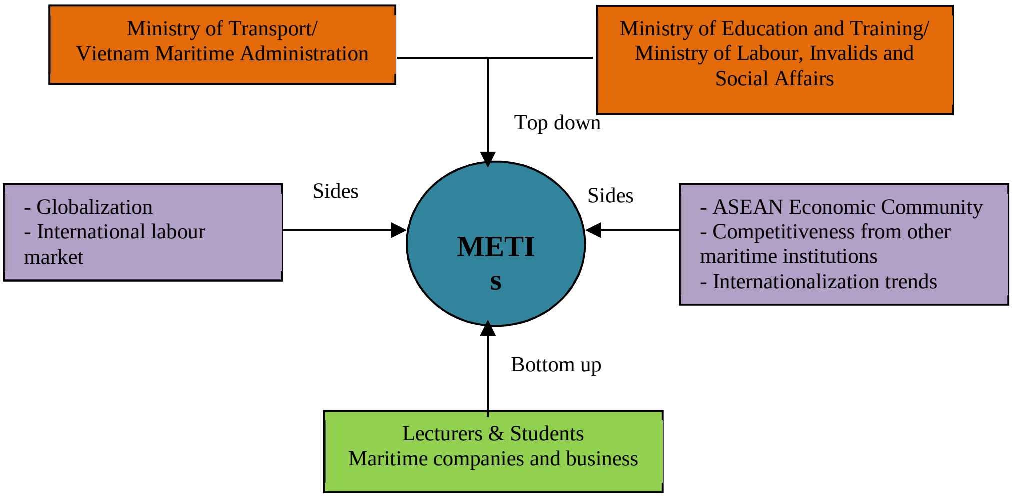

Figure 4 Different pressures on METIs in Vietnam

Figure 4 shows that Vietnamese METIs are under the authority of more than one government body: Ministry of Transport (MOT), Vietnam Maritime Administration (VMA) which belongs to MOT, Ministry of Education and Training (MOET) or Ministry of Labour, Invalids and Social Affairs (MOLISA). On one hand, MOT governs all the METIs in terms of organization, structure, and state budget while the MOET/MOLISA controls the teaching and learning activities. On the other hand, VMA controls education quality and certificates for seafarers. Besides, tuition fee framework which controls the budget of the institutions, is set by the ministries. As a result, the institutions do not have full autonomy in deciding tuition fees and the number of students recruited. At the same time, the university suffers from bottom up pressures including students' expectation to receive high-quality teaching and learning with opportunities of employability in international labour markets; the lecturers who ask for higher salary and better working conditions; and the employers who want to recruit well qualified workers with good skills for employability.

In addition, the side pressures are from international trends, especially when Vietnam becomes a member of AEC and TPP. This integration brings both benefits and challenges for Vietnamese education. Fierce competition in ranking and reputation among maritime institutions are foreseen while Vietnamese METIs are still short of qualified academic staff, innovations in curriculum design, teaching and learning activities, and limited infrastructure [5, 18, 24].

Being aware of the shortage of seafarers in quantity and quality, Vietnamese government and METIs have made considerable efforts to improve the current situation. The Resolution 09-NQ/TW by the National Assembly on the Ocean strategy for Vietnam towards 2020 and the Prime Minister decision on Vietnam's sea economy development plan towards 2020 highlighted that Vietnam would make all its efforts to rise the sea economic contribution to Vietnam's gross domestic product (GDP) up to 55%-60%. In response to these targets, METIs have some solutions to improve the quality and quantity of the students. Enhancement of the partnership between institutions and industries and international cooperation are highlighting points. Some joint ventures between Vietnamese and international METIs were established and operated effectively. The best practices are the Center for Training and

Improvement of Maritime Professions (VINIC) between VIMARU and the Nippon Steel Company; and the Human Resource Education and Development (UT-STC) between UT-HCMC and the STC Group-the Netherlands. These centres are the incubating innovation in teaching that helps to improve training quality, increasing incoming and outgoing students and lecturers, especially providing highly skilled seafarers for domestic and international shipping companies.

Vietnamese Government has issued several legal documents creating opportunities for HEIs to be innovative and internationalized. In order to deal with these changes, internationalisation of higher education is an effective way to improve the institutional educational quality and competition.

3. Internationalization to improve MET in Vietnam

3.1. What is internationalization?

Internationalisation is not a new concept and it has become popular in education sector since the early eighties [13]. Internationalization is defined as "the process of integrating an international, intercultural or global dimension into the purpose, functions or delivery of higher education" [11]. In other words, internationalisation is a way to enhance the quality of education, research and services to society [6]. Moreover, this process incorporates international, intercultural and global dimensions into the content of the curriculum as well as the learning outcomes, assessment tasks, teaching methods and support services of a programme of study [14]. However, different HEIs use different definitions which support their own overall strategic vision and mission [22].

There are two dimensions of internationalization: 'internationalization at home' and 'internationalization abroad' [9, 12]. The former mainly focuses on curriculum, and the teaching and learning process while the latter is transnational education or cross border delivery of higher education in response to the increasing competition in higher education [8]. In higher education, internationalization is programs or policies that governments and HEIs use to meet the trend of globalization [1].

3.2. Why should Vietnamese METIs internationalize?

There have been various reasons for internationalisation. First of all, the challenges of globalization with an increasingly integrated world economy, the rise of English as the dominant language, and the ever-increasing development of modern technology have influenced higher education and become over the control of HEIs [3]. The globalization process has substantially influenced higher education, affecting the institutional reputation, quality, income, and survival [7, 9]. Internationalization has even become a proxy indicator for METIs because of the internationalised characteristics of the maritime industry.

Secondly, the global labor market requires graduates having international knowledge, foreign language and intercultural skills [21]. METIs have been challenged to deal with providing well-qualified maritime human resources with both professional knowledge and skills. In addition, students' expectation of what to learn, how to learn, and when to learn have been changed together with the development of high technology.

Thirdly, internationalisation strengthens linkage between METIs and maritime industry all over the world. Under the increasing pressure of globalization in politics, economics, socio-cultural, and education, internationalization is considered a key driver to improve the institutional status to deal with globalization. Internationalization supports governments and HEIs to strengthen international partnerships towards prestige and quality improvement as well as other added values [9]. This partnership will enhance the employability for Vietnamese maritime graduates, hence, increase the number of seafarers for the industry.

Finally, more engagement with the world is also an essential way to adding value to the institution, including to its quality, revenue, prestige, and competitiveness [21]. Via international cooperation such as student exchanges, international projects, and transnational education delivery, the universities have gained added values that can support them in two international dimensions: competition and cooperation [2,8].

4. Recommendations

Internationalisation can support Vietnamese METIs to improve quality and quantity and so is the employability ratio, institutional competitiveness, income generation, and other value added.

Recommendations to METIs

First of all, in the prevailing environment of fierce competition for outstanding staff, students and resources, strategic planning is important as Vietnamese METIs need to develop internationalisation strategies which identify their position, needs, expectation, future focus, decisions, and actions. However, internationalisation is not an 'one size fits all'[13] so each institution should make a careful international assessment on its internationalisation.

Secondly, improving administrative and management system is necessary. Effective education management is the core issue. A transparent system which includes more autonomy, accountability, better quality assurance and policy to attract qualified staff and more students. Maritime is very internationalised because of the standard model courses issued by the International Maritime Organization (IMO) and regulated in the STCW Convention that all METIs must follow. In other words, METIs have already got global learning outcomes. This is a great advantage that never happens in other sectors. If this advantage is fully taken, it will facilitate METIs with lecturer and student mobility, classroom diversity, intercultural development, language acquisition, and global citizenship development.

Thirdly, the curriculum should be redesigned to meet the international standards of IMO. METIs should reform the existing educational system which proves to be unable to meet the demand for highly skilled seafarers. A work-based learning model can be applied in Vietnamese METIs so that students can experience the real working environment. They also have chance to improve their awareness of safety issues on board ship. Students should be provided with more soft skills especially international and intercultural skills. Lack of these skills may lead to the large number of seafarers leaving companies every year.

The ocean is of all people in the world and issues of ocean like safety, security and environmental protection are the concern of the world. Students should be educated with not only professional knowledge but also skills and ethical behaviour. A working culture of Vietnamese seafarers, such as good disciplines or loyalty, should be created. This culture will position Vietnamese maritime manpower in the international labour market.

Next, Vietnamese METIs should increase lecturer and student mobility to create a more international teaching and learning environment. In this environment, English is used more often and there are more English teaching materials and textbooks. This helps to improve English competence of both lecturers and students. In addition, international teaching and learning environment help students to learn intercultural skills. They will be prepared for an internationally social life in their future career.

More practice and sea time training for students are needed. The traditional teaching methodology should be changed into more active. This improvement can be made when METIs improve the institution-institution partnerships to improve teaching pedagogy of maritime lecturers. Active teaching methods can be shared among METIs in the world. Thus, soft skills can be incorporated with active teaching to produce more effective lessons.

In order to increase the number of seafarers, METIs should be more active in promotion campaigns to publicize the advantages of maritime works and lives. Seafarers should be the jobs that deserve more respects from society. University-industry partnerships should be strengthened and developed in order to get more internship places for students. Moreover, the partnership helps to create jobs which attract more graduates and seafarers to apply for, hence maritime manpower retention can be improved.

Last but not least, METIs needs more investment in technology and modern facilities for teaching and learning activities. It is understood that good maritime education is costly. Besides the state budget, dynamic international activities can increase revenue for institutions via grants or international projects. In response to the government's direction, METIs should be more active in privatisation or 'socialisation' of MET and research activities in order to create more revenue for effective operation. Such models as joint ventures or self-funding training centres can become incubators for Vietnamese METIs in internationalisation.

Recommendations to the Government authorities

In relation to the policies, the government should develop a better welfare policy for maritime jobs which are particularly characteristic. Also, there should be policies to encourage ship owners to be responsible for crew training, skills development for seafarers and potential graduates. A real Vietnam maritime labour union should be set up, not just in name but in effective action, to protect seafarers' rights and support them in any flag ship countries.

The government should create favourable conditions for crew export. Specifically, joint venture companies and international maritime training centres should be allowed to export seafarers. As the joint venture and international maritime companies have good relationship with international shipping companies and international maritime associations, they are able to find more recruiters and do better manning. Hence, the seafarers have more chance to work on board foreign shipping.

5. Conclusions

Maritime industry with the increasing growth of the world fleet is in high demand for highly skilled seafarers. Vietnamese sea economy is aimed to contribute more for the development of the country. This goal requires Vietnamese METIs to improve education and training quality and increase the number of maritime students and seafarers. Internationalisation and appropriate internationalisation strategies will improve quality of maritime teaching and learning, and produce qualified and competent seafarers.

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Standardization of maritime education as aim, result and means of its quality improvement

Pro. DSc., Irina Makashina [(1)] and Pro. DSc., Alexander Fayvisovich [(2)] and Ass. Pro. Irina Truschenko [(3)]

(1) Admiral Ushakov Maritime State University, Novorossiysk, Russia, e-mail: irmak@inbox.ru;
(2) Admiral Ushakov Maritime State University, Novorossiysk, Russia, e-mail: faivisovich@nsma.ru
(3) Admiral Ushakov Maritime State University, Novorossiysk, Russia, e-mail: irtru@mail.ru

Abstract. Standardization of maritime education is considered by all the parties concerned as a way of search for a workable mechanism of educational activities aimed at training of highly skilled maritime professionals who meet the national and the Conventional requirements and comply with the requirements of the maritime industry.

The paper shows the contradiction between the need for standardization of maritime education and the tendency of transition to the formal procedure for evaluation of education results. The paper describes the development of mechanisms for comparing the expected results with the real ones, which in turn, allow to assess the quality and effectiveness of the learning process, and everything that is used in a process of sea specialist training.

The issues related to the technological process of the maritime education standardization are considered, and methods for determining the necessary and sufficient actions for their decision are offered. It is proved that a change in standards of the maritime education is determined by both external and internal factors and their role is shown.

On the basis on the philosophical and educational concepts four components of marine education are considered: the value, the system, the process and the result. It is proved that it is impossible to consider the issue of standardization of maritime education only as the achieved level of knowledge and skills. It is substantiated that the outlook of a person defines the further vector of its development and therefore to its formation and development adequate attention should be given.

It is concluded that standardization of maritime education must be tough on the one hand, to ensure compliance with the requirements of the International Convention STCW 1978/95 and amendments adopted at the Manila Conference, 2010 [2], and flexible enough, on the other, to enable the creation and contribute to the search for new forms, methods and means of training and education of future marine specialists.

Keywords: standardization, maritime education, Conventional requirements, learning process, quality.

1. Introduction

Different researchers considering the issues of vocational education quality, determine in diverse ways thecriteria, fit to evaluate this objectively. At the same time almost all the participants of Maritime education consider standardization as a meansof finding workable mechanism of educational activities. The main goal of this mechanism is to prepare highly qualified marine specialist meeting the national [3] and conventional requirements [2] and corresponding to up-to-date level of the Maritime industry development.

The analysis of current practice of standardization of Maritime education allowedto highlight the contradiction between the need of standardization of Maritime education and the tendency to mechanical, formal assessment of its results. The resolution of this contradiction will contribute to improving the quality of marine specialist's training.

When speaking about the standard, quality is always meant. From a philosophical point of view quality is the category, showing a substantial certainty of things and phenomena of the real world. Quality is usually understood as the objective characteristics of the objects that appear in the aggregate of their properties. Under the “2010 Manila Amendments” to the Standards of Training, Certification and Watchkeeping for Seafarers (STCW) Convention and Code,Quality Standard System (QSS) requirements require “in accordance with the provisions of section A-I/8 of the STCW Code, all training, assessment of competence, certification, including medical certification, endorsement and revalidation activities carried out by non-governmental agencies or entities under its authority are continuously monitored through a quality standards system to ensure achievement of defined objectives, including those concerning the qualifications and experience of instructors and assessors [2].

It is common understanding, that the quality of education of specialists is determined by the quality of educational programs and content; quality of potential of teaching personnel; quality of potential of the applicants; quality of educational technologies; quality of resource provision (information, educational and logistical, etc.).

The logic of the proposed paper is constructedon the basis of a philosophical and educational concept according to which four aspects of the standardization of maritime education are considered: aim, system, process and result.

2. Standardization of maritime education as anaim

We believe it is necessary to note that we are talking primarily about the educational space. This space is the aggregate of the conditions ensuring the existence of education. The educational environment produces nothing, because it is not a mechanism, it provides the conditions for the functioning of the mechanism of education [7]. One of these conditions is to standardize the quality of education.

Standardization means the process of implementing and developing standards. Standardization of education, including themarine one, involves the implementation of procedures for the general standardization and dictates the definition of objectives, competencies, learning outcomes, programs, materials, assessments at the input, while process and on results of learning. Also requirements for the level of training of the teaching staff and the conditions of the educational process should be defined.

The standardization of Maritime education first of all is determined by the STCW Code “Each Party shall ensure that the education and training objectives and related standards of competence to be achieved are clearly defined and that the levels of knowledge, understanding and skills appropriate to the examinations and assessments required under the Convention are identified. The objectives and related quality standards may be specified separately for different courses and training programs and shall cover the administration of the certification system”. Further it stipulates that this evaluation shall include all changes to national regulations and procedures in compliance with the amendments to the Convention and STCW Code…” [2]. We fully agree with this statement but we believe it is also important to emphasize that any standard, even the highest one, shouldn’t be considered as final one. Society in general and maritime industryin particular, is in constant development. And the emergence of new technologies dictates the need for standards review. The way out from this situation we see in an advanced training. The most important, in our opinion, is the training of specialist, havingcompetences according to the requirements, and at the same timeready to continuingself-development. It is thetrait of a personality of a specialist which will help him to remain in demand on labour market under any circumstances.The aim of standardization of Maritime education is primarily the creation of a unified educational space and the continuity of basic educational programs at all levels of education: elementary, secondary, higher and postgraduate professional education.

3. Standardization of maritime education as a system

Certainly, the standardization is systemic phenomenon, and like any system its content presumes presence of many components and links, both direct and reverse, ensuring the functioning of this system. This system is influenced by both external and internal factors.

External factors cannot be controlled and the institution is unable to change them, but considering of trends and risk assessment, as a rule, brings positive results. These factors include: socio-demographic; geopolitical, scientific and technical; economic; infrastructure development of the industry and of labour market, requirements of STCW, IMO, ITF and etc.

As to internal factors, usually they are controlled by management of institutions. These include: personality of the heads of an institution; the institution's affiliates network; financial management system; the level of training of professor and lecturers staff; specialty and education; pricing policies; availability and completeness of usage of information resources; participation of employers in educational process (e.g. Board of Trustees), the material-technical base; stimulators, base of practices, etc.

External factors contribute to the emergence and development of the system, the internal reflecting nature of a particular educational institution and Merchant industry are generated by separate elements constituting the system, inherent only tocertain industry, in our case, the industry of merchant shipping. Their influence on the standardization as the system causes its operation and effectiveness.

The development of the standardization as a system is determined by the purpose and information resources. While attaining the aim the system accepts any useful input information, which effects the internal structure of the system of Maritime education, its quality and provides the opportunity to initiate and support the best path of its development. Properties of openness, flexibility and mobility of standardization as the system is ensured with:

- structure and content of professional training, allowing the possibility of changes in the composition and content of education;
- continuous modernization of means and technologies of training;
- openness of professionally oriented educational environment, ensuringformation of positive motivation and development of cognitive activity of trainees.

On the one hand, this system is conservative and inert, as it is built on traditions, and on the other it needs to be optimized, i.e., tuned on the development and changes taking place in the constantly evolving Maritime industry. The design and control leads the system to a stable, ordered state, and innovation, educational experiments suggest the presence of instability, i.e., the state preceding the transition to a qualitatively new level. The innovation factor (creativity etc.) is significant fluctuation in the process of development of the system [5].

The system of education, as well as the culture, is significantly influenced by the context in which it arises and develops. Russian education came from the Soviet Union, when the social circle was limited to the socialist countries, and in fact by borders of the USSR. Apparently, this condition should first be taken into account while considering the Russian education.

A distinctive feature of the Soviet, and subsequently the Russian higher education is the presence in all educational programs of an essential component of fundamental knowledge, which do not exist in European education, and in education in majority of other countries of the world. This fact shouldn't be considered as an advantage or a disadvantage.

Just this should be stated and borne in mind when analyzing the structure of the curriculum. However, it should be noted that despite the above essential difference, the Soviet experts, were highly valued on the world labor market, both in technical and in humanitarian areas, and most probablyfor this certain reason. It is clear that including additional subjects in educational process, for strengthening the fundamental component, could not fail to influence the duration of training. If one compares the same

educational program, in Russia the duration of training is 1-2 years longer. The same thing takes place in the training of sea transport specialists: navigators, engineers and electricians.
The curricula of educational programs of marine specialists training must meet both the requirements of national standards and international (STCW 78/95 with amendments 2010). Often there is a discrepancy in the titles of disciplines and in hours. As a rule, the national standard covers the international on hours. Duration of training of marine specialists with higher education is at least 5 years.

In Russian Maritime universities there is secondary vocational education, the duration of which is 2 years and 10 months, on completing which a young specialist can also take a position of the 3^{d} assistant or mechanics, but for a career and the appointment for a position of a Chief Engineer, Mate or Master, he will have to go back to maritime institution and complete the educational process to the level of a specialist (2,5 years more).Therefore, requirements to the structure of basic educational programs, conditions of realization of basic educational programs and the results of their development are the important issues of the standardization as the system.

We consider standardization of the quality of Maritime education on three levels. The first is the level of the educational institution.The ongoing transformations in the maritime education involve the entire range of activities of any educational institution: organizational, managerial, economic, legal, technological and content aspects.In this context, the need for improving the quality of Maritime education, in particular, by creating optimal conditions providing a set of purposefully created learning opportunities to meet the educational needs of students is actualized.

The task of improving the quality of education is becoming a priority. Assessment of the quality of Maritime education in connection with standards is an integral part of the work of educational institutions in the field of quality management. And that is why, the criteria chosen by a specific educational institution, will depend on the system of work of the institution based on its mission, goals and objectives. As standards Conventional and national (Federal state educational standards) requirements to the quality of education are considered [2; 3].

The importance of the following fact is evident. The quality assurance activities of an educational institution largely depend on the level of quality management, which refers not only to a system of targeted management actions to create optimal conditions for the functioning of the organization, but also the image of the organization, which is based not only on the quality of services rendered, but as well asthe reputation of the University in the scientific world.

While understanding the importance of the issues mentioned above, as an example we are consideringissues, connected with sailing practice. They are:

- logistical issues with sending and arrival of the cadets;
- the reluctance of many companies to take 1-2 people (because of a mismatch in the industrial task with the schedule of educational process);
- lack of places for the cadets sailing practice;
- the reluctance of companies to take students of first/second-year (2-3), etc.

These and other issues in organizing sailing practices significantly affect the organization of training cadets on the shore, which, in turn, affects changes to the schedule of the educational process.

The best solution to all these problems is the presence at the University its ownbase for sailingpractice in the form of training vessel. However, solving problems of practice the University takes on new challenges with the maintenance and operation of the vessel.

The second level of standardization of the quality of Maritime education is the level of participants of the educational space, i.e. teachers, students, employers, parents, etc. The educational space of the second level of educational institution is formed on such characteristics as maintenance of knowledge, skills development processes, ability to act and ensure the presentation of content, methods of action, means of action, ensuring the formation and development of the whole composition of features of an object of education and application of this composition of conditions for accomplishing educational activities. As criteria of quality assessment of participants the following can be distinguished: the motivation of people both in the choice of educational institution, and in the process of study, and their (students) social activity.

Development of the educational space involves improvement of conditions for teaching, training of future specialists to perform professional activities, i.e. improvement of the content of education, its forms, methods, technologies, relations with industrial enterprises, financing, welfare, health, conditions for the selection of applicants, etc. By changing these conditions, society changes educational space [7]. The role of standardization is difficult to overestimate. Namely, standardization helps to coordinate actions for the development of educational space, to define the vector of its development, which meets the requirements of education and industry, and society as a whole.

Ensuring the presentation of content, methods of action and means of actions, ensuring the formation and development of the qualities of a student, requires attention to all components of content of the education. As an example, we consider foreign language training of future marine specialists.

This issue is a constant object of attention of all Russian universities, preparing marine specialists. In a great measure – it is an internal problem of the University, which can be solved by "immersing" a student in the language environment. And the opportunities provided by the national educational standard are sufficient for the successful solution of this matter, in which, the potential employers are interested in. It should be noted that there are companies that take specific actions, including additional funding for the successful solution of this question. But it often turns out that the level of English language skills as learning outcome is less than desirable.

For many years there have been numerous efforts undertaken to standardize the language used for communication at sea between ships in different situations, between ships and VTS shore stations or between ships and helicopters in case of rescue operations. In this connection, under the IMO Maritime Safety Committee's decision, the Standard Marine Navigational Vocabulary was developed. It was adopted in 1977 and after being used in nautical colleges and maritime universities it was revised and amended for several times. Some years later the Standard Marine Navigational Vocabulary was updated and in result, the Standard Marine Communication Phrases (SMCP) appeared, which were adopted in 2001, and published in 2002, and its inclusion in STCW makes it a mandatory part of the MET curriculum in all of the current 156 ratifying States. The renewed version is widely used both in maritime education and training institutions ashore and on board ships. Moreover, in recent years several Model Courses were developed and approved by IMO and already implemented in curricula of different Maritime institutions.The Model Course 3.17 for Maritime English assists the Maritime English teachers and lecturers in organizing and introducing new training courses or enhancing, updating or supplementing the existing training materials and fulfills the competence regarding Maritime English contained in STCW 1995 [10]. But teachers of English Department (not English speaking countries), who teach Maritime English continue to encounter some difficulties in the process of teaching and learning Maritime English. And it isn't connected with teachers' skill, which is usually quite high, but other different factors impact on the learning outcome. It isn't a problem of one maritime institute. The great contribution in solving this problem belongs to international projects, which are developed and implemented. Majority of them aims at promoting the Maritime English competence of the people working in various maritime professions in different parts of the world so the intended users include those actually working at sea as well as those studying and working in a wide range of sea-related areas.

Another important suggestion, often neglected, is that the experience of Maritime English teachers should be updated. It is essential for the Maritime English teachers to have on board training to provide the students good knowledge of maritime education. It is also essential to have enough teaching periods for Maritime English to obtain more competence in Maritime English in the long term [4; 6; 11].

The next important point to be recommended is that it is necessary to exchange Maritime English teachers between countries to share their ideas and experiences of teaching Maritime English to each other. In this connection AUMSU offered Innovative Project on lecturers exchange in frame of BSAMI (Black Sea Association of Maritime Institutions). This Project has already been implemented and has good results, but its extension could considerably enrich opportunities we have now [8; 9; 11].

Prospective seafarers entering the Merchant Marine or the Navy are highly motivated to communicate across language and cultural borders and several of the partner institutions have already found that interest in language training is spontaneous. Seafarers are, of course, required to conduct their professional tasks in English, the lingua franca of the sea. The acquisition of Maritime English is thus of key importance in MET and naval academies and those cadets who hope to succeed at high level (officers, captains, commanders) must master English in the context of their duties. For many seafarers learning English to the high level demanded by the Merchant Marine and Navy can be a daunting task. In addition, today's multi-ethnic, multilingual crews provoke cultural and linguistic barriers, complicating and hindering communication. In both a professional and social context on board the seafarer needs to be able to display strong linguistic skills [6; 9; 11].

The third level of standardization of quality is the level of external assessment (IMO, State, society, employers).The Russian standards specify the requirements to graduate as a result of education, but also to the quality of education and to the educational process itself.
At this level, the criteria can be:

- the demand for young specialists in internal and external labour market;
- conformity of material-technical base with licensing requirements of Ministry of education, Ministry of Transport, the International Maritime organization;
- the degree of access of all participants to use information resources of the University.

4. Standardization of maritime education as a process

When considering the standardization of the quality of Maritime education as a process, we rely primarily on the understanding the essence of the concept of "process", i.e. natural, consecutive change of phenomena. And in this case the result of the standardization process depends largely on the target and conditions in which it occurs. The need forelaborating mechanism of comparing expected results with real ones, is obvious. The creation of such mechanism will allow judge the quality and effectiveness of the educational process, and all that is used in the process of training marine specialists.

Standardization presumes performance of necessary comparisons of a specific model with a standard by means of various measurements, assessments, and adjustments. The standard in this case acts as the model. The standard establishes a set of rules, regulations, requirements to object of standardization, and should be approved by the competent authorities.

The standardization process also presumes the monitoring and measuring of actions, based on international and national standards, including a number of standards: objectives, competencies, outcomes, level of teacher skills and learning environment etc.

Also there many issues associated with the technology of the process of standardization of Maritime education. These include problems relating to:

- manageability of the educational process;
- ability to change due to the constantly increasing demands from industry and educational standards;
- inclusion of employers in the process and standards development, and in educational process;
- readiness and ability to innovate;
- the need to continuous update of the material and technical base;
- the opportunity of free access to information to all participants concerned in a result of the process of education, etc.

5. Standardization of maritime education as result and means

Relevant and not solved yet is the problem of the use of quality assessment techniques, including Maritime education. Mastering of different competences becomes the aim, and the result of the learning process, managing achievement of which in the educational process determines its effectiveness, i.e. its quality. At the same time, we would like to note that it is impossible to reduce the problem of standardization of the Maritime education only to the level of knowledge, abilities and skills, formed atgraduates.

It is the worldview of an individual that determines the further vector of his development and so questions of its formation and development should be given enough attention. In this regard, we should agree with standards of learning outcome. They include:

a) personal (attitude to knowledge) – determines the social and cultural identification of the young specialist personality, his vital meanings, worldview and abilities to further self-development;
b) interdisciplinary (knowledge obtaining) –relates to self-regulation and self-control in academic and professional activities, social, communicative skills and cognitive abilities;
c) subject (possession of knowledge) – belongs to the social (social and cultural, cross-cultural) professional skills, and also communicative competences.

Criteria of the result quality evaluation can be the following:

- the stability of results over time;
- the degree of conformity of educational services to consumers' inquiry;
- educational achievement of students;
- high demand for graduates by employers etc.

All of the proposed criteria of evaluation, goals, process and result, from our point of view are very easy to handle, that allow significantly reduce the time spent on quality assessment. Such information is always generated in any educational institution in the framework of the reporting in the process of interim and final assessment, i.e. it is the typical and makes the process of data collection not difficult and at the same time the most accurate.

6. Conclusion

It is well-known that standardization allows to create a unified educational space and to provide a uniform level of education to students in different countries and universities.

The International Convention STCW 1978/95 and amendments adopted at the Manila Conference, 2010 provided guidelines on what the seafarer student should know and demonstrate before being awarded with the Certificate of Competence which is considered as the basis for their recruitments and promotions. At the same time Maritime Universities must meet National Standards of Education, which differ in some positions from the Conventional ones (e.g. period of training, assessment process, etc.). In spite of the fact that National Maritime Regulators interpret the STCW Code requirements and develop the seafarer training curriculum to assure that students can demonstrate the attainment of the minimum standards of competence, there is often a risk of individual interpretation which can result in lack of coincidence with the Conventional requirements.

The problems of standardization of professional Maritime education and evaluation of its quality do not have a unique solution. Usually, different approaches to the choice of criteria for assessing the quality of any educational system, marine, in particular, rely on different understanding of the quality of education – from traditional interpretations of it as educational or as a result of the quality of the educational process conditions to the quality of control processes. In order to achieve aimed results all developers of standards should correlate their criteria both with the STCW Code requirements and National Standards (which are certainly tough) and the dynamics of industry development.

At the same time current focus should be also made on issue of teaching, learning and assessment process which is widely vary on a global level. Criteria chosen for assessment these activities should be flexible enough that will allow creativity and will contribute to the search for new forms, methods and means of training and education of future seafarers.

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Session 1B

ONBOARD TRAINING, SIMULATORS

Study on the Training Effect of Sail Training

Professor Yoshiaki KUNIEDA[1], Captain Naoya NAKAMURA[2] and Professor Koji MURAI[3]

1. Tokyo University of Marine Science and Technology, ykunie0@kaiyodai.ac.jp
2-1-6 Etchujima, koto-ku, Tokyo, 135-8533, Japan
2. National Institute for Sea Training
3. Kobe University

Abstract It is thought that not only the sail training does the improvement in the knowledge and skills of vessel operation have an effect, but also it has an effect in the improvement in emotional competence, such as leadership, self-control, and communications skills. We created the questionnaire for the self-assessment of a trainee's feelings and actions and investigated the emotional competence of the trainee using the results. An investigation was conducted before and after sailing vessel and motor ship trainings on trainees at a university. The investigation was also performed on the trainees of a technical college before and after motor ship training. The questionnaire consists 80 items, including nine questions measuring the competence of eight kinds of emotions such as "Self-control." As a result of the investigation, improvement regarding leadership is remarkable among the eight items of competence, and the significant difference was shown by $p < 0.01$ as a result of the *t*-test. Although six items, except "Thinking of others," were improving, a predominant difference was not found. In contrast, in motor ship training, which boarded continuingly, although leadership improved, it is $p > 0.05$, and the significant difference was not accepted. Moreover, although six items, except "Thinking of others," were improving, predominant differences were not found. Moreover, in motor ship training, seven items for the technical college trainees who boarded simultaneously with the university trainees, except "Thinking of others," were improving. The significant difference was shown by four items, which are leadership, situation awareness, ability to be active, and the ability to manage stress. Furthermore, in the investigation of sailing vessel training, the improvement in competence was investigated according to each group. For the group that had an improvement in the competence of six groups, a significant difference was shown by four items.

The following can be hypothesized based on these results:
(1) The effect of sailing vessel training is greater than motor ship training. However, since the motor ship training followed the sailing vessel training, motor ship training may have had little room for improvement.
(2) In the same motor ship training, the technical college students (aged 20-21 years) had a greater improvement in capability than the university students (aged 22 years and over).
(3) The improvement of competence was not found in "Thinking of others" in the sailing vessel training or the motor ship training. And also the improvement of competence was not found in "Thinking of others" in the university students and the technical college students. It is guessed that it is more severely self-assessed when the competence of "Thinking of others" improves.
(4) There is a clear difference in the improvement in of the competence of a group.

Keywords: Sailing vessel training, motor ship training, university student, technical college student, training effect, significant difference

1. Introduction

It is thought that not only an improvement in the knowledge and skill of vessel operation has an effect, but also the sail training has an effect on the improvement in emotional competence such as leadership, self-control, and communications skills. We investigated the trainee's Emotional Intelligence Quotient (EQ) competency and showed that seven items of the EQ competency, such as "Leadership," were improved by the sailing vessel training [1]. Moreover, it was shown that sailing vessel training improves creativity, and qualitative analyses of trainee's essays were also performed [2, 3]. Lastly, we investigated the before and after sailing vessel and motor ship trainings of the university trainees and trainees of the technical college.

2. Investigating Emotional Competence

The sail training vessel Kaiwo Maru accepted 64 trainees in April 2015 from three schools: Tokyo University of Marine Science and Technology, Kobe University, and the Marine Technical College, and it carried out the training voyage on ocean-going voyage. From Tokyo University of Marine Science and Technology and Kobe University, 35 trainees performed the training voyage, which included an ocean-going voyage on the motor training ship Ginga Maru during July 2015. We conducted a self-assessment questionnaire survey about their emotional competence with the 35 trainees who performed motor ship training on Ginga Maru and 64 trainees who performed sailing vessel training on Kaiwo Maru. Moreover, in motor ship training during July, the same self-assessment in was carried out 43 Technical College trainees who had trained simultaneously. The composition of the trainees for investigation is shown in Table 1.

Table 1 Composition of the trainees for investigation

	Tokyo University of Marine Science and Technology	Kobe University	Marine Technical College	Technical College
Sailing vessel training	18(1)	17(0)	29(3)	-
Motor ship training	18(1)	17(0)	-	43(8)

( ): The number of female

The questionnaire consisted of 80 items, including nine questions that measured the competence of the following eight kinds of emotions: (1) Self-control, (2) Leadership, (3) Situation awareness, (4) Communication, (5) Ability to be active, (6) Ability to manage stress, (7) Thinking of others, (8) Teamwork. The respondents rated their answers on a 4-points scale where 4 = It is well applied, 3 = It is applied a little, 2 = It is not applied a little, 1 = It is not applied at all.

3. Result and Discussion

3.1 Comparison of sailing vessel training with motor ship training

Fig. 1 shows the results of the self-assessment survey conducted before and after the sailing vessel trainings. Although there is almost no change in most of the competences before and after each voyage, leadership has a difference of 3.39 points on an average. The result of the *t*-test was $p < 0.01$; it was a significant difference. On the contrary, the result of the self-assessment survey performed before and after the motor ship training, which continued after the sailing vessel training, is shown in Fig. 2.

Although it is almost the same as the result of sailing vessel training and leadership was going up slightly, they were $p > 0.05$ and a result without a significant difference in the *t*-test. Moreover, although both sailing vessel training and motor ship training were improving seven items except “Thinking of others,” a significant difference was not seen anywhere other than in the “Leadership” in the sailing vessel training.

While more detailed investigation is required, we suppose the cause for the improvement in relation to “Leadership” and sailing vessel training is that trainees naturally obtain these competences by the necessity of leadership at the time of sail handling command and the necessity of cooperation and leadership at the time of setting sail and making fast sail. However, in motor ship training, instructions for leadership and teamwork carried out. As the result, though improvement in in the related competences is found, they have not reached a significant difference.

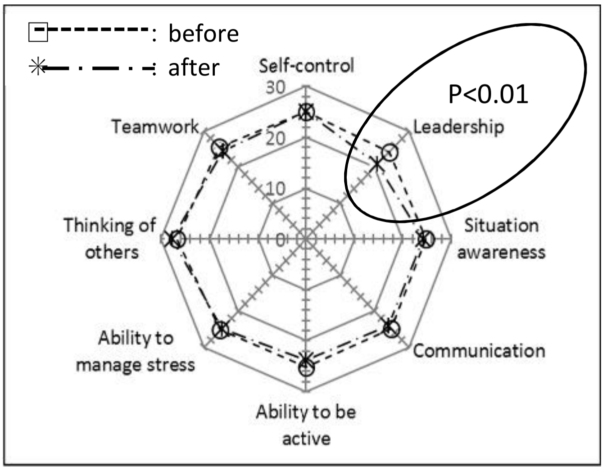

Figure 1 Comparing competences before and after sailing vessel training

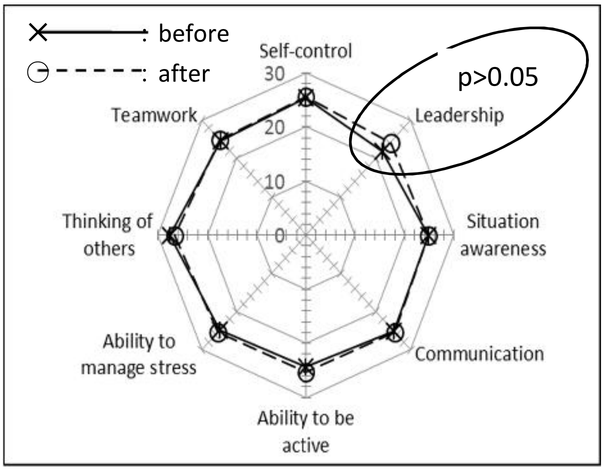

Figure 2 Comparing competences before and after motor ship training

Fig. 3 and Fig. 4 show changes in “Ability to be active,” “Leadership,” “Thinking of others,” and “Teamwork.” A horizontal axis shows time, and the period for sailing vessel training is 0 - 2.3 months. About 0.7 months is a period of holiday, and 3 - 5.3 months is the period for motor ship training. A vertical axis shows an average score (a maximum of 36 points).

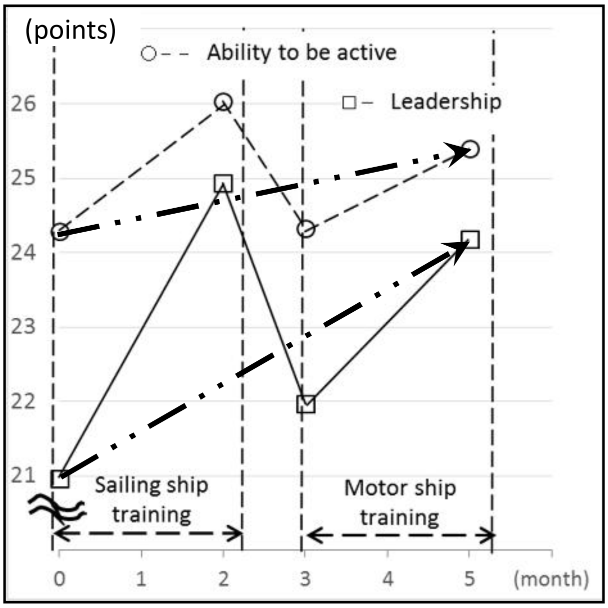

Figure 3 Change of “Ability of active” and “Leadership”

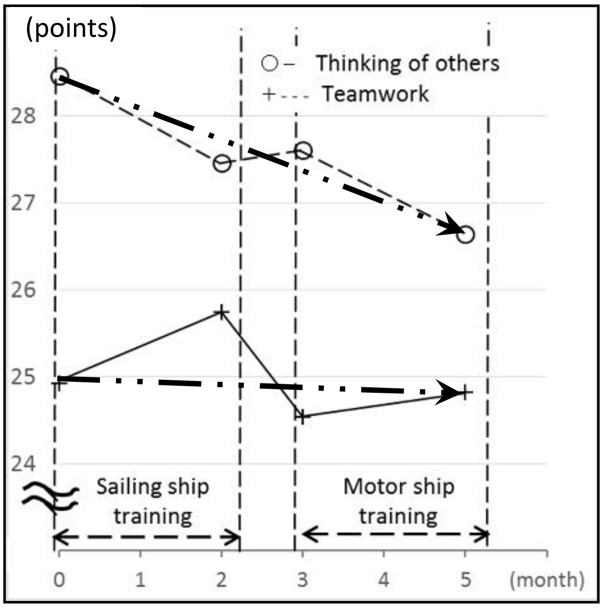

Figure 4 Change of “Thinking of the others” and “Teamwork”

From the Fig. 3, the fourth time shows more improvement than the first time in the competence of “Ability to be active” and “Leadership.” On the other hand, from Fig. 4, the fourth time shows a decline in comparison with the first time in the competence of “Thinking of others,” and “teamwork.” Moreover, as for the competence of “Thinking of others,” contrary to other competences, the improvement in some is found during the holiday. The effect of the sailing vessel training and motor ship training is shown for each competence, excluding “Thinking of others” from these results. It is surmised that it is the result of becoming self-disciplined and evaluating oneself severely by training about “Thinking of others” from our experience.

3.2 The Difference in the Training Effect According to Group

In the sailing vessel training and the motor ship training, navigational duty, and maintenance training are mandatory for every group. Therefore, changes in the competence of each group in sailing vessel training were investigated. The *p* value as a result of the *t*-test of each group is shown in Table 2, and the comparisons of the before and after sailing vessel training of group No.2 and group No.4 are shown in Fig. 5 and Fig. 6, respectively. There is a clear difference for every group. Compared with other groups, group No.2 has no significant difference among the items; the cause for the lack of difference is unknown. However, two persons who provided the same reply to all questions belong to group No.2. It may have been influential to the atmosphere of the group but these two persons were excluded from the analysis. Moreover, in the essay at the end of the training, a negative comment was indicated about 30 % of the time. For example, “I was not able to climb the mast till the end of training, and I felt mortified,” “Since the heart might be shaken privately, I was not able to have training calmly,” “I did not have any friends and it was mentally painful.” We were unable to clearly detect the cause in the essays although the improvement of the competences of group No.4 was remarkable.

Table 2 The p value in the *t*-test according to group

	Group 1	Group 2	Group 3	Group 4	Group 5	Group 6
Self-control	$p > 0.05$	$p > 0.05$	$p > 0.05$	$p > 0.05$	$p > 0.05$	$p > 0.05$
Leadership	$p < 0.05$	$p > 0.05$	$p < 0.01$	$p < 0.01$	$p < 0.01$	$p < 0.01$
Situation awareness	$p > 0.05$	$p > 0.05$	$p > 0.05$	$p > 0.05$	$p > 0.05$	$p > 0.05$
Communication	$p > 0.05$	$p > 0.05$	$p > 0.05$	$p > 0.05$	$p > 0.05$	$p > 0.05$
Ability to be active	$p < 0.05$	$p > 0.05$	$p > 0.05$	$p < 0.05$	$p > 0.05$	$p < 0.05$
Ability to manage stress	$p > 0.05$	$p > 0.05$	$p > 0.05$	$p < 0.05$	$p > 0.05$	$p > 0.05$
Thinking of others	$p < 0.05$	$p > 0.05$	$p > 0.05$	$p > 0.05$	$p > 0.05$	$p > 0.05$
Teamwork	$p > 0.05$	$p > 0.05$	$p > 0.05$	$p < 0.05$	$p > 0.05$	$p > 0.05$
Average	$p < 0.05$	$p > 0.05$	$p > 0.05$	$p < 0.01$	$p > 0.05$	$p > 0.05$

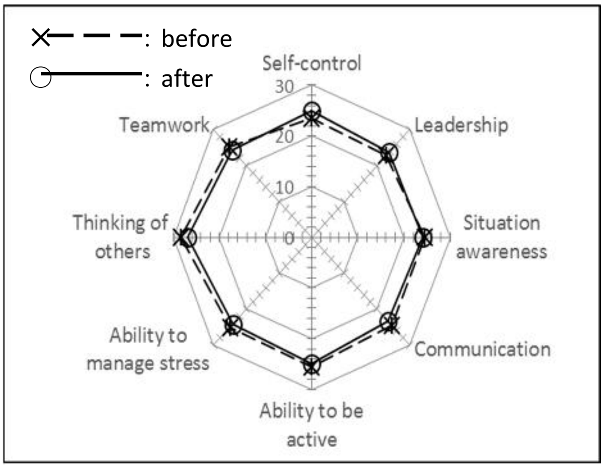

Figure 5 Comparing competences before and after sailing vessel training of Group No.2

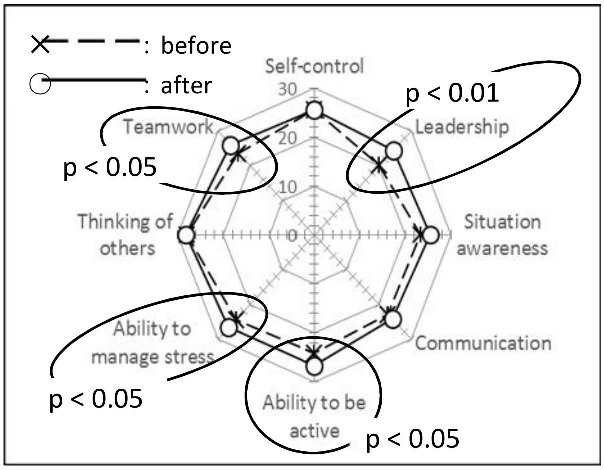

Figure 6 Comparing competences before and after sailing vessel training of Group No.4

3.3 Comparison of University Students and Technical College Students

The result of the *t*-test in the motor ship training of the university students and technical college students is shown in Table 3. Comparing competences before and after motor ship training of the university students is shown in Fig. 7, and comparing competences before and after motor ship training of the technical college students is shown in Fig. 8. For university students, in the motor ship training following the sailing vessel training, a significant difference was not found in each investigation item mentioned earlier. On the other hand, seven items, except "Thinking of others," for the technical college trainee who had training on the motor ship with the university students showed improvement. As a result of the *t*-test, four items "Leadership," "Situation awareness," "Ability to be active," and "Ability to manage stress" were shown at $p < 0.01$, and a significant difference was found.

Table 3 The *p* value in the *t*-test
(Comparison of a university and a technical college)

	University student	Technical College student
Self-control	p>0.05	p>0.05
Leadership	p>0.05	p<0.01
Situation awareness	p>0.05	p<0.01
Communication	p>0.05	p>0.05
Ability to be active	p>0.05	p<0.01
Ability to manage stress	p>0.05	p<0.01
Thinking of others	p>0.05	p>0.05
Teamwork	p>0.05	p>0.05
Average	p>0.05	p<0.01

The following can be considered as the causes of the differences between a university student and a technical college student.

(1) There was a difference in their ages: almost all technical college students were 20-years-old, but the university students were 22-years-old or older.

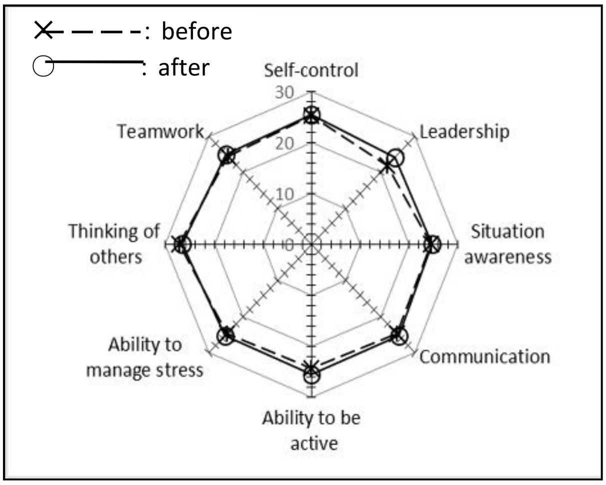

Figure 7 Comparing competences before and after motor ship training of the University Students

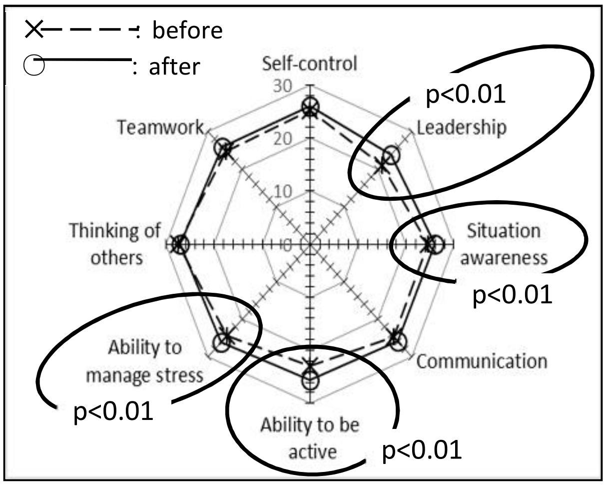

Figure 8 Comparing competences before and after motor ship training of the Technical College Students

(2) The university students took the motor ship training following the sailing vessel training. On the other hand, the technical college students took motor ship training following the other motor ship

training. This may influence the difference between the competences of the university students and the technical college students.

4. Summary

The questionnaire for the self-assessment was carried out before and after the sailing vessel training and the motor ship training, and the following results were obtained.

(1) There was improvement after training for seven items, except “Thinking of others” out of the eight items of emotional competence. In particular, “Leadership” improved remarkably.

(2) The same investigation was conducted for the motor ship training, which followed the sailing vessel training, and it had the almost the same results. However, “Leadership” did not show a significant difference.

(3) Seven items of emotional competence, except “Thinking of others,” improved by the sailing vessel training, and declined during the holiday for about 20 days following that training. Furthermore, it is improving by subsequent motor ship trainings. However, the improvement in the competences in the motor ship training was lesser than that in the sailing vessel training.

(4) Unlike other competences, “Thinking of others,” for both sailing vessel training and motor ship training shows decline. Moreover, unlike other competences, it shows slight improvement over the holiday.

(5) Although the university students were seen to show some improvement in the competences in the motor ship training that was carried out following the sailing vessel training, there was no significant difference. On the contrary, an improvement indicating a significant difference in four items among the eight items in the motor ship training for the technical college students was found.

We would like to investigate the factor for the improvement in the competence in the sailing vessel training further.

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Enhancing the effectiveness of marine engine room simulator-based training

Salman Nazir [(1)] and Tae eun Kim [(2)]

[(1)] Training and Assessment Research Group, Department of Maritime Technology and Innovation University College of Southeast Norway, Email: Salman.nazir@hbv.no
[(2)] Training and Assessment Research Group, Department of Maritime Technology and Innovation) University College of Southeast Norway, Email: taiqi@me.com

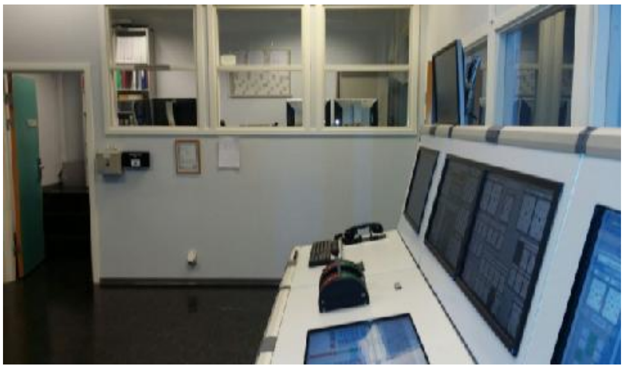
Abstract. Simulation technology – incorporated with high-fidelity machinery and immersive environment – has been widely utilized in training programs to systematically develop, refine and enhance industrial operators´ professional skills and knowledge. The effectiveness of simulators for skill acquisition are subject to adequate and scientific curriculum development, instructional support and continuous learning assessment. Nevertheless, considerably less attention has been devoted to evaluate the effectiveness of the education/training methods engaged in simulation training, which indicated the needs to investigate the current methodologies with attempt to improve and enhance the effectiveness of simulator-based training. By taking an experimental approach, this study evaluates the current training methods used in marine Engine Room Simulators (ERS), whilst proposes specific changes that can be implemented to enhance the effectiveness of training method being used. The result shows that the revised training method provides trainees with improved operative performance, which can be further developed and implemented as a means for ensuring proficiency.

Keywords: Simulator-based training, engine room simulators, training/education method, performance assessment, performance indicators, skill acquisition

1. Introduction

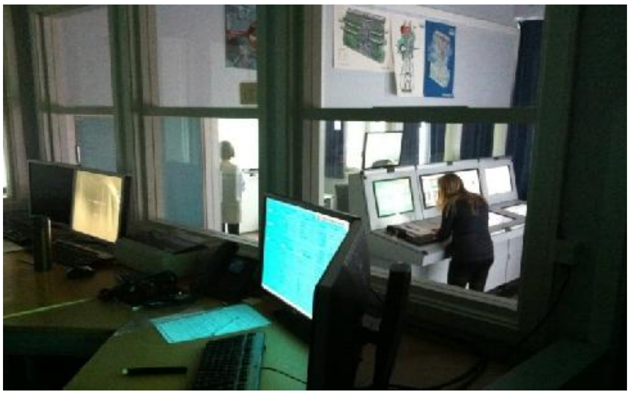
As a significant number of the ship engine room tasks are knowledge-basedactions (Kluge, 2014), to ensure competence, knowledge and skills of engine room operators prior to real-world practices is of paramount importance (Nazir, Colombo, & Manca, 2013; Salas & Burke, 2002). Many of the maritime accidents can often be traced to the flawed, inappropriate or inadequate control actions of human operators (Kim & Nazir, 2016). Simulator-based training, in a controlled and non-risk environment, can provide marine engineers an opportunity to learn, operate and practice with a variety of realistic situations that would be dangerous or unlikely to be simulated in real life (Colombo, Nazir, & Manca, 2014; Swezey, Owens, Bergondy, & Salas, 1998). A great effort has been devoted to advance the fidelity of simulators to provide trainees a more immersive learning environment to deal with both normal and abnormal situations (Schlacht, Del Mastro & Nazir 2017). However, simulation technologies often being inserted into existing training programs without customizing or tailoring the courses in the light of learning theories to maximize the effectiveness of simulators towards achieving the training and education goals (Kluge, 2014).

The world of maritime education and training has received great attention and subsequent improvements since last decade. Engine Room Simulator(ERS) training is a necessary component of any given marine engineer training course or bachelor program in this domain. The use of simulator for engine room training/education is a common practice as it enables a realistic simulation of various types of machinery, equipment and scenarios (Cicek & Uchida, 2002). There are various types of ERSs available and being used in different universities/educational settings. This study aims at improving the training methods used for ERS-based training in Norwegian maritime institution. The ERS used in this study is K-Sim engine simulator produced by Kongsberg group as shown in Figure 1 (a, b, c and d).



a. The engine control room and the instructor room

b. The dark engine room



c. View from the instructor room

d. View from the instructor room

Figure 1 Engine Room Simulator (ERS)

One possible way to improve the training method for ERS training is to uncover the limitation of current training methods exercised, and use it as a basis to develop measures in order to enhance the effectiveness of this simulator-based training. To ensure the effective utilization of ERS and resources, while maximizing the learning outcome of engine room trainees, this study is designed with an experimental approach to systematically identify loop holes of current training curriculum and instructional support exercised and propose effective changes that can be implemented in order to improve the effectiveness of marine ERS-based training.

2. Methodology

2.1. Experiment design and measurements

Proficiently and correctly starting the main engine from cold conditions is often considered as the fundamental knowledge and key learning target for engine room trainees and students. To identify the potentials for improvement of current training method used for addressing this fundamental activity, a quasi-experimental design is performed which can be further divided into two phases.

Phase 1 aims to investigate the potential limitations of the current training method used in ERS, and to evaluate students´ learning outcome generated through current ERS-based training method. All participants are invited to follow training program to start the main engine from cold conditions with the instructions provided by the trainer/instructor. Participants received the first questionnaire regarding their backgrounds, motivations, and feedbacks of current training. The aim is to understand the satisfaction level and learning outcomes of participants in current ERS-based training. Two researchers – one has over 10 years' working experience in engine room and the other one is an expert in training theories –are involved in observations of phase 1experimentto identify the possible loopholes, which can be improved in upcoming phase.

Drawing upon the limitations identified, several potential changes will be proposed in the light of expert opinions, student evaluations, and observations. To identify whether the proposed changes have positive effect on the effectiveness of ERS training, post-training experiment i.e., Phase 2, will be conducted to implement the changes proposed in the previous phase whilst measuring the effect of changed training methods on learning outcomes. Fifteen marine engineering trainees/students including 3 females and 12 males (average age 22.8) were participated in phase 1 and phase 2 experiment. Participants were requested to fill the pre and post questionnaires during experiment period with the aim to enable students' self-evaluation towards their learning outcomes generated through the period of training. Those questionnaires answered by participants will be analyzed by Wilcox on signed-rank test used when comparing two related samples, matched samples, or repeated measurements on a single sample to assess whether their population mean ranks differ (Wilcoxon, 1945).

2.2. Performance indicators

To objectively evaluate the effect of the current simulator-based training methods, outcome-oriented performance indicators are used to signal whether the training methods are sufficient to instill the required knowledge and skills to the trainees. Through a rigorous task analysis from preparation process to start of the main engine and interview with two marine engineers (trainers), six measurable performance indicators are developed which are shown in Table 1. The performance indicators can be further classified into two categories: time taken and errors made. *Time taken* represents participants' proficiency in operating, the effectiveness of communicating, and the understanding of the system. Measurable parameters including the time taken to start the emergency air compressor, time taken to have the lights on, and the time taken to start the main engine. At the start of emergency compressor will trigger the first sound effect of ERS, which is a relatively clear signal and easy to be observed. Similarly, bring the light into a dark engine room is also considered as an effective indicator. Last, the start of main engine is not only a performance indicator, but also the goal of this exercise.

Table 1 Measurable performance indicators

	PI	Units	Reason/ Description
1	Time taken to start the emergency air compressor	Time (min)	Easy to identify with sound effect
2	Time taken to have lights on	Time (min)	Easy to identify with lightening
3	Time taken to start the main engine	Time (min)	The goal of the exercise
4	Participants being corrected by instructor	Numbers	How many errors they made
5	Can participants solve tasks given by instructor	Percentage	The successful rate of task solving
6	The lube oil level in DG1 when ME start	Percentage	If participants follow correct procedure

The following three PIs (fourth to sixth in Table 1) were related to the frequency of errors the participants made during the training process. Numbers of helps taken (participants being corrected by instructor) can reflect the performance of trainees during the training. The instructor is not informed with this measurement to reduce the potential biases on instructor's behaviors. The fifth PI, solving the task given by instructor normally happened after the main engine was started. The instructor will set some malfunctions such as dirty filters in subsystems, overlord speeds or higher temperature. It will trigger the alarms, thus, the participants experience *error* training. The sixth PI was chosen because two groups of participants fell into this *trap* in the descriptive observation. If participants ignore some necessary instructions or procedures, the lube oil level will not be around 60% when started the main engine, this will trigger the alarm once it is below 30%. The performance indicators generated above, thus can be used as an objective assessment method to signal the degree of knowledge/skills acquisition for the participants in the engine room training program.

3. Results

E-coach - an electronic instruction system - is used in current ERS-based training. The pop-up messages displayed on the screen aimed to provide consistent guidance for the beginners, which can reduce the dependency of instructor, the learner´s mental workload while enhancing the training efficiency. The participant can focus on necessary task steps instead of dividing attentions between strategy development and operation. In order to be effective, the e-coach systems should provide the learners with clear instructional supports in a step-by-step manner following the procedures of the task. However, in general, the current e-coach systems designed in ERS has limitations in its scientific consistency, accuracy and precisions. For instance, instructions such as "Go to MD 78"are often provided without mentioning the actual system name i.e., "Go to MD 78, Emergency Diesel Generator." By giving less sufficient instructional supports, simulator based training may not demonstrate full potentials to enhance students´ understanding, thus further analysis and modification of current e-coach messages are necessary. Total 126 messages - which are currently being used in ERS- were evaluated and revised, the revisions involve change the wording (33%), change of format (25%), reverse the sequence (12%), delete non-necessary messages (3%), and create new instructions (8%).

Consistent with the assumption, poor participant satisfaction is also revealed through the first questionnaire responses. Participants feel that the use of ERS have not reached the maximum potential intensity (average point 5.6 out of 10) with inappropriate instruction provided. Furthermore, after finishing the phase 1 observation, the result shows participants take average 111.3 minutes to start the main engine. However, they have only average 76.5 minutes to practice in ERS, which means they do not have sufficient time to start the main engine. The compressed exercise provides little opportunity to contemplate results of individual training sessions. This lack of time to reflect may especially significant for individuals who have limited nautical experience, such as first-year marine students or the one not familiar with ERS-based training. The instructor should be given extra time to have a debriefing outside the ERS, adding 38.5 minutes of practicing time to phase 2 training experiment is necessary. These proposed changes are implemented in the second phase of experiment to examine their effects on the training outcome. The comparison of time taken between phase 1 and phase 2 is shown in Figure 2.

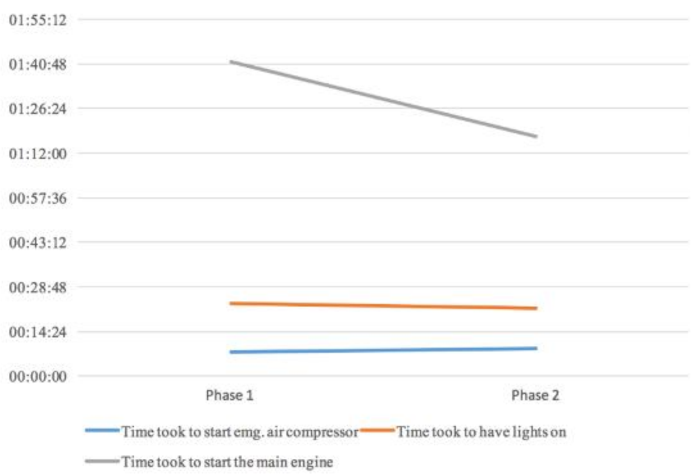


Figure 2 Comparison of time taken between phase 1 and phase 2

Significant improvement on time taken for starting the main engine, slightly decreasing for having the lights on, slightly increasing to start the emergency air compressor were observed in phase 2 after implementation of the changes in e-coach system and education time for ERS-based training method.

The result for PIs related to error made also indicated the improvement of learning outcomes in phase 2, the average performance shows in Table 2. Also, when conducting the Wilcoxon signed-rank test, it shows three tests are all being statistical significant (Asymp. Sig., 2-tailed=.001, .012, .001).

Table 2 The performance of average error made in both phases

No.	*Performance indicators*	*Phase 1*	*Phase 2*
4	Participants being corrected by instructor	5.47 (times)	2.87 (times)
5	Participants solve tasks given by instructor successfully	70.13%	91.33%
6	The lube oil level in DG1 when ME start	49.27%	63.27%

The descriptive statistics of each question can be seen in Table 3, which demonstrate the result of post-tests in comparison of the pre-tests.

Table 3 Results of student self-evaluation

Subject		*Phase 1*		*Phase 2*	
		Mean	SD	Mean	SD
Evaluate current knowledge level from cold ship condition to start main engine	Pre test Post test	6.40 7.67	1.06 1.05	6.80 9.27	1.74 .59
I feel confident whencommunicating with colleagues.	Pre test Post test	7.47 8.40	1.46 1.30	7.33 9.53	1.29 .74
I know the operating process from cold ship to start the main engine very well.	Pre test Post test	5.53 7.33	1.06 1.29	6.33 8.87	1.80 .92
I know the functions and menu of simulator panels very well.	Pre test Post test	5.80 7.33	1.21 1.18	6.67 8.27	1.18 1.10
Evaluate the your overall improvement		8.93	.96	9.60	.83

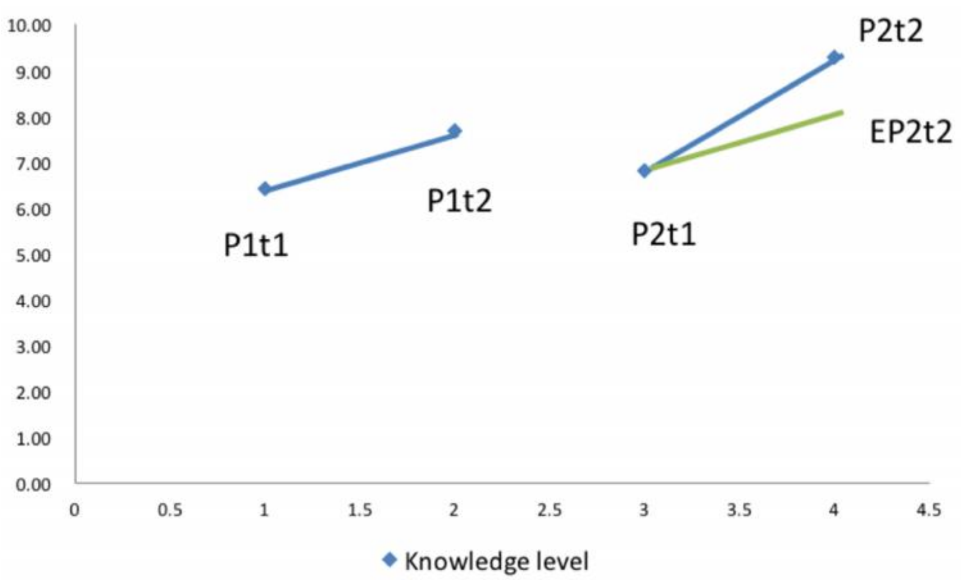


Figure 3 The slopes of knowledge increasing in each phase (P = phase, t = time)

In addition, based on the result derived from the student self-evaluation, Figure 3 shows the improvement of knowledge level evaluate by participants. P1t1 represents pre-test in phase 1, while P1t2 is the post-test in phase 1. The gradient of line P1t1 to P1t2 is the margin of knowledge grows. As the operational performance and knowledge level after phase 1 training are supposed to increase, when compare the significance of improvement with the post training outcome at phase 2 can demonstrate the effect of changed method on the training outcome.

Assuming participants will have same level of improvements in phase 2with equivalent performance improvement ratio, the score for post-test in phase 2 should be EP2t2 (see Figure 3). However, the actual value of P2t2 is higher than expected, which indicated that performance of participants improved more than previously assumed.

4. Discussions

The needs for improvement in the simulator-based training has been recently recognized by several researchers (Nazir & Manca, 2015). This study is an effort to first investigate the aspects that can be improved in existing practices in ERS Training. Drawing upon the shortcomings of existing training methods identified, some changes (use of e-coach system, training time extension, etc.) were proposed and subsequently implemented during the experiment. To ensure the effectiveness of proposed changes, both subjective and objective measurements– student self-evaluation and performance indicators assessment- were performed. Clear improvements on performance indicators from phase 1 to phase 2 were observed with large decrease in time taken to start the main engine, and the less errors made. Simultaneously, the increase in slope of knowledge also indicated the significance of improvement.

The time taken for the startup is an important performance indicator as it indicates the proficiency of trainees. A trainee with improved understanding, knowledge combined with necessary skills shall be able to start the engine with higher proficiency. Figure 2 shows how the participants improved in their proficiency of starting the engine room.

During the design stage of the experiment, we have formulated a performance indicator with aim of evaluating the number of helps each participant requested during the course of exercise. It was natural to assume the higher the number of times participant was corrected by the instructor the lesser his/her proficiency is. As the exercises were meant for learning and not for final evaluation/assessment of their learning, therefore, the performance indicator i.e., Participants being corrected by instructor proved vital in final analysis. Participants being corrected by instructor during the phase 2 was reduced to half in second phase.

In phase 2 experiment, significant improvements are observed after the implementation of the proposed changes. The improvements are measured with the reference of predefined performance indicators as well as the student self-assessment. 11 out of 15 participants indicated that the proposed changes facilitated learning. The revised e-coach messages get most feedback (from the participants) considering helpful on learning, and it is ranked number two in the analysis of factors cause improvement.

Some limitations deserve note. The sample of current study involved a relatively limited number of students and professionals to participate in the university training program. The sample size did not permit to provide examination of the degree to which level of training or professional background may have influenced training results. Therefore, future outcome studies will need to be conducted with sufficient power to determine whether the developed training curriculum in this study is differentially effective in various professional and student subgroups.

5. Conclusion

The use of ERS-based training has increasingly received significant attention from the industry for marine professional development. Nevertheless, little research has been devoted to enhance the effectiveness of the education/training methods engaged in simulation training. This paper thus has taken an experimental approach to propose several changes in the light of identified limitations of the current marine engine room simulator-based training with attempt to improve and enhance the effectiveness of simulator-based training. This study reveals that the ERS-based training method at one institution in Norway possess several possibilities of improvement. Implementation of proposed changes resulted in evident improvements in the learning outcomes of the participants/students.

By enhancing the marine simulator-based training with the surplus of the thought which we can generate, hopefully can pave the way for future work aiming at improvement of education/training in maritime domain.

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Monitoring of the quality of Maritime specialists training in the system of Maritime education

PhD. Igor Marichev

Admiral Ushakov Maritime State University, Novorossiysk, Russia, e-mail: igormarich@inbox.ru

Abstract. Maritime universities are focused on the principal issues of the maritime education, including creation of new competitive image of the merchant shipping industry, its support through scientific and technological development. The result of set tasks first of all depends on quality of training which should guarantee professionalism of specialists working in the branch.

Currently, the need to improve the quality of Maritime education is connected with the rapid development of shipping industry and a number of documents both national and conventional, regulating activities in this field.

The article shows that there are many methods of quality control of the educational process at the Maritime universities, from collecting information on the performance and other indicators set by regulatory documents to complex psychological and pedagogical tests.

It is proved that there is no optimal model of monitoring, which could validly describe different aspects of the quality of the educational process at the Maritime Universities. The issue of criteria of quality in Maritime education is considered; its links with the elaboration of educational standards are shown and grounded.

The method of monitoring the quality of marine specialists training in the system of Maritime education is submitted. Criteria of the quality of training are highlighted and the mechanism for monitoring the quality of training of future marine specialists is described.

This paper provides theoretical justification to application of the Matrix approach to the construction of the educational space which can contribute much to development of the issue of monitoring and estimation of qualityof Maritime specialists training. The theoretical arguments are supported with empirical evidence from the previous research.

Key words: seafarer, quality of training, standardization, maritime transport, maritime university, skill development, educational space, coefficient of comfort.

1. Introduction

Issues of regular monitoring of Maritime education quality are explained by need of scientific and technical progress in professional training of specialists for the Maritime industry. The need to improve the quality of Maritime education currently is associated with the rapid development of merchant shipping and a number of documents regulating activities in this branch. The urgency of considering the issues of improving the quality of professional training of future sea specialists at Maritime universities is obvious. The main contradiction here is the discrepancy between criteria for its (quality) assessment: on the one hand:in any educational institution the main evaluation criterion is volume and quality of knowledge, abilities and skills of the graduate on certain disciplines, on the other hand: the customers of the «product» of the Maritime Universities consider a real readiness of the graduates to the solution of multidimensional tasks while performing the professional activity.

There are some inconsistencies which should be solved. Often professionals with high learning outcomesafter graduating from the Maritime institutions, with sufficient engineering knowledge, skills and abilities, are not always able fully to apply knowledge in the professional activity. This is particularly evident in the lack of readiness of young seafarers (and other specialists working in the

Maritime industry) to solve complex professional tasks especially in stressful and unusual circumstances, which often leads to various kinds of accidents. Hence, the cause of much quantity of accidents is the human factor. To some extent, the system of quality of professional training in Maritime universities is urged to resolve this situation.

The essence of the system of quality of professional training at Maritime universities as a pedagogical system is the ratio of activity of participants of education with the pedagogical result. The eternal task (at least, due to the fact that educational standards are constantly changedowing to development of industry) and require constant attention. Therefore, a system-forming factor of the system of quality of marine specialists'professional training is the goal, determined by demands of consumers of services of Maritime education – by Maritime companies (crewing, shipping, forwarding etc.). The result of wide implementation of this system must reflect the readiness of graduates of Maritime universities to perform complex professional activities and correspond to the requirements of the International Convention STCW 1978/95 and amendments adopted at the Manila Conference, 2010 [5].

2. Monitoring of quality of educational process in Maritime universities

The quality of professional training in the Maritime universities is not only a complex system, but complex systemic objectfor management or control. Namely, the quality of management of professional training determines the achievement of the objectives of the quality system of professional training and it is subject to appropriate control and regulation of the functioning of all its (the system's) elements. Orientation of the purpose of quality management of training for the creation of conditions for formation of graduates'readiness for professional activity determines the appropriate change in its objectives, content, forms and methods of realization of this training. We do not speak about competence assessment or learning outcome of a student to demonstrate his/her capacity to perform tasks listed in the STCW Code. We will focus on one aspect of this issue, on method of control of the educational process quality in Maritime universities, i.e. monitoring.

Monitoring of quality of the educational process means thesupervision for its development to ensure optimal choice of tasks, their solutions and used methods while organizing this process. Monitoring involves a systematic diagnosis of qualitative and quantitative characteristics of efficiency of the educational system functioning, and therefore, interaction of all components of the pedagogical system, including direct and feedback amongits (system) components.

Currently, there aredifferent methods for monitoring of the quality of the educational process in Maritime universities, from collecting information about students' performance and other indicators set by regulatory documents to complex psychological and pedagogical tests.

It goes without saying that criteria or indicators under which the quality is assessed should be clear enough, easy to handle, but at the same time it must be grounded on the scientific approach. While estimating quality of education all aspects should be accounted: learning outcomes of students, work of educational institutions and all participants of the educational process. Obviously, there is no optimal model of monitoring, which could reliably classify most aspects of the quality of the educational process in all and in each certain University, including a Maritime University. And this state of affairs only complicates the task of the monitoring.

Maritime education is a special category due to the fact that its realization occursboth on the basis of Federal StateStandards and Conventional ones. Maritime education institutions work with increasing independency although it is supposed to work according to STCW Convention.And the Conventional standards and requirements play often a leading role«…each Party shall ensure that an independent evaluation of the knowledge, understanding, skills and competence acquisition and assessment activities…»and «…each Party shall also ensure that an evaluation is periodically undertaken, in accordance with the provisions of section A-I/8 of the STCW Code, by qualified persons who are not themselves involved in the activities concerned. This evaluation shall include all changes to national regulations and procedures in compliance with the amendments to the Convention and STCW Code…» [5].

As a rule, the monitoring of quality of Maritime education provides the following:

- evaluating the overall goals and objectives of training marine specialists and determination of parameters of this assessment;
- analysis of curricula content of various disciplines, consistent both with national and international standards and the requirements of employers;
- quality assessment of learning resources (textbooks, software products, simulators, etc.);
- the verification of the effectiveness of the used teaching methods and their adjustment and optimization if necessary;
- creation of special agencies, departments, groups, etc. for rapid assessment and analysis of the quality and trends of the educational system both on state level and on level of educational institution;
- development of operational methods for assessing the current quality and its relationship to a model (although, the model is always conditional);
- assessmentboth of a process of development of professional competences and personal qualities (for example, all-intellectual development, the formation of value orientations, ethnic and cultural competence, etc.) and learning outcomes.

Regardless of what aspects of the educational process will be subject to monitoring, for its implementation it is necessary to ground on certain principles of monitoring arrangement. While implementing the Quality System in Admiral Ushakov Maritime State University (Novorossiysk, Russia) the following principles were developed and introduced:

- the principle of the system arrangement, ensuring the integrity of the construction and the relationship of components included in the monitoring system;
- the binarity principle, reflecting the basic pattern of the effectiveness of the educational systems that is binary (inseparable) combination of teaching and self-learning, education and self-education, external control and self-discipline;
- the principle of management including organization of processes, procedures of measurement, analysis and improvement, as well as the choice of ways to manage the entire monitoring process adequate to the set task;
- the principle of informational activity, which includes collecting information about the learning outcomes of the graduates as the main objective of the management of the quality system, preparation and implementation of decisions on the adjustment of processes (teaching methods, applied aids, pedagogical technologies, etc.);
- the principle of continuity that defines the sequence of changing requirements to knowledge, abilities and skills of learners, the interrelation among the content, methods and forms of educational process;
- the principle of predictability, which is determined primarily by demands of the Maritime Industry, as well as scientific and methodological and financial support of the educational institution.

Reliance on these principles contributes to systematic and profound analysis of the monitoring system.

Typically, monitoring in the Maritime University is carried out in several stages:

- general control of the educational process (education and training);
- evaluation of the shipboard training process and its parameters reflecting, primarily specifics of Maritime activities;
- control of the educational process outcome (bothlearning outcomeand the monitoring of employment of graduates);
- certification of the educational process in general (both by the national bodies, and IMO, different Quality Systems, etc.).

According to results of such monitoring, typically the specific proposals for improving the educational process are submitted and someoffers on improving the quality are given.

3. Criteria of quality of Maritime education

The concept «quality» is one of the most difficult one. The interpretation of this concept involves the determination of the list of properties and characteristics, as well as methods of their measurement. These difficulties arise because the category «quality» reflects the great diversity of properties of objects and phenomena.

The concept of «quality» of professional training of seafarers is a large-scale in nature. In conditions of labor market and competition the quality of marine specialisttraining often influencesbothon the level of production, andon human life. Improvement of quality of training is associated with the development of human potential at educational institutions. Moreover, it includes the ability of a graduate to meet current and anticipated requirements of consumers.

However, there is no a unified attitude to the definition of quality in today's educational environment. It is to be noted that the concepts «quality of education» and «training quality» used in the work are not identical.

The concept of «quality of education» often has more formalized content (presence of scientific schools at universities; potential demand for vocational/professional education; financial stability of aneducational institution; employability of graduates; qualification of scientific and pedagogical personnel, staffing of libraries, results of scientific and publishing activities, focus of educational programs, international activities, etc.). These and other features are taken into account while assessing the effectiveness of the certain University. However, this information in the framework of modern approach to assessing quality is more likely to be considered for the characterization of capabilities of any University, but is not always able to give an adequate assessment of a result – a level of training of a particular specialist, his/her learning outcome.

The meaning of the term «quality of professional training», involves a greater emphasis on adequacy of results to objectives of educational activities, i.e. readiness of graduates for professional activities in a particular industry, in this case, in the sector of the Merchant Shipping.

The issue of measuring the quality of training causes a lot of disputes. Almost all researchers and practitioners agree on the necessity of search of quality indicators, acceptable for any University. We are sure it is impossible, due to the fact of different directions of educational institutions, different traditions and different culture.

A significant role in this aspect belongs to educational standards, which define the set of competencies, and hence, determine the choice of methods, ways and means of developing these competences. The case with the monitoring of the process of developing these competences is different one. Here again, a number of issues related to the choice of evaluation criteria arises. In this case, the STCW Convention indicates very clearly the required level of competencies of graduates of Maritime educational institutions, but how to assess the formed competence objectively, and what criteria to use? This issue is not fully resolved and it requires further attention. Different authors describe criteria as the essential qualities expected from a graduating student’s performance, i.e. ability to demonstrate and provide evidence of the achievement of learning outcomes. Despite the existing different approaches to the concept “criteria”, its description should contain measurable terms across a range of cultural and performance context. Moreover, the criteria should be explained by a wide number of performance levels that ensure a gradation of the quality of performance.

4. The ratio of the monitoring methodology and coefficient of comfort of educational space of Maritime University

The creation of a normative and methodological base for assessing the quality of professional training is the most important task forany University. Methods of evaluationof graduates training quality should be grounded onthe system and structural analysis, taking into account all the internal opportunities of the University and external factors influencing on its activities.

Any method of monitoring of training quality is subject to the conditions of educational space of the University. In this regard, we propose to consider the coefficient of comfort of educational space of a Maritime University, which measure of conformity is characterized by general condition of all its functional objects.

We would like to point out, that understanding of comfort of educational space of any educational institution in much contributes to quality of education in general and quality of learning outcome of a student in particular. That is why we pay so much attention to it.

Grounding on the statement of M. Heidegger [1], according to which the place is some point of space for existence, arrangements of object in it, we understand«educational space» as conditions for implementation of educational interactivity, which main objective is the changing of objects located in this space.

We've distinguished the basic attributes of educational space. They are the following:

– filling of emptiness by material and (or) virtual educational objects;
– prevalence (concerning objects and their quantity) and coherence of educational objects;
– determination of educational objects of space [3; 4].

Educational objects include: the contingent of learners (pupils, students, trainees, etc.), the staff of teachers, state standards of education, educational literature, educational-material resources, hostels, etc. Prevalence of objects is characterized by their «volume» and quantity. Determination of educational objects consists in the following. Each of them has the sphere of existence, the borders, differs from others. Objects of one level of the maintenance consist of objects of another (more concrete, detailed).

We relied on the fact that an applied structure of the educational space of any institution has the characteristics of multi-dimensional matrices. Hence, the orderliness and predictability of the structure component of the educational space is evident. Based on this structure when creating the next level of conditions of educational space, it is possible to predict in advance what conditions, and with what purpose it can or should be created.

Each component while distinguishing and detailed consideration can be decomposed by selection of the characteristic inherent to the components of the next level. This process of constructing of new levels can be continued depending on available information and opportunities to specify the conditions for implementation of educational actions.

We assumed that any quality of a personality is a property of the brain and consists of the actions that it performs. Actions performed by a man on the basis of his «human formation» can be subdivided into two groups. First group includes those which primary purpose is the formation and/or the development of any human feature (knowledge, personality traits...). Theseare educational actions. Their productivity depends on their adequacy to the set objective. The second group includes all other actions. They are performed to meet the different needs of life, achieve different purposes (cultural, labor, etc.). They also to some extent affect the formation of human features. This effect can be called as natural.

Effective formation of professional competences requires adequate targeted actions. To see it happen, it is necessary to create conditions for them based on specific level of education and capacity to perform necessary actions. These conditions are subdivided into established spontaneously and purposefully created. Actions to develop features of aperson are also subdivided into natural and purposeful. The first is considered as socialization, and the last is understood as education. Actions of the educational process are executed in a certain social environment,hence the formation of personality traits is also influenced by the social circumstances.

The foregoing allows conclude, that in the society there are conditions that can be called socialized, and their combination – the «socialized space». It exists together with educational space and intersects with it, as pedagogues use the conditions of social medium for solution of educational tasks. The combination of educational and socialized conditions of formation and development of professional competences can be considered as a space of formation of personal and professional features of a person.

In this development the dominant role is played by an educational institution. It acts under programs based on the national and the international training standards that establish mandatory requirements to the formation and development of competences of future specialists. The space of formation of professional competences must contain the terms (objects), the existence of which allows to each person perform his relevant actions.

In this connection in an educational institution both the educational and social space are created.

The space of formation of professional competences of students in educational institutions may be in a different state of readiness. It is advisable to have a tool for its evaluation allowing reliably track its completeness and state its level. We've attempted to create its original image on the basis of our proposed anthropological matrix structure of educational space [2] and index of its comfort [4], characterizing its quantitative readiness.

Developing of the matrix approach to the construction of the educational space-based on solutions of educational targets reveals the prospects of constructing of the objects in this space, the formed level of detailed elaboration, as well as consequent transition to next levels.

Application structure of the educational space of the institution has a symptom of a multidimensional matrix. Hence, the orderliness and predictability of the structure of the educational space is evident. Grounding on this structure when creating the next level of conditions of the educational space in advance, we can predict what conditions for what can or should be created.

Each component when concrete defining and detailed elaborating can be decomposed by highlighting the inherent characteristics to the components of the next level. This process of new levels building can be continued depending on the available information and opportunities to specify the conditions for performing educational actions.

Criteria of readiness of the educational space are: securing of the functional conditions for the development of a person; ensuring an adequate range of conditions for implementation of the educational actions. The degree of correspondence of the educational space to the service of the educational activity is characterized by the ratio of his comfort, which summarizes the status of all of its functional components.

The actual material for evaluation of objects of meaningful matrix can be assembled through a survey, evaluation by experts, questionnaires, inspections of conditions of the considered space (readiness of the institution to solution of the set tasks) or otherwise. It is necessary that the analysis of conditions was continuous (collecting of information about each object) and uniform as possible. We should not expect that the result will be absolutely correct. Its objectivity depends on the experience and expertise of the involved in the research experts, respondents; onunderstanding the core of educational institution; on provided time to collect information and on many other circumstances.

5. Conclusion

The growth of the ships capacities is obvious and this process is resulted in increasing quality of operability, bringing onboard the ship the newest technology and people able to work in these new conditions. The constant development of technology and its implementation onboard ships, requires highly skilled sea specialists to perform complex professional functions. The first step in achievement of high results is training of future seafarers in maritime institutions where monitoring of the educational process takes one of the most important place.

There is no single model of monitoring which meet the requirements of different universities from different countries. Monitoring establishes not only the uptake of generated knowledge and skills, but also the quality of this assimilation, which is specified by aims of educating process and creates possibilities for the correction of learning process. A record of all proposed parameters significantly complicates the procedure of evaluating the quality of the educational process. This paper suggests that use of the matrix approach to the construction of the educational space can contribute much to development of the issue of monitoring and estimation of quality.

Despite the relativity of the expected results of applying the proposed methodology, its use undoubtedly will help develop the analysis of readiness of the educational institutions to the solution of their tasks. Now in this analysis mapping of individual opinions and impressions prevails, and the suggested method of finding the index of comfort of created space of professional competence formation represents the attempt of the orderly collection and processing of objective information.

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Assessment of STCW Competencies Aboard a Maritime Academy Training Vessel

Scott Saarheim[1] and Captain Steven D. Browne[2]

1. California State University Maritime Academy, ssaarheim@csum.edu, 200 Maritime Academy Drive, Vallejo, CA, USA, 94510
2. California State University Maritime Academy, sbrowne@csum.edu

Abstract. Each summer, approximately 340 deck cadets sail aboard the United States Training Ship *Golden Bear* as part of their sea time requirements for Officer in Charge of a Navigation Watch (OICNW). These cadets are students enrolled in the California State University Maritime Academy (Cal Maritime) or the Texas Maritime Academy in the United States. During this training period, the cadets receive training on watchstanding, terrestrial and celestial navigation, and hands-on skills such as mooring, marlinspike seamanship, firefighting and first aid. In addition, training is conducted using the Full Mission Bridge (FMB) simulator and the part-task simulator fitted on board the *Golden Bear*.

While on board, cadets are assessed on 143 STCW competencies from the OICNW, Able Seafarer Deck, and Ratings Forming a Part of the Navigation Watch tables. The remaining STCW competencies are assessed ashore, in the classroom, laboratories, simulators, or aboard the maritime academy's small vessels. Although the cadets also get OICNW sea time on board commercial vessels, Cal Academy does not accept STCW assessments conducted during this commercial training period. Nor does the Academy accept the transfer of STCW assessments from other universities or schools.

In this paper, the authors examine the advantages and disadvantages of sea time aboard academy training vessels as compared to sea time on board commercial vessels. In addition, details are provided of the on board training program for deck cadets on the *Golden Bear* including the use of our shipboard Navigation Laboratory (Nav Lab) which is equipped with state-of-the-art simulation equipment. This is intended to inform the international Maritime Education and Training (MET) community and those who may wish to utilize aspects of this training program aboard their own training vessels.

Keywords: Maritime Education and Training, STCW, assessment, simulation training, training ship

1. Introduction

In order to achieve certification as an Officer in Charge of a Navigation Watch (OICNW), cadets must document twelve months of sea time aboard a qualifying vessel and be assessed in a wide range of professional knowledge areas and skills sets as determined by the International Maritime Organization (IMO). These requirements are specified in the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) [1]. In addition to the STCW requirements, maritime cadets at the California State University Maritime Academy (Cal Maritime) must also meet the national licensing standards of the United States Coast Guard (USCG). These national standards licensing requirements further enhance the STCW code by requiring more detailed and thorough knowledge, understanding and proficiency in certain areas [2].

Degree granting maritime universities approach STCW assessments through various methodologies to ensure the degree/license candidate receives all required assessments during their tenure. In order to graduate with a Bachelor of Science degree in Marine Transportation and to be certified by the United States Coast Guard as Officers in Charge of a Navigation Watch, cadets at Cal Maritime receive the majority of their STCW assessments while onshore during the their regular academic year; however, as enrollments have increased along with the number of STCW and national requirements, the training program aboard the academy's vessel, U.S. Training Ship *Golden Bear* (Figure 1), has increasingly been integrating more assessments into the onboard curriculum. With 320 deck cadets on campus on an average year, the resulting 173,760 annual assessments require a significant investment in time and manpower.

Figure 1 U.S.T.S. Golden Bear

Cal Maritime deck cadets participate in two training cruises aboard the *Golden Bear*. After their first year at the academy, students sail for approximately 65 days as Third Class Cadets. During this training period, they are assessed on many of the competencies from the Ratings Forming Part of the Navigation Watch (RFPNW) [3] and Able Seafarer Deck (ASD) [4] tables. At the start of their fourth year at the academy, students return to the *Golden Bear* for 65 days as First Class Cadets, when they are assessed on several OICNW tasks [5]. The ship is at sea for two 65-day training periods, with approximately half of the students participating in each training cruise.

While on board the *Golden Bear*, cadets are assessed on 143 STCW tasks. While 143 competencies may seem like a manageable number of assessments to cover during a 65 day training cruise, with 340 deck cadets on board the training ship during the two training cruises of 2016, the resulting 48620 individual assessments require a significant investment of time, manpower, finances, and educational technology.

The integration of STCW assessments into the training program on the *Golden Bear* has been challenging and has, in some cases, resulted in a significant reduction of training. For example, in previous years the shipboard simulation center on vessel was used with great success to train third class cadets in radar plotting, ARPA, ECDIS, and navigation piloting techniques [6]. In recent years, however, the simulator has primarily being used to conduct STCW assessments and the radar training has been reduced from four days to two days while the ARPA, ECDIS and piloting training have been eliminated.

2. Training Ships vs. Commercial Vessels

As mentioned, in order to become licensed as an Officer in Charge of a Navigation Watch, a cadet must log twelve months of sea time [1]. There is a frequent debate in Maritime Education and Training (MET) circles about whether cadet sea time is best served on academy training ships or on board commercial ships [7]. Cadets at many, probably most, of the world’s maritime universities serve the bulk of their days at sea aboard commercial vessels. Others, such as the cadets at the state maritime academies in the United States, obtain most of their sea days aboard training ships, also known as “schoolships”. Although there are strong proponents of both systems, the reality is that both methods have advantages and disadvantages.

2.1 Advantages and disadvantages of schoolship training

There are several advantages of schoolship training. 1. The university can control the training environment, including the vessel's itinerary and the daily routine, in order to achieve the educational goals. 2. The vessel is manned by a crew of professional maritime educators that have extensive experience in training and assessing cadets in their knowledge and skills. 3. The ships typically have abundant education resources such as classrooms, library, computer labs, and simulation facilities, and 4. The maritime university has direct control over the assessment of the required STCW knowledge, understanding and proficiency (KUP).

There are, however, disadvantages to schoolship training as well. 1. There are a lot of cadets on the training ships, as many as 700 in some cases [7]. As a result, there are limited opportunities to stand watch on the bridge. At Cal Maritime, we typically sail with 60 to 70 4^{th} year deck cadets (seniors). During a 65 day training cruise, each cadet will stand only 4 or 5 watches as the Cadet Watch Officer on the bridge. 2. The cadets get a limited understanding of the realities of working on commercial vessels, and 3. Training ships are very expensive to operate and maintain.

2.2 Advantages and disadvantages of commercial ship training

Cadet sea service on commercial ships also has its advantages. 1. Cadets gain a realistic understanding of life and work aboard a commercial ship, and 2. The shipping company pays most of the costs of the training, greatly reducing the expense to the academy and to the cadet.

There are some disadvantages, as well, to cadet sea time obtained on commercial vessels. 1. On some ships, cadets spend more time painting and doing maintenance than they do on watchkeeping. 2. The training opportunities available to the cadets will vary greatly from vessel to vessel, depending on the type of ship and the operational schedule. 3. Vessel officers often do not have time or teaching experience necessary to effectively train cadets in essential skills. 4. Placing cadets on commercial vessels can be challenging with the availability of cadet berths being determined by economic factors and pressure from other maritime institutions, and 5. The assessment of STCW KUPs conducted on the vessel is out of the control of the academy. As a result, some KUPs might not be assessed at all due to the vessel's operational schedule or type. In such cases, the academy must make an individual assessment plan for each cadet, to ensure that all KUPs are assessed prior to graduation.

2.3 The hybrid approach

There is a third option in the debate between commercial sea time and training ships. That option is a hybrid approach in which cadets obtain sea time in two or more ways. This approach seeks to maximize the advantages of both of the options, above, while minimizing the disadvantages. For example, Cal Maritime cadets sail for two summers (approximately 130 days) aboard the Training Ship *Golden Bear* and one summer (approximately 100 days) on commercial ships. The remaining sea time is obtained through simulation training and operation of the academy's smaller vessels during the academic year. All assessments of STCW KUPs are conducted at the academy, during the academic year, or on board the training ship during the summer training cruises. At Cal Maritime we have chosen to administer all of the assessments ourselves so that we don't have to create an individual assessment plan for each cadet that would otherwise be necessitated by their varying experiences while on their commercial vessel.

3. Assessment of STCW KUPs at Cal Maritime

Conducting assessments of competence in STCW KUPs is a modern reality for Maritime Education and Training establishments. In order to graduate with a Bachelor of Science degree in Marine Transportation and to be certified by the United States Coast Guard (USCG) as Officers in Charge of a Navigation Watch, cadets at Cal Maritime must complete all of the requirements in several of the STCW tables. These tables are as follows: Officer In Charge of a Navigation Watch (Table A-II/1), Rating Forming Part of a Navigation Watch (Table A-II/4), Able Seafarer Deck (Table A-II/5), GMDSS Radio

Operator (Table A-IV/2), Basic Training – Personal Survival Techniques (Table A-VI/1-1), Basic Training – Fire Fighting (Table A-VI/1-2), Basic Training – Elementary First Aid (Table A-VI/1-3), Basic Training – Personal Safety and Social Responsibilities (Table A-VI/1-4), Proficiency in Survival Craft (Table A-VI/2-1), Fast Rescue Boat (Table A-VI/2-2), Advanced Fire Fighting (Table A-VI/3), Medical First Aid (Table A-VI/4-1), Medical Care (Table A-VI/4-2), Ship Security Officer (Table A-VI/5), Security Awareness (Table A-VI/6-1), and Seafarers with Designated Security Duties (Table A-VI/6-2).

The United States Coast Guard has issued further guidance to US mariners and maritime educators concerning STCW assessments through a series of Navigation and Vessel Inspection Circulars (NVICs). The NVICs elaborate and expand upon the STCW code and provide multiple assessment tasks for each competence and associated KUPs. For example, the first competence in STCW Table A-II/1, OICNW, is "Plan and conduct a passage and determine position" and the first KUP is "Ability to use celestial bodies to determine the ship's position" [5]. The national assessment guidelines for that KUP, as published in NVIC 12-14 [2], require the assessment of six independent tasks: 1.1.A - Adjust a sextant, 1.1.B - Measure the altitude of the sun, 1.1.C - Measure the altitude of at least 3 stars, 1.1.D - Measure the altitude of the sun at meridian passage (LAN), 1.1.E – Celestial running fix, and 1.1.F - Plot star fix. In all, a Cal Maritime cadet needs to be assessed on 543 tasks. With 320 deck cadets on campus on an average year, the resulting 173,760 annual assessments require a significant investment in time and manpower.

3.1 Assessing STCW tasks on the training ship

As stated previously, Cal Maritime has chosen to conduct all assessments of STCW competencies directly. The majority of the assessments are done on campus during the academic year, in the classroom, labs, on small craft, and in the full mission bridge simulator. The remaining 143 tasks are assessed aboard the *Golden Bear*. In all, 90 tasks are assessed for the third class cadets and 53 are conducted for the first class cadets (seniors). More will be discussed regarding these shipboard assessments later in the paper.

4. Training Program Overview

The annual training cruises on the United States Training Ship *Golden Bear* serve as a practical training platform and classroom for 340 deck students from Cal Maritime and the Texas Maritime Academy. The deck training program covers almost all aspects of a student's learning experience aboard, and was designed by the Cal Maritime Department of Marine Transportation to require students to participate actively in all aspects of training necessary to obtain a level of competency and to successfully advance toward their degree and OICNW certification. With enrollments increasing and more stringent standards of training, certification and watch keeping for licensing of graduates, the department has been increasing the number of STCW assessments conducted onboard the Training Ship *Golden Bear*.

At the conclusion of a deck cadet's third class cruise the student will possess the knowledge and skills consistent with an able bodied seaman (able seafarer deck). The student should be competent to stand watch as a helmsman and lookout, proficient in the training objectives of the practical, and navigation training programs, and adequately participate in shipboard maintenance projects.

Upon completion of the first class cruise period, students should be competent to stand watch as an officer in charge on a navigation watch, proficient in the training objectives of the entire training program, competent in celestial navigation, flashing light, and able to adequately supervise work projects and programs.

To account for the operations of the ship and to ensure efficient progression through their respective cruise training programs, the students are grouped by major (deck or engine) and class (third class or first class) and divided into divisions (e.g. 1 Deck – 1D, 2 Engine 2E, etc.). Each third and first class deck division rotates through four activity cycles for a total of eight rotations of five days each. Students must pass all eight major rotations and embedded STCW assessments, as well as other ongoing requirements such as computer based training modules, exams and drills.

4.1 Shipboard training modules

To address the increasing numbers of Cal Maritime students and the ship sharing program with Texas Maritime Academy, the cruise period has been divided into two separate training periods of approximately 65 days each. Of those days, 43 days are set aside as at-sea training days. During the cruise students will spend approximately ten days on each of the following rotations: practical training, day work, bridge watch, and simulation/navigation training. To ensure students have the required knowledge and understanding of topics covered in a particular training module, students are required to review computer based training and complete a set of short exams.

4.2 Practical Training rotation

The third class Practical Training rotation is designed to introduce and reinforce various professional "on deck" knowledge and hands-on skill sets. Topics covered during this rotation include First Aid (Figure 2), Block and Tackle, Canvas Work, Firefighting, Ground Tackle, Knots, Bends, Hitches, Splicing, and Mooring. Fourteen Able Seafarer – Deck and Rating Forming Part of a Navigation Watch STCW assessments are also covered during this rotation to include mooring and anchoring, deck equipment, line handling, block and tackle and basic firefighting.

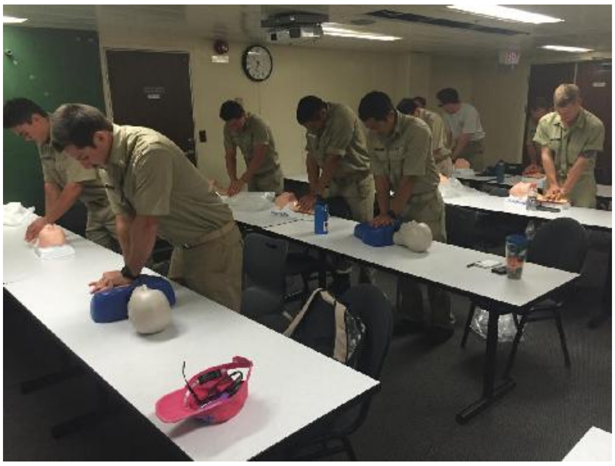

Figure 2 First Aid Training aboard Golden Bear

During the first class Practical Training rotation, cadets are training and assessed on Damage Control, Enclosed Space Entry, Fast Rescue Boat, Firefighting, Flashing Light/Morse Code, Mooring, Safety Inspections, and Survival Craft.

4.3 Watch rotation

The third class Watch rotation was designed to develop bridge familiarization, steering, and watch proficiency skills. There are four modules in this rotation which cover bridge watch as a helmsman and lookout, in port watch, security watch and safety watch. There are seventeen Able Seafarer – Deck and Rating Forming Part of a Navigation Watch STCW assessments accomplished in this rotation, fifteen covering helm and lookout duties and two covering environmental protection at sea and in port.
The Watch rotation for the first class students is composed of seven modules covering at least three four hour bridge watches (Figure 3), a 1-day engineering familiarization watch, a communications and

meteorology watch, in port watches, a safety and security watch and at least one navigation watch. Thirteen OICNW STCW assessments are accomplished during this rotation.

Figure 3 First Class Bridge Watch aboard Golden Bear

4.4 Day Work rotation

Third class day work (Figure 4) consists of introduction in day-to-day shipboard operational and maintenance routines under supervision from first class cadets and ship’s officers. Structural maintenance, cleaning, lubrication of deck machinery and various other projects are undertaken as would be expected from an Ordinary Seaman (OS).

Figure 4 Day Work aboard Golden Bear

Through experiential learning, the third class day work rotation introduces students to the care and maintenance required to keep a sea-going vessel seaworthy. During this rotation emphasis is placed on personal safety, tool and equipment safety, product safety, and environmental safety. There are no STCW assessments conducted during this rotation.

Day work for the first class rotation is designed to develop practical proficiency in managing the vessel's deck student workforce accomplishing continued development of seamanship and other shipboard skills as expected of a ship's officer. Once again, there are no STCW assessments performed during this rotation.

4.5 Simulation and Navigation Rotation

During this rotation, third class cadets are introduced to basic navigation and chart plotting techniques and utilize the onboard simulation facilities to learn Radar Plotting and Rules of the Road. In addition, they are assessed on several tasks from the Able Seafarer Deck and RFPNW tables.

As previously discussed, the pressure to accomplish more STCW assessments has significantly reduced the training to two days of radar followed by assessing Ratings Forming a Part of the Navigation Watch tables. The remaining days in the simulator are devoted to assessing lookout and helm duties along with anchor watch relief and detection and reporting of various bridge alarms. Because each cadet must be assessed individually a significant amount of time must be held aside to perform the assessment and any re assessing that must follow.

The Simulation and Navigation rotation for the first class consists of five modules covering Radar Refresher, ECDIS, ARPA, license exam preparation and two full-mission bridge simulation exercises. Twenty three OICNW STCW assessments are conducted during this rotation.

The watchstanding simulation exercises in the FMB are of great benefit to the first class cadets. Because of the increasing numbers of cadets, the opportunities to stand watch on the bridge of the training ship are limited. And, in long ocean passages, several of those watches might be completed without seeing another vessel or changing course. The FMB exercises give each cadet extra opportunities for watchstanding involving piloting, maneuvering for collision avoidance, and VHF communication. The shipboard simulation capabilities of the *Golden Bear* will be further discussed in the following section.

5. Shipboard Simulation

Figure 5 Full-Mission Bridge Simulator aboard Golden Bear

In order to increase both the quantity and quality of training offered to the increasing number of cadets on the training ship, Cal Maritime constructed a multi-million dollar Navigation Laboratory (Nav Lab) onboard the *Golden Bear* [8]. (See Figure 5.) The Nav Lab on the ship contains a full-mission bridge (FMB) simulator and a part-task integrated bridge electronic systems trainer (IBEST). The FMB simulator, in the forward compartment of the Nav Lab, consists of an Integrated Navigation System and three display monitors. The IBEST, in the after compartment of the Nav Lab, consists of 10 simulation stations that can be used to train up to 20 students on radar, automatic radar plotting aids (ARPA), electronic display and information systems (ECDIS), shiphandling and navigation.

5. Conclusion

Recent changes to STCW regulations have had a significant impact on the training program aboard the *Golden Bear*. As mentioned in the paper, the number of STCW assessments continues to grow along with national requirements which add additional complexity to course design and implementation. We continue to adapt the onboard training program to reflect these ever evolving requirements, but at what cost?

STCW was envisioned as a leveling mechanism to ensure professional competence is maintained throughout the world's merchant fleets by setting a minimum standard of training and assessment. The elimination of license mills churning out dangerously unqualified mariners is one beneficial aspect of STCW. However, the process of ensuring our cadets meet the minimum STCW standards, much time and manpower is devoted to this endeavor and as courses are modified to accommodate STCW assessments, content must be reduced or eliminated. Time spent on traditional lecturing and experiential learning is increasingly being replaced with instruction on assessment topics and the subsequent time consumed assessing KUPs.

In order to ensure our cadets' competence in all STCW KUPs, Cal Maritime does not accept STCW assessments conducted outside our institution. This is a benefit in that we can ensure that the assessments are of high quality and meet our academic standards. However, that also results in a larger administrative burden and comes at a cost of time available for direct instruction. While the majority of all STCW assessments are conducted ashore during the regular academic year, increasingly, in order to regain instructional time, there is pressure to incorporate more assessments into the at sea training program.

The training program aboard the *Golden Bear* has been designed to take advantage of the educational resources available on board including highly qualified maritime instructors, classrooms fitted with the latest educational technology, a library, computer based training and sophisticated simulators. This training program been adapted multiple times over the years and will continue to evolve to meet changing regulations, technology, and industry requirements.

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Inventory of the engineers' competences for a new CoC course by using simulators

Lecturer PhD. M. Castells[1], Dean S.Ordás[2], Lecturer C. Borén[3] & Lecturer M. Rodríguez[4]

[1]*Barcelona School of Nautical Studies, Universitat Politècnica de Catalunya (UPC), BarcelonaTech, Email: mcastells@cen.upc.edu, Pla de Palau, 18 08003 Barcelona, Spain.*
[2]*Barcelona School of Nautical Studies, Universitat Politècnica de Catalunya (UPC), BarcelonaTech, email:sordas@cen.upc.edu*
[3]*Barcelona School of Nautical Studies, Universitat Politècnica de Catalunya (UPC), BarcelonaTech, email: cboren@cen.upc.edu*
[2]*Barcelona School of Nautical Studies, Universitat Politècnica de Catalunya (UPC), BarcelonaTech, email: mrodriguez@cen.upc.edu*

Abstract This paper presents achieved results of the first stage of the IAMU Development Project titled "CoC course to revalidate marine engineers' competences by using simulators", relevant for Maritime and Education Training and Simulation. This development project is for the completion of the project awarded in the Call for Proposals FY2013 titled: "Simulation-based course to demonstrate seafarers' competences (for deck department)". The main objective of this development project is obtain four complete revalidation courses (deck and marine engineer disciplines) using simulation technology to obtain a well-defined project to reach a common academic programme to demonstrate all competences to license the revalidation certification by using simulation.

In accordance with Part A, Chapter I, Section I/11 Revalidation of certificates, continued professional competence shall be established, among others, successfully completing an approved training course or courses. Every master, officer and radio operator holding a certificate issued or recognized under any chapter of the Convention other than chapter VI, who is serving at sea or intends to return to sea after a period ashore, shall, in order to continue to qualify for seagoing service, be required, at intervals not exceeding five years, to establish continued professional competence.

This paper will describe the first stage of the project, WP1: inventory of marine engineers' competences by using simulators. The main objective of this paper is to identify which competences can be demonstrated by approved simulator training, according to the STCW 95/2010 in order to design the following step of the development project: a revalidation model course structure using simulation technology to assessment, examination and certification of seafarers' competence in accordance with the provisions of STCW Code for existing marines who need upgrade their professional maritime certificates in accordance also with the Standards governing the use of simulators, Reg I/12 of 2010 STCW Code.

Keywords: Maritime Education and Training, Simulation, STCW Code, Revalidation of certificates, Marine Engineer

1. Background of the project

International Maritime Organization's (IMO) international convention on Standards of Training, Certification and Watch-keeping for seafarers (STCW) [1] was ratified by all maritime nations. Today, IMO has advised/encouraged all contracting governments/interested parties to review and, as necessary, to revise their crew academic/vocational competency described in STCW. Furthermore, the European Maritime Safety Agency (EMSA) started a regular assessment process providing quality improvement in the MET institutions throughout EU members, candidate countries and others.

This development project is for the completion of the project awarded in the Call for Proposals FY2013 titled: "Simulation-based course to demonstrate seafarers' competences (for deck department)" [2]. The main objective of this IAMU Development Project titled "CoC course to revalidate marine engineers' competences by using simulators" is to obtain four complete revalidation courses (deck and marine engineer disciplines) using simulation technology to obtain a well-defined project and reach a common academic programme to demonstrate all competences to license the revalidation certification by using simulation.

The specific goals are:

- Prepare a publication and integrate all courses as a result of a whole project that can be used by any member that needs to revalidate CoC's, based on STCW Code.
- Develop teaching materials (simulator scenario's) that can be used by IAMU and member universities.
- Provide schools and maritime authorities with a modern way to examine the revalidation of the expired CoCs, incorporating into the IAMU's e-learning platform and it represents a considerable value of practically applicable work which often lacks in most academies.
- Provide maritime industry revalidated and newly educated seafarers.
- Promote the implementation, development, harmonisation and unification of the maritime programme contents.

The development project is divided into following different stages (work-packages, WP):
WP1. Inventory of the competences
WP2. Design courses structure
WP3. Developing and testing simulator exercises for competence assessment
WP4. Incorporating into the IAMU's e-learning platform
WP5. Integration of projects, review and final discussion

2. Maritime simulation

Within IMO an Inter-sessional Simulator Working Group (ISWG) was established in order to organize and structure simulator related matters for inclusion in the STCW revision. One definition adopted by ISGW [2] reads: *Simulation is a realistic imitation, in real time, of any ship handling, radar and navigation, propulsion, cargo/ballast or other ship-system incorporating an interface suitable for interactive use by the trainee or candidate either within or outside of the operating environment, and complying with the performance standards prescribed in the relevant parts of this section of the STCW code.*

The fact that a simulation system represents a powerful teaching tool, which can lead to more effective training outcomes as well as a more efficient use of available teaching time, adds to the increased popularity of simulation equipment. Additionally, the assessment of competence of seafaring skills can be performed in a lifelike simulation centre, which resembles as closely as possible the real system called "ship". As IMO is seeing the necessity to assess competence rather than knowledge in order to improve shipping safety and simulators are offering possibilities for such, it seems without doubt that much more emphasis will placed on marine simulation in the years to come.

It is quite surprising to see which other types of activities and equipment have become models for a maritime training simulator system and up to date have been developed and installed:

- navigation equipment trainer
- communication procedures/GMDSS equipment trainer
- radar simulator
- radar and navigation simulator
- ship handling simulator with/without motion platform/image generation
- fisheries simulator
- inland waterways simulator
- dynamic positioning simulator
- crane handling simulator

- vessel traffic management simulator
- **engine room simulator (ERS)**
- search and rescue management trainer
- oil spill management trainer
- **propulsion plant trainer**
- **team generation plant trainer**
- **electrical power plant trainer**
- **refrigeration plant trainer**
- cargo handling trainer
- ballast control trainer
- dredging ship trainer
- offshore process simulator
- drilling technology simulator

Note: name in brackets and bold is assigned to refer the type of simulator later on.

This list is not intended to be all-inclusive. As technology advances, new systems, both from the shipping industry as well as within the simulation techniques, are being created with certain regularity. From the list it will be clear that all elements of a ship are becoming available for simulation application.

3. Inventory of the engineers' competences

This section will make the inventory of which competences can be demonstrated by approved simulator training, according to the STCW 95/2010 code Part A Competence tables.

In the CoC Revalidation Model Course structure [3], these are the competences that will no longer require theoretical, written or oral examinations, but can be practically demonstrated by means of simulation, identification of which is one of the objectives of this development project.

The competences that will be taken into consideration will be the ones related to the Engine Department as described in STCW Code Part A Chapter III.

The STCW function Groups in Chapter III are as follows:

- Marine engineering.
- Electrical, electronic and control engineering.
- Maintenance and repair.
- Controlling the operation of the ship and care for persons on board.

3.1 Listed competences considering Chapter III assessable by simulator

In this section a list of competences of chapter III assessable through Engine Room Simulator are described for the model course scenario development and testing.

The legal basis for evaluating only with simulator is found in column 3 of the tables provided, where it says for all these cases (see figure 1):

Column 3. Methods for demonstrating competence; Assessment of evidence obtained from one or more of the following:
(…)

In all cases, one of the modalities is: approved simulator training, where appropriate

Table A-III/2

Specification of minimum standard of competence for chief engineer officers and second engineer officers on ships powered by main propulsion machinery of 3,000 kW propulsion power or more

Function: Marine engineering at the management level

Column 1	Column 2	Column 3	Column 4
Competence	**Knowledge, understanding and proficiency**	**Methods for demonstrating competence**	**Criteria for evaluating competence**
Manage the operation of propulsion plant machinery	Design features, and operative mechanism of the following machinery and associated auxiliaries: .1 marine diesel engine .2 marine steam turbine .3 marine gas turbine .4 marine steam boiler	Examination and assessment of evidence obtained from one or more of the following: .1 approved in-service experience .2 approved training ship experience .3 approved simulator training, where appropriate .4 approved laboratory equipment training	Explanation and understanding of design features and operating mechanisms are appropriate

Figure 1 Table A-III/2 of the STCW Code
Source: International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, STCW 1978 as amended in 1995/2010

We found that 16 competences out of all the ones (31) described in column 1 of tables AIII/1 and AIII/2 of the STCW 95/2010 (corresponding to the operational and management levels respectively) may be evaluated by using a simulator.

They are the following for **operational level**:

Marine Engineering.
- Maintain a safe engineering watch. (1)
- Use internal communication systems on board. (2)
- Operate main and auxiliary machinery and associated control systems. (3)
- Operate fuel, lubrication, ballast and other pumping systems and associated control systems. (4)

Electrical, electronic and control engineering.
- Operate electrical, electronic and control systems. (5)

Maintenance and repair.

Controlling the operation of the ship and care for persons on board.
- Maintain seaworthiness of the ship. (6)

In table A-III/1, there are a total of 17 competences for the operational level, and 6 of them may be evaluated by simulator; that is the 35.3%.

More specifically the Marine engineering section (operational level) consists of 5 competences, 4 of them may be evaluated by simulator representing the 80%; the Electric, electronic and controls engineering section (operational level) consists of 4 competences, 1 of them may be evaluated by simulator which means the 25%, and the Controlling the operation of the ship and care for persons on board section (operational level) has 8 competences but only 1 may be assessed by simulator, that is the

12.5%. There are no competences that may be evaluated by simulator in the Maintenance and repair section.

The competences that may be evaluated at **management level** are the following:

Marine Engineering.

- Manage the operation of propulsion plant machinery. (7)
- Plan and schedule operations. (8)
- Operation, surveillance, performance assessment and maintaining safety of propulsion plant and auxiliary machinery. (9)
- Manage fuel, lubrication and ballast operations. (10)

Electrical, electronic and control engineering.

- Manage operation of electrical and electronic control equipment. (11)
- Manage trouble-shooting, restoration of electrical and electronic control equipment to operating condition. (12)

Maintenance and repair:

- Detect and identify the cause of machinery malfunctions and correct faults. (13)

Controlling of operation of the ship and care for persons on board.

- Control trim, stability and stress. (14)
- Monitor and control compliance with legislative requirements and measures to ensure safety of life at sea, security and protection of the marine environment. (15)
- Use leadership and managerial skills. (16)

In table AIII/2 there are a total of 14 competences for the management level and 10 of them may be assessed by simulator; that is the 71.4%.

More specifically, the Marine engineering section has 4 competences and all of them may be evaluated by simulators, which means 100% of the competences; the Electric, electronic and controls engineering section (management level) consists of 5 competences, 2 of them may be evaluated by simulator which means the 40%; the Maintenance and repair section consists of 3 competences, 1 of them may be evaluated by simulator which means the 33.3% and the Controlling the operation of the ship and care for persons on board section (management level) has 5 competences and 3 of them may be assessed by simulator, that is the 60%.

Considering the two levels being analysed (management and operational) there are a total of 31 competences and 16 may be evaluated by using simulators; that is the 51.6%.

Table 1. Summary table of competences (in percentage) evaluable by simulator considering STCW function Groups

STCW function Groups	Evaluable by simulator (operational level)	Evaluable by simulator (management level)
Marine engineering	80%	100%
Electric, electronic and controls engineering	25%	40%
Maintenance and repair section	0%	33.3%
Controlling the operation of the ship and care for persons on board	12.5%	60%

Finally some competences, although they may be evaluated by simulator, also require some supporting material (SM):

- For competence (3), (4), (7), (8), (10), (11) the supporting material may be mechanical publications, dismantling schemes, flow charts and safety procedures review.
- For competence (6) and (14) the use of stability, trim and stress tables, diagrams and stress calculating equipment is required.
- For competence (15) there should be a review of international maritime law, international agreements and conventions during briefing due to the fact that this point is not completely assessable with simulator but must be included in the training program.

3.2 Knowledge, understanding and proficiency of the column 2 of Table A-III/1-2

In column 1 of tables A-III/1 and A-III/2, the competences to remember (or update) and to assess are mentioned, but in column 2, the knowledge to acquire is specified. Therefore, of the sixteen competences evaluable with simulator, not of knowledge of each of these competences is assessable by simulator. On the other hand, there are certain skills that are not strictly evaluated by simulation, but may require the use of additional material. Therefore, this knowledge may also be updated and evaluated through additional material. In other words, although these points cannot be developed or evaluated with the training tool (simulator), they must be included in the training program.

This section aims to determine the knowledge required for each of the 16; that is, more detailed selection will be provided based on the specific knowledge that students need to refresh or update, and for which they must demonstrate their understanding and proficiency.

Table 2 shows a list with the specific knowledge areas for each competence and the use of Engine Room Simulator (ERS). If a knowledge aspect is evaluable by using additional material apart from the ERS, rather than mentioning the type of simulator, this is indicated as Supporting Material (SM). In case of a specific knowledge that today cannot commonly be assessed by simulator or SM, it is indicated by “It depends on the simulator”.

Table 2 ERS and SM required for competences from (1) to (6)

Competence (1) Maintain a safe engineering watch	With **ERS**
Competence (2) Use internal communication systems	With **ERS**
Competence **(**3) Operate main and auxiliary machinery and associated control systems	With **ERS**
Competence (4) Operate fuel, lubrication, ballast and other pumping systems and associated control systems	With **ERS &** a) Operational characteristics of pumps and piping systems, including control systems. **With ERS; some SM may be used during briefing (dismantling schemes, power point presentations or video tutorials)**
Competence (5) Operate electrical, electronic and control systems	With **ERS &** Control system: a. Various automatic control methodologies and characteristics. **With SM during briefing.** b. Proportional-Integral-Derivative (PID) control characteristics and associated systems devices for process control. **It depends on the simulator.**
Competence (6) Maintain seaworthiness of the ship	With **ERS &** *Ship stability.* **With SM during briefing and debriefing understanding that comprehension must be demonstrated by simulated action.** *Ship construction.* **With SM during briefing such as structural ship design programs.**

And for competences at management level:

Table 3 ERS and SM required for competences from (7) to (16)

Competence (7) Manage the operation of propulsion plant machinery	With **ERS**
Competence (8) Plan and schedule operations	With **ERS &** a) Physical and chemical properties of fuels and lubricants. **With SM during briefing.** b) Technology of materials. **Depending on the simulator**. c) Naval architecture and ship construction, including damage control. **With SM during briefing such as structural ship design programs**
Competence (9) Operation, surveillance, performance assessment and maintaining safety of propulsion plant and auxiliary machinery	With **ERS**
Competence (10) Manage fuel, lubrication and ballast operations	With **ERS**
Competence (11) Manage operation of electrical and electronic control equipment	With **ERS**
Competence (12) Manage trouble-shooting, restoration of electrical and electronic control equipment to operating condition	With **ERS**
Competence (13) Detect and identify the cost of machinery malfunctions and correct faults	With **ERS**
Competence (14) Control trim, stability and stress	With **ERS & With the SM during briefing and debriefing, understanding that comprehension must be demonstrated by simulated action**
Competence (15) Monitor and control compliance with legislative requirements and measures to ensure safety of life at sea, security and protection of the marine environment	This competence consists of a wide knowledge of legislative requirement, which can be explained and evaluated with the **SM during the briefing**. Nevertheless, **some skills may be simulated**, like for example, discharging oily water using a virtual flow-meter according to Marpol.
Competence (16) Use leadership and managerial	With **ERS**

4. Conclusions

In accordance with the spirit of STCW which promotes the use of simulators in MET since 1995 and considering that nowadays the competences of seafarers are usually demonstrated only in oral or written exams, it is necessary make the inventory of the marine engineer competences that can be demonstrated by approved simulator training, according to STCW 95/2010 Code Part A competences table.

This paper presents achieved results of the first stage of the IAMU Development Project titled “CoC course to revalidate marine engineers’ competences by using simulators”. Due to the fact that some of the competences necessary for revalidation are not assessable on simulator, an inventory of marine engineers’ competences by using simulators has been carried out. Considering the two levels being analysed (management and operational) there are a total of 31 competences and 16 of them may be

evaluated by using simulators; that is the 51.6%. Moreover, more detailed analysis is carried out based on the specific knowledge in Column 2 of tables A-III/1 and A-III/2.
This selection process of competences will be the point of departure for the following stages of this development project: the design of two CoC model courses to provide training and use of simulation material for marine engineers.

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Session 1C

MARITIME ENVIRONMENTAL ISSUES & ENERGY EFFICIENCY

(No. 1)

A method to identify an optimum speed of ships for ship efficient operation

Prof. DSc. Dang Van Uy[1]; Dr. Pham Xuan Duong[2]

1.Vietnam Maritime University, dvuy@hn.vnn.vn, 484 Lach Tray Str., Haiphong City
2. Vietnam Maritime University, phxduong@vimaru.edu.vn, 484 Lach Tray Str., Haiphong City

Abstract: An efficient operation of ships is essential task required to all shipping companies in over the world. The concept of ship efficient operation is very different; however the minimum consumption of fuel for a voyage is a good explanation of the ship efficient operation. To use a minimum fuel for a voyage can be achieved by optimum speed of a ship, but the ship optimum speed is depending on some factors such as sea condition, ship condition, mode of ship charter and so on. In this paper, there presents a method to calculate an optimum speed of a ship within actual operation conditions in order to help operators following well Ship Energy Efficiency Management Plan-SEEMP).

Keywords: ship operation, optimum ship speed, SEEMP.

1. Introduction

The expenditure of fuel in shipping is normally taken about 35% to 40% of the total operation cost of a ship. Although, shipping companies are aware about this problem, but almost companies do nothings to minimize the fuel consumption even at the period in which the fuel price was as highest. Recently, in Vietnam, we carried out some surveys about what method a shipping company usually uses to minimize the fuel consumptions during ship operation. The answers from almost shipping companies are to set a package of fuel for a voyage or to set an operation speed for a ship and on a base of the ship speed, an amount of fuel per hour is supplied for a ship. So, it is clear that shipping companies do not have appropriate methods to control usage of fuel on board ships. Therefore, there results in increasing operation cost of a ship and also there may create a good condition for crews to do cheating in using fuel oil.

At present time, the shipping is highly competitive worldwide. Although, the fuel price sometimes is decreased from last year. But, the pressure of the environment protection is higher due to the requirements on control of NO_x emission from marine diesel engines in Annex VI, MARPOL 73/78. According to those requirements, marine diesel engines must be equipped with special exhaust gas emission treated apertures and shipping companies also must be required to minimize the fuel consumption in order to meet the EEOI.

For complying with the dual purposes such as minimizing fuel consumption and environment protection, International Maritime Organization has already proposed so called the Ship Energy Efficiency Management Plan (SEEMP). In this Plan, there are many recommended items which should be implemented in order to help shipping companies and ships to meet safe and efficient operation of ships. However, among those recommended items, how to reach optimum operation speed of a ship rather is most important.

2. Proposed concept of optimum operation speed of ships

In practical, a concept of optimum operation speed of ships is very different in connection with boundary conditions. In some cases, the optimum speed is depending on a minimum fuel oil consumption of a main engine. It means that the optimum speed will be calculated on base of function between ship speed and minimum fuel usage per hour. But in other case, the optimum operation speed of ships will be determined by using an objective function between ship speed and operation expenditure for one voyage. However, the above explanation about optimum operation speed of ships can achieve only limited operation conditions and does not concern anything with a contribution into the environment protection which is mentioned by the Index of Energy Efficient Operation (EEOI).

2.1 Procedure to determine an optimum operation speed of ships

The requirements of IMO covering multi-purposes which include both effective operation of a ship and engine exhaust gas emission control make shipping companies in difficult situation of implementation. An appropriate solution for this objective is to raise a suitable function which can estimate an optimum operation speed of ships on a base of boundary conditions such as actual loading conditions, sea state, and mode of ship chattering, fuel price and some others. Therefore, an appropriate concept of an optimum operation speed of ships is presented by a function (1) as follow:

$$V_{opt} = f(R_s, D, P_f, M_{charter}, S_{con}) \quad (1)$$

In which: R_s- basic ship resistance; D- ship draft; P_f - actual fuel price; $M_{charter}$- mode of ship charter (voyage charter or time charter); S_{con}- sea state.

A new ship was designed and built with specific technical features such as total length, width, draft speed, propulsive power and displacement. With that, the resistance of ship can be determined and defined as a basic resistance (total resistance). The basic resistance of a ship will be changed dramatically during operation depending on load conditions, sea state and technical state of hull, propulsion system.

The basic resistance of a ship consists of many source resistances that can be classified into three main groups: frictional resistance, residual resistance and air resistance. In fact, during ship sailing on open sea, the basic resistance of a ship is influenced by sea wave, air, hull fouling and wind direction to ship. Therefore, the basic resistance of a ship is normally increased. The phenomenon of ship resistance increase makes a reduction of ship speed and increase of main engine fuel consumption. So, if shipping companies want to operate ships with high efficiency, the companies must find out an optimum speed of ships. To solve this problem, a calculation procedure of an operation optimum speed of a ship is proposed to be carried out into five stages.

- Ship basic resistance will be determined on a base of specific technical features of an actual ship;

- A change of ship basic resistance will be estimated on a base of actual operation conditions such as loading condition (ship draft), sea state, wind direction and some other more if it is necessary;

- Based on a mode of ship charter and calculated results from first two stages mentioned above, a ship optimum operation speed will be determined;

- To verify the determined optimum operation speed of a ship (stage 3), let check a time of ship arrival to a port based on criteria “Just on time”;

- To determine the index of energy efficient operation of ship (EEOI) in certain period of ship operation in orders to verify a ship operation in compliance with requirements of the environment protection.

2.2 Formulas needed in determination of ship optimum speed

In practice, to determine an optimum operation speed of ships is complicated. There is no concert mathematical model for this purpose due to many boundary conditions influencing on the optimum speed of ships. Therefore, helping to come to final result of optimum speed calculation, there needs to use several formulas concerning with ship resistance, gross profit of shipping and some others. Our idea in order to create a method to determine an optimum operation speed of ships is to divide needed formulas into four groups:

a- Formulas to calculate basic resistance of ships

b- Formulas to calculate changes of ship resistance such as:

- Wave resistance:

$$\Delta R_w = dR_0\left[0.667 + 0,333\cos\sim\right]; \quad \Delta R_0 = 0.64 H_w^2 C_B \frac{B}{L} g^{\circ} \qquad (2)$$

In which: $\sim$ - angle of wave to ship (0^0 is head sea) [^{0}]; H_w - height of wave [m]; C_B - block coefficient of ship; B- width of ship [m]; L-lengthen between perpendiculars [m]; $^{\circ}$ - density of sea water [kg/m3].

- Air and wind resistance:

$$\Delta R_A = 0.28 \times 0.5 B^2 \times V_w^2; \quad V_w = 5.53 H_w - 0.093 H_w^2 \qquad (3)$$

In which: V_w - wind velocity [m/s] and wind velocity is calculated on base of height of sea wave.

- Resistance due to hull roughness:

$$\Delta R_{Foul} = \frac{140d}{630 + d} \text{ [\%] or } \Delta R_r = K \times S \times V^n \qquad (4)$$

In which: d- days out of dock; K- coefficient; n- coefficient [1.9 to 2.1]; S- wet surface of ship and $S = 2.56(W \times L)^{0.5}$ [m2].

- Resistance due to draft:

$$\Delta R_D = 0.65 R_T\left(\frac{\nabla_0}{\nabla} - 1\right); \quad R_T = 0.5 \times {}^{\circ} \times V_0^2 \times S \times C_T \qquad (5)$$

In which: R_T- basic resistance of ship; ∇ - actual displacement of ship; ∇_0 - design displacement of ship; S- wet surface of ship; V_0- design speed of ship; C_T-coefficient.

c- Formulas to determine an optimum operation speed of ships:

As it is well known, the fuel consumption of a marine diesel engine is so much depending on an operation speed of a ship. Therefore, there must identify an optimum speed during a ship operation. To do so, it is necessary to create an objective function in order to find the optimum speed in conjunction with ship chartering mode (time charter or voyage charter). In fact, there are some objective functions, but an objective function which is chosen is a function determining a gross profit per day of a ship as mentioned in (6);

$$GS(d) = P \times W \times V\left[d - c_R - pF(d)\right] \qquad (6)$$

In which: P - freight rate per ton of good; W - ship displacement (DWT); d - ship sailing distance including ballast ship [nautical mile]; V - ship speed [knot/h]; C_R - expenditure of ship per day [USD/day]; p - fuel price[USD/ton]; F(d) - fuel consumption depending on ship speed V.

A fuel consumption of a ship can be expressed by F(d)= k.V^3; k - coefficient depending on operation conditions. Based on the mentioned relation of F(d), there can find a formula to identify an optimum operation speed of a ship as (7):

$$V_{opt} = \left(PW/3pkd\right)^{1/2} \tag{7}$$

The formula (7) can be used to determine an optimum operation speed of a ship if a calculated speed is higher than operation speed which is already set in a charter contract. This formula can also be developed to calculate an optimum operation speed of a ship in more complicated operation conditions which include a time in port, delay time due to bad weather and sailing time in canal of a ship. However, the mode of ship charter is real factor influencing on a mathematical model to determine an optimum operation speed of ships and the mathematical model can be expressed as follows:

- In case of ship time charter:

$$V_{opt} = V_{\max}\left[\frac{C_s + F_{Aux}}{(k-1)F_{ME}}\right]^{1/k} \tag{8}$$

In which: C_s- ship charter price per day [USD/day]; F_{Aux}- Fuel expenditure of auxiliary engines per day [USA/day]; F_{ME}- Fuel expenditure of main engines per day [USA/day]; k- coefficient depending on technical conditions of propulsion system; V_{max}- highest speed that can be generated by a ship [knot/h].

- In case of ship voyage charter:

As it is known that a goal of ship voyage charter is to reach maximum profit for every day. So, a mathematical model to determine an optimum operation speed of a ship will be expressed in other form as mentioned in (9)

$$24V_{opt} + \left[\frac{k \times S/RT\left(24V_{opt}\right)^{k-1}}{(k-1)P_{time}/RT}\right] = \frac{C_i\left(24V_{\max}\right)^k}{(k+1)\times F_{nl}\times P_{time}/RT} \tag{9}$$

Where: k- coefficient for both formulas and k = 3 for diesel propulsive system, k = 2.5 for steam turbine propulsive system; C_i - freight income and is equal to gross a value minus expenditure such as port fee, loading and unloading fee and some others; S - sailing distance for one round trip; RT- round trip of ship. Then the formula (9) can be realized by using trial and error method and final mathematical model as follow:

$$V_{opt} = \left[\frac{24\times C_i \times \left(V_{\max}\right)^k}{k \times F_{ME,V\max} \times S/RT}\right]^{1/k\_+1} \tag{10}$$

Where: F_{ME}, V_{max}- fuel consumption per day at maximum operation speed of a ship.

d- Formula to determine EEOI

An index to ensure whether a ship, which is complied with requirement of environment protection is an Index of Energy Efficiency Operation mentioned in Annex VI, MARPOL 73/78. The index is expressing a ratio between CO2 volume [M] discharged by a ship per unit of ship transportation. The index is modelled to express an energy efficiency operation of a ship for one voyage and for a period of ship operation. For a voyage, the index is expressed as follow:

$$EEOI = \frac{\sum_j FC_j \times C_{Fj}}{m_{cargo} \times D} \quad \text{[MCO2/voyage]} \qquad (11)$$

and for a period of ship operation:

$$Average\,EEOI = \frac{\sum_i \sum_j \left(FC_{ij} \times C_{Fj}\right)}{\sum_i \left(m_{cargo,i} \times D_i\right)} \qquad (12)$$

In which: FC- total fuel consumption of ship on open sea and in port for a voyage or a period of operation; j - a kind of fuel (DO or FO); i - voyage number; FC_{ij}- the mass of consumed fuel j at voyage i; CF_j is the fuel mass to CO_2 mass conversion factor for fuel j; m_{cargo} is cargo carried (tonnes) or work done (number of TEU or passengers) or gross tonnes for passenger ships; and D is the distance in nautical miles corresponding to the cargo carried or work done.

2.3 Determination algorithm of ship optimum speed operation

Based on the procedure to determine an optimum speed operation of ships and to ensure a ship in compliance with the environment protection, the above mentioned formulas are used to create an algorithm to determine an optimum speed operation of ships. The algorithm is expressed in figure 1 and then there can use MATLAB package software to solve the mentioned mathematical model to get unknown variables such as an optimum operation speed of concert ship, the EEOI and some other needed parameters.

3. Application on board ships

The mentioned method to determine an optimum operation speed of ships has been applied on board of two ships belonging to Khaihoan Ship marine Corp. Khaihoan Ship Marine is an Oil Tanker Company which has a Head Quarter in Ho Chi Minh City.

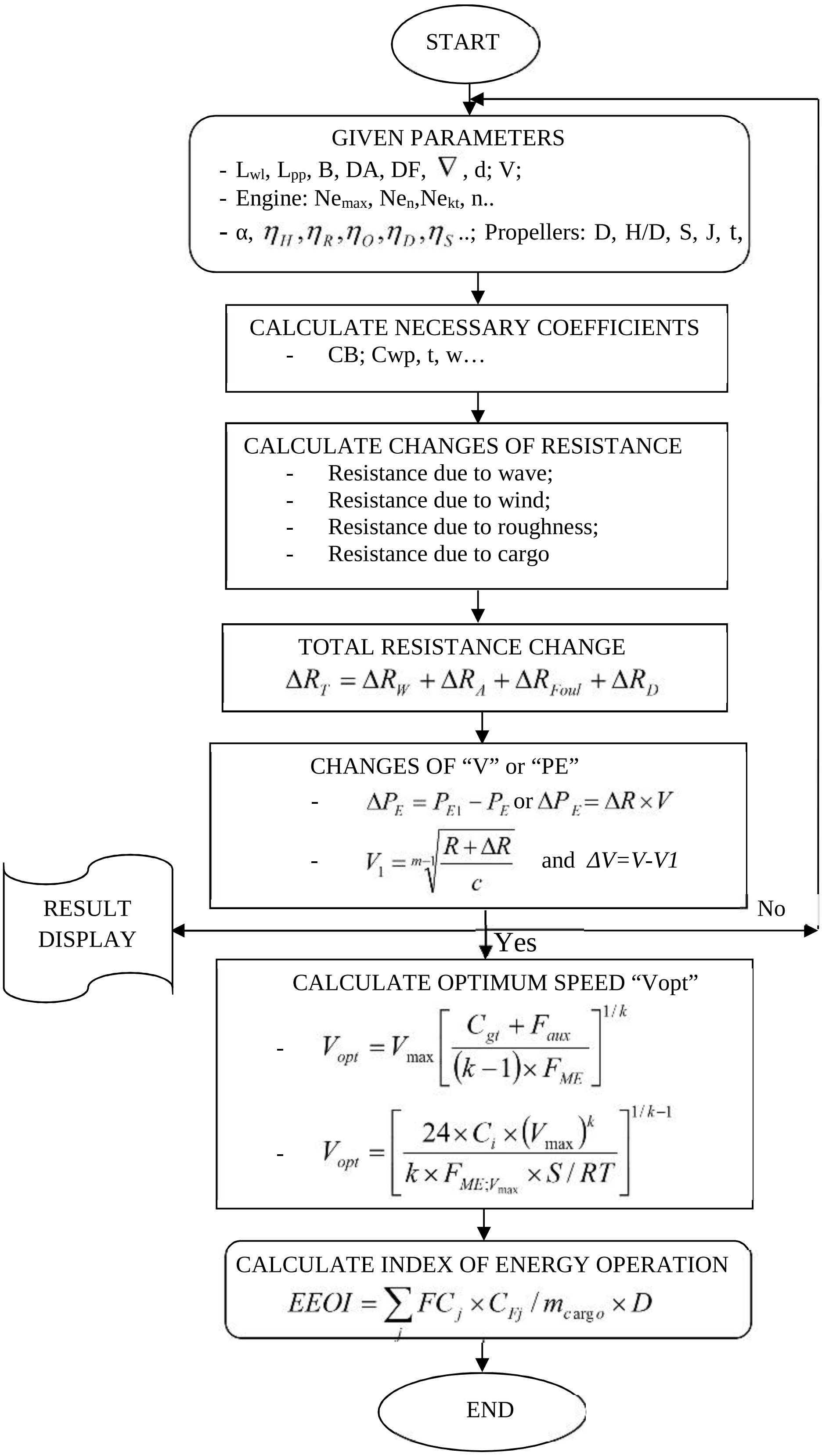

Figure1 Algorithm to determine an optimum operation speed of a ship

3.1 Technical features of M/S “Glory Ocean”

The Glory Ocean is oil/chemical tanker and she is under Bureau VERITAS classification. Her main technical features are mentioned in table 1.

Table 1 Main technical features of M/S Glory Ocean

No	parameters	value
Hull		
1	Dead weight [DWT]	12.806
2	Total length[m]	134,85
3	Length between perpendiculars[m]	126,8
4	Register width [m]	22,0
5	Register draft [m]	10,6
6	Design draft [m]	7,78
7	Operation speed [knot]	13,2
8	Maximum operation speed [knot]	14.0
Main engine		
1	Engine Name	8PC2-6/2L, 4 strokes
2	Number of cylinders	8
3	MCR [kW]	4400
4	Nominal revolution[rpm]	520
5	Reduction gear ratio	3.0

3.2 Application results

- **Voyage**: The Glory Ocean was sailing from Vungtau City to Quinhon port and back with full load and ballast. Distance of sailing is about 356,8 [nautical miles]. We did test on board ship under two operation conditions namely: under ballast condition and full load condition. The technical features of the both conditions are mentioned in tables No.2. Meanwhile, test results are showed in table No.3 for the ballast condition and No.4 for the full load condition.

Table 2 Operation conditions of M/S Glory Ocean

No	Operation conditions	Value	Remark
Ship under ballast			
1	Bow draft	3,2 [m]	
2	Stern draft	5,8 [m]	
3	Sea state	NE Bo 3 and 4	
Ship under full load			
4	Bow draft	10,0 [m]	
5	Stern draft	10,0 [m]	
6	Sea state	NE Bo 3 and 4	
7	Mode of ship charter	Voyage Charter	
8	Operation speed and revolution of a main engine	500 [rpm]; 166,6 [rpm]; 13,2 [knot/h]	
9	Kind of fuel	FO	

- **Ship under ballast**

Based on the technical features and operation conditions, selection of an optimum operation speed of m/s Glory Ocean has been determined by using the algorithm (figure1). The algorithm then was solved on MATLAB package software and all necessary results are showed in table 2.

Table 3 Selection of an optimum operation speed under ballast conditions

Operation parameters	Optimum operation plans					Remark
	Calculation	**PA2**	**PA3**	**PA4**	**PA5**	
Engine revolution [rpm]	460	457	465	475	478	
Ship speed [knot/h]	13.02	12.9	13,2	13,8	14,8	
Arrival time (#)	-1h	-2 h	Just in time	+1h08	+2h53	
Fuel consumption [l/h](*)	639.4	620.0	643.69	648.26	661.16	
Fuel consumption per day [T/day]	13.5	12.8	14.10	14.20	14.50	

(*) fuel consumption measured by flow meters

(#) Arrival time is indicated by (-) [late arrival] and (+) [earlier arrival]

- **Ship under full load**:

Using the same procedure as for the ship sailing under ballast, results of selection of an optimum operation speed are presented in table 4.

Table 4. Selection of an optimum operation speed under full load

Operation parameters	Optimum operation plans					Remark
	Calculation	**P1**	**P2**	**P3**	**PA5**	
Engine revolution [rpm]	465	460	470	472	-	
Ship speed [knot/h]	~13.0	12.8	13.2	13.5	-	
Arrival time (#)	- 20 [min]	-1,5 [h]	Just on time	+34 [min]	-	
Fuel consumption [l/h](*)	659	651.43	666.00	698.06	-	
Fuel consumption per day [T/day]	13.95	13.85	14.59	15.29	-	

3.3 Discussion

To find an optimum operation speed of M/S Glory Ocean, the procedure and algorithm mentioned above have been used. For both cases, optimum operation speeds of the ship were calculated, then on a base of the calculated speeds, let the ship sailing with that in certain period of time (may be one or two hours). During this period of trial, a fuel consumption of main engines was taken by flow meters and an arrival time also should be estimated. Next stage is to make some other plans with the ship operation speeds which are lower or higher than the calculated speeds and then all the optimum plans should be taken into comparison. Best plan is a plan in which an operation speed of a ship will allow ship arrives on time with minimum fuel consumption. In case of M/S Glory Ocean, a good operation plan can be chosen as follow:

- For ship under full load: there can operate the ship with a main engine revolution of 460 rpm or 465 rpm (calculated speed) and used fuel for only main engine can be saved 0.74 T/day, although the ship will arrive to port a little bit late in comparison with plan "just on time";

- For ship under ballast: the plan with calculated speed should be chosen and ship may arrive to port about one hour later.

4. Conclusion

At present period, the shipping is very competitive worldwide. One hand, the shipping companies must ensure their ability in carrying goods safely with reasonable freight rate and in the other hand, shipping companies also must comply with the requirements of environment protection. It means that ships have to be in good technical conditions; therefore they may or have to be equipped with further necessary equipment in order to support ships in compliance with strict standards set by IMO in Annex VI, MARPOL 73/78. However, according to our survey results, even some newly built ships cannot match the criteria of EEOI during operation. There can conclude some reasons, but mainly ship crews have a problem with understanding about ship optimum operation speed and EEOI.

The procedure and algorithm of determination of ship optimum operation speed as mentioned above is necessarily to be developed and applied on board ships. The test results in m/s Glory Ocean are very positive and are highly appreciated by the owner (Khaihoan Ship Marine Corp.). The method is being in further development under support of Vietnam Ministry of Transportation and it will be widely used to help shipping companies and ship crews in Vietnam.

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Polarworthiness and Co-operation – Efficient education of risk management for arctic environment

Peter Ivar Sandell, Senior lecturer of Maritime and Commercial law

Satakunta University of Applied Sciences, peter.sandell@samk.fi, Suojantie 2, 26100 Rauma, Finland.

Abstract The Polar Code enters into force and the Maritime Academies and Maritime Universities have a task to train the seafarers and company management facing the implementation into the vessels practice and company practice. The subject of the article is to examine the changes brought by the Polar Code that influence the environmental risk management. The International Maritime Organization IMO is to update the SOLAS, MARPOL and STCW Conventions, to take account of the specific features of the Polar Regions. These updates will take effect at the beginning of 2017. At the beginning of the article there is a short description of Polar Code key issues, as well as a brief explanation of the existing regulation in the Arctic regions from environmental protection point of view.

The effects of the Polar Code were investigated by the term polarworthiness. When the vessels move in region where polar code is effected, new rules will require ships of different things, and their importance to ship's seaworthiness is described in this article in relation to environmental risk management.

Teaching these new issues has potential for co-operation between Maritime Universities. Polar Code implementation is an important issue not just northern shipping companies, but also all companies which consider the use of northern route from Asian markets to Europe in the future.

Maritime Universities can do research and co-operate with the companies already present in the Arctic environment. The co-operation between Universities and companies can and will be used to provide in depth study courses, which can be delivered also to other Maritime Universities through student exchange and seminars. Building a course module for environmental risk management for ice operations will be presented - Company representatives have taken their Master of Maritime Management degree and produced parts of in-depth study course in Arctic Shipping Management based on their research together with Satakunta University of Applied Sciences. The topics presented as examples are STS-operations in the arctic environment, oil pollution response planning in the arctic and DP ice management. The model of using the Master of Maritime Management student´s expertise in creation of new knowledge and use of the alumni organisation in teaching the specialised courses will be presented.

Keywords: Maritime education and training (MET), Polarworthiness, Polar Code, risk management, environmental risk assessment, environmental liability, methods of learning, safety and security, student exchange and co-operation.

1. Introduction

The IMO Polar Code enters into force creating new standard of seaworthiness for Arctic Shipping.

The new code sets the standards of seaworthiness in the Polar context. Implications for maritime contracting (risk management and risk sharing) in the polar environment needs to be addressed by the shipowner´s and their masters. The International Maritime Organization IMO is to update the SOLAS, MARPOL and STCW Conventions, to take account of the specific features of the Polar Regions. These updates will take effect at the beginning of 2017. Polar Code is not an own Convention, but it updates SOLAS, MARPOL and STCW conventions [1].

2. Polar Code raises standards of seaworthiness in the Polar Context

The effects of the Polar Code were investigated by the term polarworthiness. When the vessels move in region where polar code is effected, new rules will require ships of different things. Fitness is a relative term, and implies fitness to the vessel's working environment: Equipment (propulsion, navigation, safety, cargo, etc.), supplies, number and training of crew, etc.IMO's Polar Code addresses both technical issues and training issues. Polar Code recognizes the unique nature and risks of the Arctic environment [1].

Polar Codes part on operations and manning relates to navigation (ice conditions, weather). Ship entering polar waters need a specific Polar Ship Certificate and Polar Water Operational Manual.
Appropriate basic training for open-water operations and Advanced training for other waters, including ice needs to be created and arranged [2]. The Code provides standards for both polar ready vessels and crews in order for the vessel to be considered Polarworthy.

Specific problems arise when meeting the demands of Polarworthiness. The harsh and fragile environmental conditions create challenges for operation in Polar waters. Lack of infrastructure is a special problem. Especially this consists of lack of navigational aids, lack of bunker facilities and lack of repair facilities. The vessels entering Polar waters need to need to be able to operate more independently than usually. Technical assistance, salvage and ice breaking are services which are not available like elsewhere in more southern levels.

Achieving polarworthiness demands is crucial for ship owners who need to assess their potential risks and liabilities. If the vessel is not seaworthy in arctic conditions the environmental liabilities cannot be limited. The insurance aspects are also related to seaworthiness: If the vessel is not seaworthy in arctic environment, the insurance cover will not be in force or if the safety regulations are breached, according to Nordic Marine Insurance Plan, the insurance will not cover the casualty. The Polar Code is automatically considered as a safety regulation under the Nordic Marine Insurance Plan [3].

Many Nordic ship owners insure their vessels on Nordic standard conditions and for those using these conditions it is enough for their risk management and insurance cover to follow the SOLAS, MARPOL and STCW conventions in version updated by Polar Code rules (as well as other conventions by IMO related to safety of vessels) to be certain that their risks are covered also by their insurance conditions. However, few non Nordic owners use Nordic insurance conditions and in the future many ship owners who will be interested in entering Polar waters will be covered by English law of marine insurance and English Marine Insurance Clauses and conditions.

Seaworthiness in English law may be defined like *Tetley*: "Seaworthiness may be defined as the state of a vessel in such a condition, with such equipment, and manned by such a master and crew, that normally the cargo will be loaded, carried, cared for and discharged properly and safely on the contemplated voyage." [4]. In other words, the essential issue is fitness for purpose and carriage relating to the polar and arctic environment. Therefore, the term polarworthiness is the term which we need to address and examine when we concentrate on the specific requirements in risk management for the Polar regions.

What is required of a vessel in order to be polarworthy throughout the voyage? Fitness is a relative term, and implies fitness to the vessel's working environment and harshness of the conditions to be expected during and throughout the voyage contemplated. When examining the expected fitness in Polar waters the Polar Code concentrates on equipment (propulsion, navigation, safety, cargo, etc.), supplies, number and training of crew, etc.IMO's Polar Code addresses technical issues and training issues. Polar Code recognizes the unique nature and risks of the Arctic environment and for the first time as a mandatory regulation it creates a standard of seaworthiness specifically for Polar environment which needs to be addressed by the ship owners as a part of their risk management in order to comply the international standards of safety in this region and to held their insurance cover in force throughout the journey.
Seafaring is especially risky business. Therefore, the modern insurance system was first established for maritime trade. Risk management in the Polar shipping defines the issue: Who is to bear the risk (of

casualty, cargo loss, damage to the environment or delay) in the Polar context and how can these risks be shared or carved out? Polar Code as well as the other safety conventions is also a tool of risk management: Following the international standards is of utmost importance and procedures in complying with the standards by company procedures is the starting point.

Developing the company procedures in critical issues (relating to Polar environment) in uniform manner is the key element which can be achieved by in co-operations with the education and ship owners risk management professionals as we will examine below in the chapter four in this article. The investment on developing company procedures relating to safety in the arctic regions is a necessity – It has to be also a clear indication of company strategy if the company wants to avoid the negative publicity in using the arctic regions. In Nordic countries we have examples of companies facing severe difficulties with public image and organisations like Greenpeace if the company management has not made a decent risk assessment on the operations in the Polar region. Even though the organisations like Greenpeace do not have that purpose, their actions create environmental concerns when they forcefully enter the offshore platforms or supply vessels or try to prevent them from working in the region.

3. Educating seafarers for the Arctic

IMO gives guidance for implementation of the new Rules [2]. Model courses do not however meet all the demands the shipowner´s and masters are facing in the area. Teaching these new issues has potential for co-operation between Maritime Universities.

Polar Code implementation is an important issue not just northern shipping companies, but also all companies which consider the use of northern route from Asian markets to Europe in the future. The economic advantages are lucrative when using the northern route. This creates possibilities especially for Nordic Maritime Universities in exporting the education and attracts students to choose Nordic Universities as a destination for student exchange. The Nordic Universities should use this challenge and develop their activities to meet this challenge.

As approximately 80 % of maritime accidents have human elements involved when casualty occurs in relation to a vessel, the training of the seafarers for the Polar conditions is an important part of Polarworthiness of vessels when the Code enters into force. After 1 January 2017, ships operating in polar waters shall be appropriately manned with adequately trained, qualified and experienced seafarers, taking into account the relevant provisions in the STCW Convention and Code [2].Amendments to the STCW Convention and Code regarding the training and certification associated to the Polar Code are expected to become effective in 2018. New training guidance for personnel serving on board ships operating in polar waters need to implemented before that. Measures to ensure the competency of masters and officers of ships operating in polar waters has to be created by the Maritime Universities. Training for Masters, Chief Mates and Officers in charge of a navigational watch on ships operating in polar waters is mandatory requirement but the problem is that not all Maritime Universities have enough expertise in teaching the navigation in the Polar waters. The starting point for the training are the international requirements, but several countries have local legislation which need to be implemented in the training requirements when the vessels are about to enter their waters, e.g: Russia, Canada, Norway and the US [2].

When considering the basics of the education needed for Masters and officers in charge of a navigational watch, they should receive basic training or instructions as determined by the Administration on Ice characteristics and ice areas, relevant education on Ship's performance in ice and cold climate as well as Operating and handling a ship in ice. For masters and chief mates on board ships sailing in Polar waters the following skills are needed in addition: Knowledge of voyage planning and reporting, knowledge of equipment limitations, knowledge of safety, knowledge of commercial and regulatory considerations [2].
The importance of expertise in teaching these topics is essential for the safe operation of those who take the courses. The issue of Polarworthiness in relation to the quality of training will probably be raised in a court - If there will be a casualty. Therefore, we need to think how to achieve the best possible modes

for educating crew for polarworthy vessels? – At least it is the maritime Universities who should take care that if there will be vessels found not to be polarworthy.

It is up to the training institutions to assure the vessels are not breaking the rules on seaworthiness due to indecent training for the Polar environment. The co-operation here is more important than ever before. As most Maritime Universities have no experience at all on training crews for the vessels operating in the arctic, we must share our experiences in a situation when entering Polar waters in the future is lucrative for most ship owners. In this respect I see the IAMU organisation and family of Universities as an important tool for Unification of the training in the years to come.

4. Modes of co-operation for achieving arctic excellence

Maritime Universities in Nordic countries have a huge benefit when they develop education for arctic environment. Many Universities do research and co-operate with the companies already present in the Arctic environment. The co-operation between Satakunta University of Applied Sciences and companies is already used to develop in depth study courses, which can be delivered also to other Maritime Universities through student exchange and seminars. Building a course module for environmental risk management for ice operations is already on its way. Company representatives have taken their Master of Maritime Management degree and produced parts of in-depth study course in Arctic Shipping Management based on their research together with Satakunta University of Applied Sciences.

Some examples of the research conducted in co-operation with the student working in the companies with arctic experience and the University can already be listed. This co-operation is part of the research work of the University as well as risk management procedure of the companies working in the Polar regions:

Tanker operations in the arctic environment are especially risky due to the environmental vulnerability of the region and the specific risk element for tankers relating to the ice pressure. The ship to ship operations of tankers (STS-operations) in the arctic are however a necessity in specific circumstances. In a research study the safety procedures of STS operations in this environment are analysed, data from previous operations is collected as well as silent information from the captains with tens of years of experience from the arctic altogether is analysed in order for the risk assessment tool for the tankers operating in the arctic to be developed [5]. Tanker fleet personnel operating in the arctic environment is highly skilled group of seafarers. The experience and practices adjusted to the new Polar code requirements is a model example of the co-operations between Maritime Universities and specialised shipping companies. Tanker operations in ice is one of the expertise courses to be developed based on the co-operation in research work.

Another important research project to be analysed is oil pollution response planning of the company operating in the arctic [6]. The problems of collecting oil from sea with ice cover or ice blocks has been an issue for researchers for decades. Taking the technology to Polar areas is especially important but also extremely costly. Effective as well as cost effective produces and equipment together with a company environmental response strategy are part of a research combined into Master's thesis and company development project which will also benefit the Arctic environmental risk courses of the University in the future. The oil catastrophe in the arctic is something which no one dares to imagine – But the companies planning their activities has to prepare for the worst scenario. The Maritime training institutions cannot turn a blind eye either.

Third example of an ongoing research project is DP ice management, which is also a topic very little examined by researchers [7]. The topic is and research is highly based on persons with long experience in offshore activities in the arctic environment. This project is well targeted to serve the persons who need further education on DP in the arctic environment in the future years when the offshore industry recovers and the arctic drilling projects now waiting for implementation will be carried out. Safe offshore drilling in the harsh environment is highly dependent on the skilled experts navigating and operating in ice.

Satakunta University of Applied Sciences uses the Master of Maritime Management student´s expertise as well as the own staff'sexpertise in creation of new knowledge and use of the experienced Masters are also used in teaching the specialised arctic courses. The strength of the education is close co-operation with the companies workingin the Polar region. The companies which can be specially referred to are Neste Shipping Ltd. and Arctia Shipping Ltd. and Arctia offshore Ltd. We feel privileged to have their best people working together with our University´s staff and further educating together crews for the vessel operating in the Polar waters and ensuring that all our students and exchange students visiting our institution get the best possible education and the latest experience from the Polar water navigation experts.

The ship design and shipbuilding industry in Finland is concentrating also to designing and building specialised vessels for arctic regions. Combining this knowledge to the course development and using the expertise of the companies in teaching the courses gives also great advantages for those attending the courses in Nordic Universities.

5. Conclusions

Polar Code is an important tool for the industry. Its implementation needs to be done with cautiousness by the companies that intend to operate in arctic regions. Therefore, the educations of those who will operate in the region also needs to be done properly. It is also important for the image of seafaring and shipping community in general.

The environmental organisations are strongly opposing the use of arctic regions for transportation and especially for offshore activities. We all remember the consequences of the *Exxon Valdez* accident in Alaska 1989 and its impact in the oil transport industry as well as the legal implications that followed the incident. If the industry wants to operate in arctic regions, we cannot afford to allow any more fatal catastrophes even near the arctic. The education is of the essence and we need to use every opportunity to show that the education system together with the shipowners is ready to invest in education and preventing the spills to the sensitive areas. Therefore, we need to seek co-operation together with the Universities and the industry to make the arctic shipping as safe as possible. I hope our practice in this field described in this presentation is an example for other institutions. We are happy to share our experiences to fellow colleagues and visiting professors as well as exchange students.

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Energy Efficiency Design Index Verification through Actual Power and Speed Correlation

Quang Dao Vuong[1], Professor Don Chool Lee[2], Professor Ronald D. Barro[*]

1. Mokpo National Maritime University, quangdao.mtb@gmail.com
2. Mokpo National Maritime University, ldcvib@mmu.ac.kr
**. Corresponding Author: Mokpo National Maritime University, rbarro@mmu.ac.kr, 91Haeyangdaehak-ro, Mokpo-si, Jeonnam, South Korea*

Abstract. The International Maritime Organization (IMO) mandatory requirement for Energy Efficiency Design Index (EEDI) has been in place since 01 January 2015 to address emission and global warming concerns. This regulation must be satisfied by newly-built ships with 400 gross tonnages and above. In addition, the MEPC-approved 2013 guidance, ISO 15016 and ISO 19019 on EEDI serves the purpose for calculation and verification of attained EEDI value. As such, verification should be carried-out through an acceptable method during sea trial and this demands extensive planning during propulsion power system design stage. Power and speed assessment plays the important factor in EEDI verification. The shaft power can be determined by telemeter system using strain gage while the ship speed can be verified and calibrated by differential ground positioning system (DGPS).

An actual measurement was carried-out on a newly-built ship during sea trial to assess the correlation between speed and power. In this paper, the Energy-efficiency Design Index or Operational Indicator Monitoring System (EDiMS) software developed by the Dynamics Laboratory-Mokpo National Maritime University (DL-MMU) and Green Marine Equipment RIS Center (GMERC) of Mokpo National Maritime University was utilized. Mainly, EDiMS software employs four channels – engine speed, ship speed, shaft power and fuel consumption - for the verification process. In addition, the software can continuously monitor air pollution and is a suitable tool for inventory and ship energy management plan. Ships greenhouse gas inventory can likewise be obtained from the base of emission result during the engine shop test trial and the actual monitoring of shaft power and ship speed. It is suggested that an integrated equipment and compact software be used in EEDI verification. It is also perceived that analog signals improve the measurement accuracy compared to digital signal. Other results are presented herein.

Keywords: shaft power, ship speed, exhaust gas emissions, energy efficiency design index (or operational indicator) (EEDI, EEOI), ship energy efficiency management plan (SEEMP).

1. Introduction

Shipping is the most efficient form of cargo transportation and with its increasing globalization have lead to the continued growth of the maritime transport. Along with this development, ships'exhaust emissions into the environment have become a big concerning issue. In addition, potential harmful influence on human health, cause acid rain and contribute to global warming are seen to be some of the negative effects of these emissions. In 2009, the shipping sector was estimated to have emitted around 3.3% of global CO_2 emissions of which the international shipping contributed roughly 2.7% or 870 million tonnes. If unabated, shipping's contribution to greenhouse gases (GHG) emissions could reach 18% by 2050 [1].

To address this concern, the IMO's pollution prevention treaty (MARPOL) under Annex VI has adopted the mandatory energy-efficiency measures to reduce emissions of GHG from international shipping. In July 2011, the 'Energy Efficiency Design Index' (EEDI) was adopted setting the minimum energy efficiency requirements and must not be exceeded the given threshold by new ships built after 2013. It is based on a complex formula, taking the ship's emissions, capacity and speed into account. The target requires most new ships with 400 gross tonnages and above to be 10%-, 20%-, and 30% more efficient by the year 2015, 2020 and 2025 respectively. The required EEDI value for newly-built tanker vessels with variation capacities is shown in Figure 1.

$$E = \frac{C \;_2 e\imath}{T \qquad w} = \frac{\sum P \quad \times C \quad f \quad \times S \quad .f \quad c \qquad io}{C \quad \times S}$$ (1)

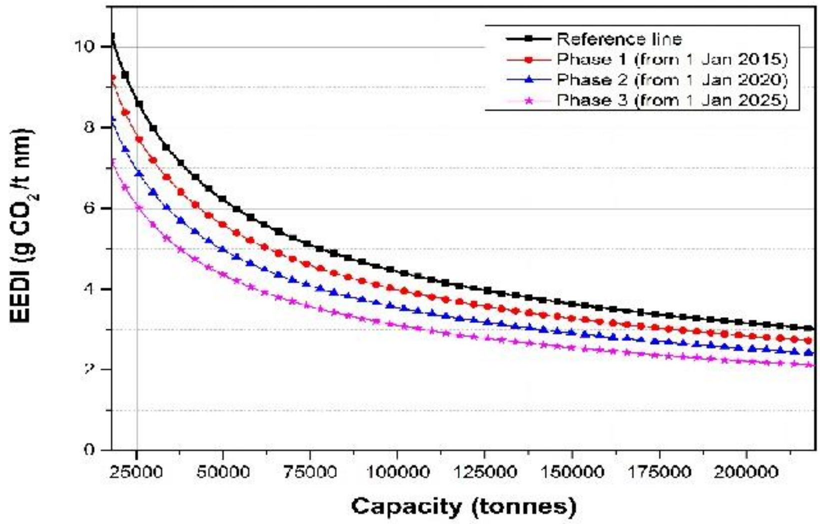

Figure 1 Required EEDI newly-built tanker vessels with variation capacities

Power and speed assessment plays the important factor in EEDI verification in accordance with the ISO regulations (Equation 1). The engine power can be measured by telemetric system using strain gage. The ship speed is obtained by differential ground positioning system (DGPS). An actual measurement was carried-out on a newly-built ship during sea trial to assess the correlation between speed and power. During sea trial, the output power, sailed route and ship speed were measured simultaneously. All signals were recorded and analyzed by **EVAMOS (Engine / Rotor Vibration Analysis Monitoring System)** software with **EDiMS** developed by the DL-MMU and the GMERC of Mokpo National Maritime University [2]. The software can continuously monitor air emission and is a suitable tool for inventory and ship energy management plan. Ships GHG inventory can likewise be obtained from the base of emission result during the engine shop test trial and the actual monitoring of shaft power and ship speed. It is suggested that an integrated equipment and compact software be used in EEDI verification. It is also perceived that analog signals improve the measurement accuracy compared to digital signal.

2. Engine power and ship speed measurement with EDiMS software

2.1 Power measurement

For power measurement, the MANNER telemetric system was used. One full bridge strain gage (Wheatstone bridge) was installed to measure the shear stress on the intermediate shaft when the engine is running. The basic diagram of the Wheatstone bridge is shown in Figure 2. It includes 4 gages having variable resistors changing proportionally with the changing of the surface length of the shaft. When stress exists, it results in shaft deformation and changes the gage resistance and consequently change the ratio between the output and input voltage (V_{out}/V_{in}) applied on the strain gage. This ratio varies as a linear function of the stress on shaft. As such, the torque generated on shaft by the diesel engine can be measured after calibration. Together with the shaft speed measured by tachometer, the shaft power can be obtained by the following equations:

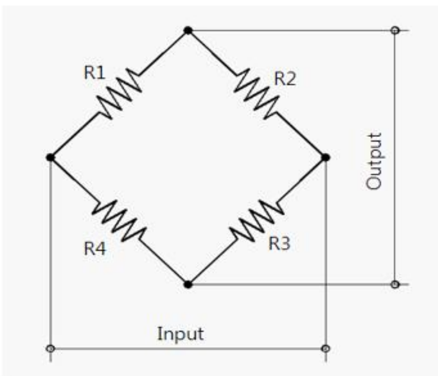

Figure 2 Wheatstone bridge

$$P = T \quad = T\frac{2\pi}{6} \qquad (2)$$

with:
$$T = 2\varepsilon \; Z_p \qquad (3)$$

$$Z_p = \frac{\pi d^3}{1} \qquad (4)$$

Where: ***P*** is power (W); ***T*** is torque (N); ***ω*** is angular velocity (rad/s); ***n*** is shaft speed (r/min); ***G*** is modulus of elasticity (N/m^2); $\boldsymbol{Z_p}$ is section modulus (m^3); ***d*** is shaft diameter (m).

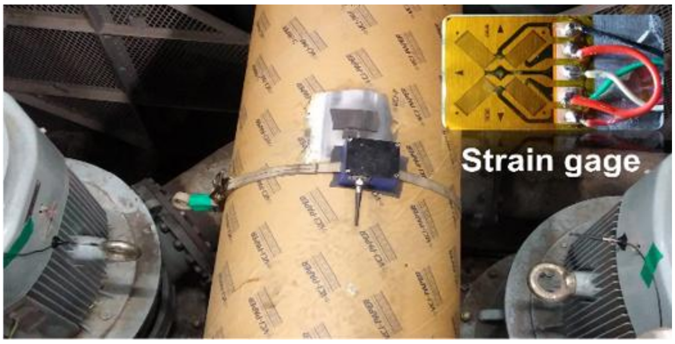

Figure 3 Telemetric system and strain gage installation

The engine power also can be measured via angular velocity signal. Two systems are recommended to be installed to ensure continuous engine power measurement in the event one of them failed. The principal method for measuring angular velocity is using equidistant pulses over a single shaft revolution. Rotating motion sensors such as gap sensor, magnetic switch sensor, or an encoder can be used to get the signal of pulses train which has frequency proportional to the angular velocity of rotating body. The frequency can be measured and then converted to voltage by an F-V converter. From achieved angular velocity, the angular acceleration can be calculated where torque and engine power is obtained. The telemetric system and strain gage installation is shown in Figure 3 while the system used for measuring engine power and ship speed is illustrated by schematic diagram in Figure 4.

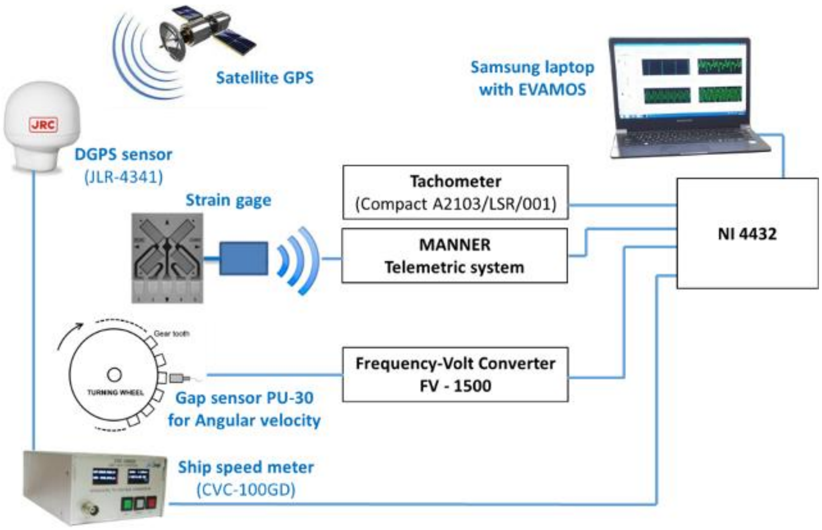

Figure 4 Schematic diagram for power and speed measurement

2.2 Ship speed measurement

In order to measure the ship speed, the speed system including one DGPS antenna and the ship speed meter (CVC-100GD) was installed. In this system, the antenna acquires the DGPS signal in purpose to determine the ship's location (by longitude and latitude) in real time. By the location signal, the ship speed and the sailed route can be obtained.

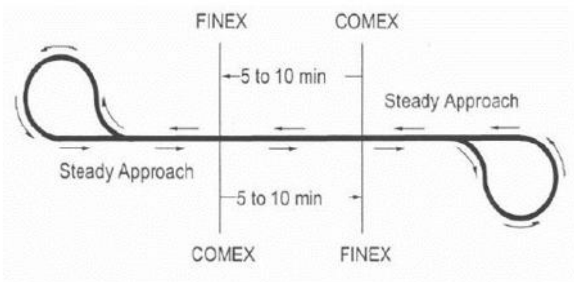

Figure 5 Sailing route guidelines for speed trial

Figure 5 shows the sailing route guidelines for speed trials and should be carried out using double runs, i.e. each run followed by a return run in the exact opposite direction performed with the same engine settings. The number of such double runs shall not be less than three and should be performed in head and following winds preferably. Each run shall be preceded by an approach run, which shall be of sufficient length to attain steady running conditions [4].

2.3 EEDI monitoring by EDiMS

Full formula for EEDI calculation:

$$EEDI = \frac{\text{Main engine's Emission} \oplus \text{Auxiliary engine's Emission} \oplus \text{Shaft generator / Motor's Emission} - \text{Efficiency Technologies}}{\text{Transport work}}$$

$$= \frac{\left(\prod_{j=1}^{n} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)}.C_{FME(i)}.SCF_{ME(i)}\right) \oplus \left(P_{AE}.C_{FAE}.SCF_{AE}\right) \oplus \left(\left(\prod_{j=1}^{n} f_j . \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)}.P_{AEff(i)}\right) C_{FAE}.SCF_{AE}\right) - \left(\sum_{i=1}^{neff} f_{eff(i)}.P_{eff(i)}.C_{FME}.SCF_{ME}\right)}{f_i.Capacity.V_{ref}.f_w} \quad (5)$$

Engine Power (P) at 75% load

P_{eff}	main engine power reduction due to individual technologies for mechanical energy efficiency
P_{AEff}	auxiliary engine power reduction due to individual technologies for electrical energy efficiency
P_{PTI}	power take in
P_{AE}	combined installed power of auxiliary engines
P_{ME}	main engine power

CO_2 Emissions (C)

C_{MFE}	Main engine composite fuel factor
C_{FAE}	Auxiliary engine fuel factor
C_{FME}	Main engine individual fuel factors

Ship Design Parameters

V_{ref}	Ship speed
Capacity	Deadweight Tonnage (DWT)

Specific Fuel Consumption (SFC)

SFC_{ME}	Main engine (composite)
SFC_{AE}	Auxiliary engine
SFC_{AE}^{*}	Auxiliary engine (adjusted for shaft generators)
$SFC_{ME(i)}$	Main engine (individual)

Correction and Adjustment Factors (F)

f_{eff}	Availability factor of individual energy efficiency technologies (=1.0 if readily available)
f_j	Correction factor for ship specific design elements
f	Coefficient indicating the decrease in ship speeddue to weather and environmental condition
f_i	Capacity adjustment factor for any technical /regulatory limitation on capacity (=1.0 if none)

EDiMS software is included in EVAMOS program developed by DL-MMU. Figure 6 shows the design concept display unit of EDiMS. For monitoring EEDI on the simple propulsion system, EDiMS software simply requires signals from engine speed, ship speed and shaft power. The fuel consumption and NO_x, SO_x, PM emission value measured from shop test can be used by the curve fitting method of the Equation 6. Likewise, the fuel consumption of prime mover can be applied alternatively by converting voltage signal of fuel flowmeter. SO_x emission is calculated from sulphur content and fuel consumption quantity.

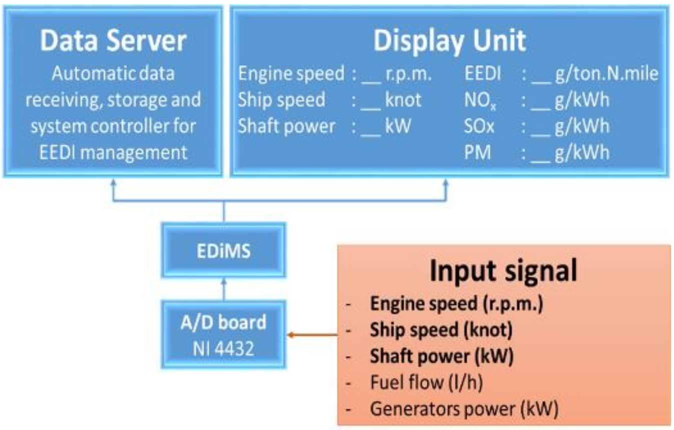

Figure 6 EDiMS system and display unit configuration

$$y = c_0 + c_1 x + c_2 x^2 + c_3 x^3 \qquad (6)$$

Where c_0, c_1, c_2, c_3 are coefficients for each of fuel consumption, NO_x, SO_x, PM emission - y; x is the part load ratio for maximum continuous rating.

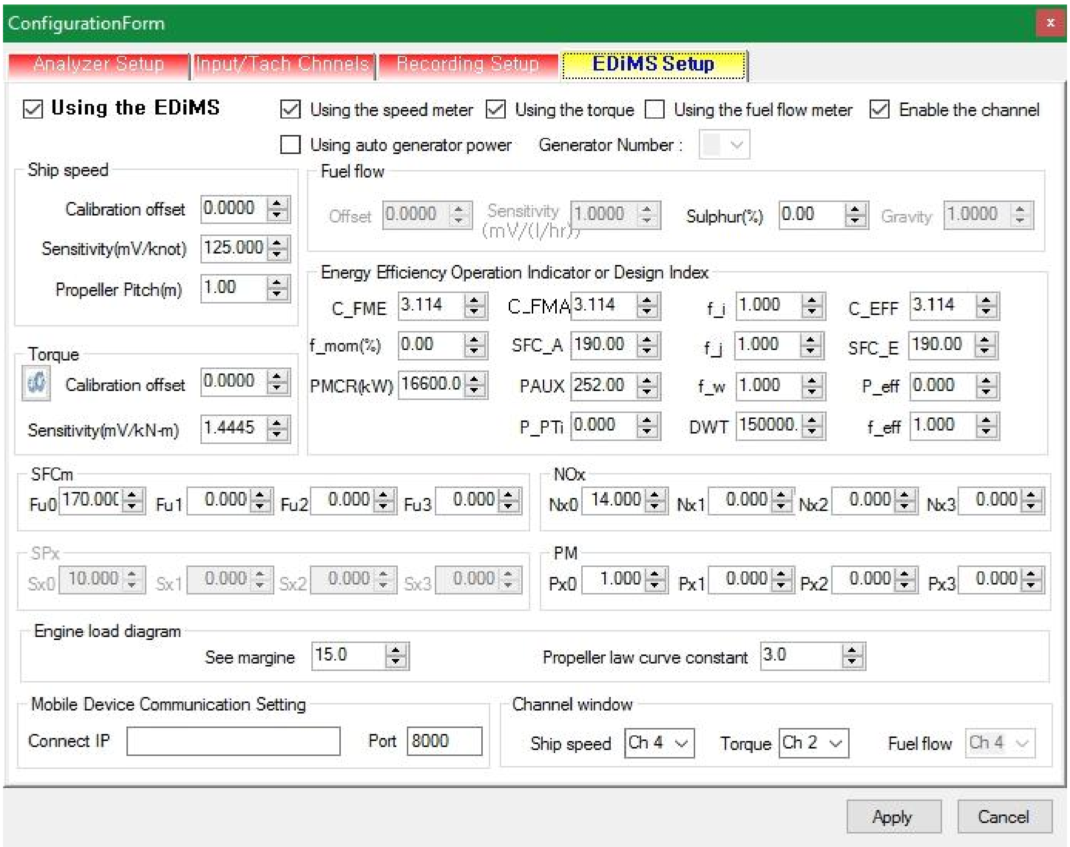

Figure 7 EDiMS monitor display configuration

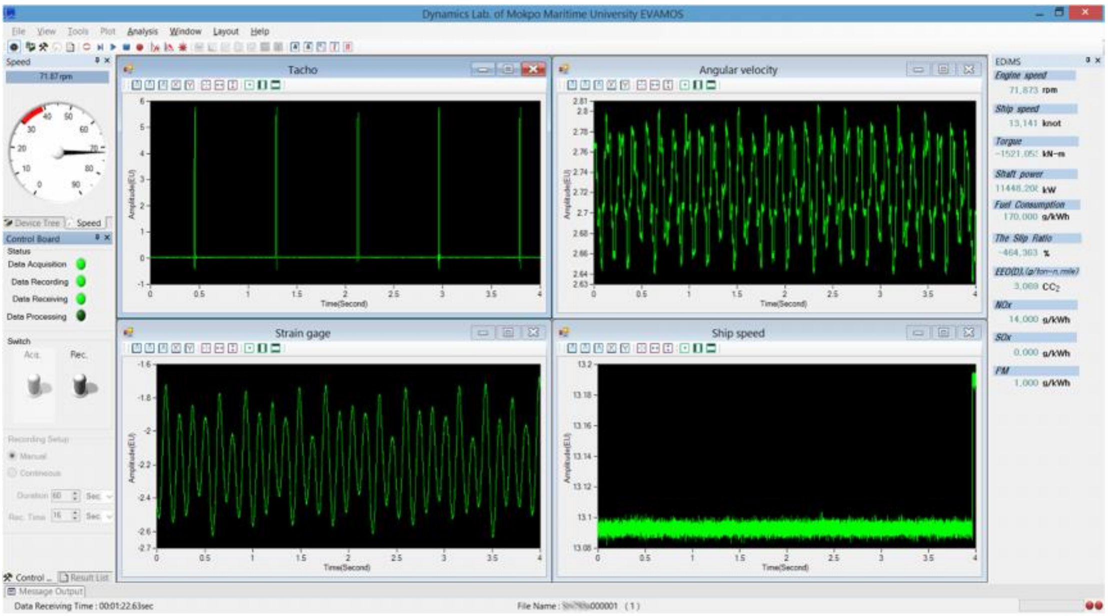

Figure 8 EDiMS raw signal and emission values display

Figure 7 shows the setup configuration of EDiMS software. In the case of absence of ship speed signal form DGPS, ship speed can be estimated by using the shaft speed and propeller pitch data with assuming there is no slip. The full equation of EEDI (Equation5) used for EDiMS includes several adjustment and tailoring factors to suit specific classes of vessels and alternate configurations and operating conditions, but in the case of simple propulsion system without driven generator installed on shaft and ignoring the negligible factors, the fundamental formula can be simplified to Equation 7:

$$EEDI = \frac{(P_{ME} \times C_{FME} \times SFC_{ME}) + (P_{AE} \times C_{FAE} \times SFC_{AE})}{Capacity \times V_{ref}} \quad (7)$$

For ships with main engine power of 10,000 kW or above:

$$P_{AE} = 0.025 \times MCR_{ME} + 250 \quad (8)$$

For ships with main engine power below 10,000 kW:

$$P_{AE} = 0.05 \times MCR_{ME} \quad (9)$$

with MCR_{ME} is main engine power at MCR (kW).

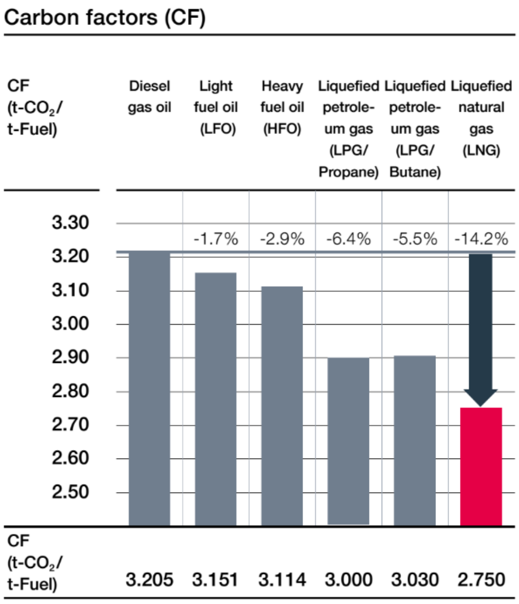

Figure 9 CO_2 emission rate based on fuel type emission values display [1]

2.4 EEDI monitoring by EDiMS on actual ship test

The EVAMOS program including EDiMS software was used for EEDI monitoring on a new built ship. Table 1 lists the ship and main engine specifications. The measurement was carried out during the speed test of sea trial in order to settle the relation between ship's speed and engine load as well as the EEDI calculation. The comparison of measured fuel consumption during sea trial and the builder shop test is given in Table 2.

Table 1 Specification of experiment ship and main engine

Ship	Type	Tanker	**Main engine**	Type	6G70ME-C9.2
	Capacity	158,863 tonnes		Power at MCR	16,590 kW
	Ship length	247.17 m		Max. continuous speed	77.1 r/min
	Breadth	48.00 m		Cylinder bore	700 mm
	Draft	17.15 m		Stroke	3,256 mm
	Year	2016		No. of cylinder	6

Table 2 Fuel consumption of 6G70ME-C9.2 engine at sea trial and builder shop test

Load	25%	50%	70%		75%				100%	
M/E r/min	48.6	61.2	71.9		73.6				80.5	
Round	-	-	R-1	R-2	R-1	R-2	R-3	R-4	R-1	R-2
Mean value at sea trial (g/kW-hr)	-	-	164.98	164.79	168.2	166.25	167.75	166.84	171.66	171.83
			164.89		167.31				171.75	
Shop test result (g/kW-hr)	175.66	165.34	163.46		165.86				170.18	

Based on the fuel consumption of builder shop test, the coefficients for fuel consumption were obtained to be: $\boldsymbol{c_0}$ = 208.86; $\boldsymbol{c_1}$ = -1.896, $\boldsymbol{c_2}$ = 0.0253, $\boldsymbol{c_3}$ = -0.0001. By using these coefficients, EDiMS software can estimate the engine fuel consumption for each power load ratio at any certain engine speed. The fuel used for engine is heavy fuel oil (HFO), the CO_2 emission rate C_{FME} = C_{FAE} = 3.144 ton CO_2/ton fuel (Figure 9); SFC_{AE}= 190 g/kW-hr; P_{AE} = 664.75 kW. In addition, with the signals of shaft power from strain gage and ship speed from DGPS sensor, the EEDI was calculated and monitored online. Under the IMO guidance for speed - power measurement, the measuring time for each round is at least 10 minutes at constant condition. All data were saved on computer and can be analysed again in laboratory.

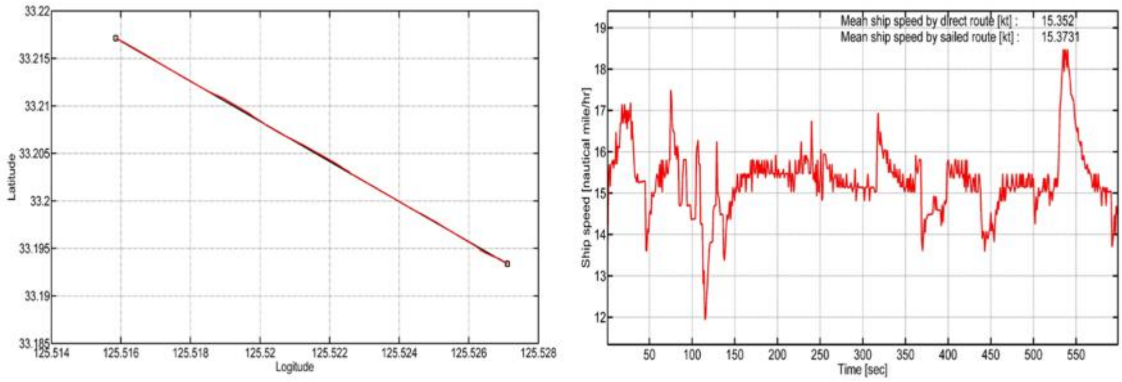

Figure 10 Sailed route and ship speed measured by DGPS sensor at 75% load Round 1

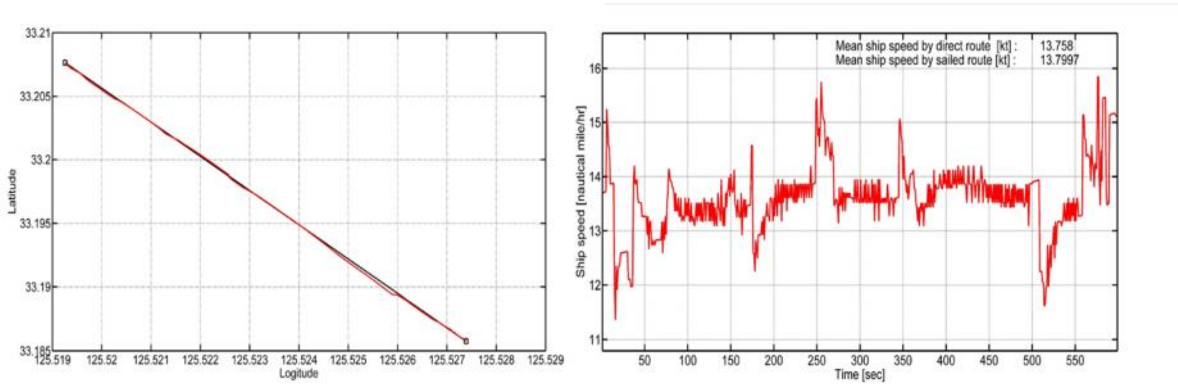

Figure 11 Sailed route and ship speed measured by DGPS sensor at 75% load Round 2

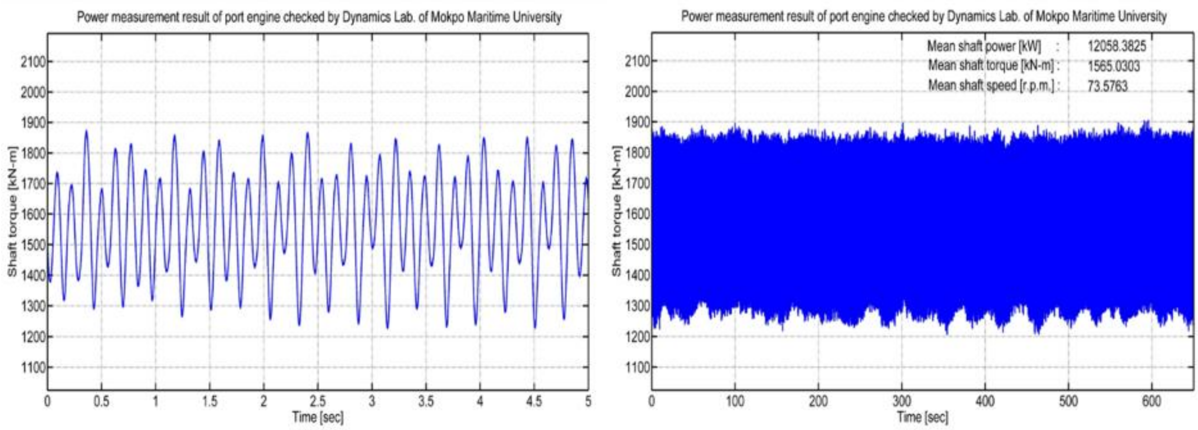

Figure 12 Shaft power measured by strain gage at 75 % load Round 1

Table 4 Measuring results and EEDI calculation

Load	70%		75%				100%	
Round	R-1	R-2	R-1	R-2	R-3	R-4	R-1	R-2
Engine power (kW)	11,314	11,076	12,058	11,866	11,862	11,970	15,673	15,648
Fuel consumption (g/kW-hr)	164.98	164.79	168.2	166.25	167.75	166.84	171.66	171.83
Ship speed (knots)	13.52	14.53	15.37	13.80	15.60	14.72	15.36	17.79
EEDI (g CO_2/t nm)	2.89	2.63	2.75	2.98	2.66	2.83	3.59	3.10
$EEDI_{average}$	2.76		2.80				3.35	

The data measured during this sea trial using the EDiMS software confirms the correlation between engine fuel consumption, shaft power, ship speed and CO_2 emission. Based on these factors, EDDI value was calculated and shown in Table 4. Officially, the correction speed should be used for calculation with the concern of the wind, sea wave and the other sea conditions and is a complex calculation. The ship speed used in this study (non – official test) is actual speed without correction. The measurement results indicated that the EEDI value of subject vessel increases at higher load. The required EEDI is the limit for the attained EEDI of a ship and depends on its type and size and its calculation involves use of ***reference lines*** and ***reduction factors***. Reference line represents the reference EEDI as a function of ship size. Reduction factor represents the percentage points for EEDI reduction relative to the reference line, as mandated by regulation for future years. This factor is used to tighten the EEDI regulations in phases over time by increasing its value. The reduction factor at different phase implementation is shown in Table 5.

Table 5 Reduction factor (%) for the EEDI relative to the EEDI reference line [5]

Ship type	Capacity (DWT)	Phase 0 from Jan 2013	Phase 1 from Jan 2015	Phase 2 from Jan 2020	Phase 3 from Jan 2025
Tanker	>15,000	0	10	20	30
	3000-15,000	n/a	0-10*	0-20*	0-30*
General cargo ship	>20,000	0	10	15	30
	4,000-20,000	n/a	0-10*	0-15*	0-30*

* Reduction factor to be linearly interpolated between the two values dependent upon vessel capacity. The lower value of the reduction factor is to be applied to the small ship size.
n/a means that no required EEDI applies.

The reference line values can be calculated as (see Figure 1):

$$R \quad E = a \times D^{-c} \tag{10}$$

$$R \quad E = (1 - r \quad f \quad /100) \times Re \quad E \tag{11}$$

For tanker: ***a*** = 1218.80, ***c*** = 0.488 [5]. ***Attained EEDI*** must always be less than or equal to ***required EEDI.***

The subject vessel was built in 2016 and thereby must adhere to Phase 1 of the EEDI reduction factor equivalent to 10%. The shaft power ratio required by the IMO regulation is at 75% load only, however at all the other load conditions, the EEDI value (Table 4) is lower than the required limit (about 3.53 g CO_2/t nm). As such, the subject vessel satisfies the IMO regulation for Energy Efficiency Design Index. In addition, monitoring the SO_x, NO_x, PM emission are available in EDiMS software. All of these signals can be measured, analysed and displayed online. File management of all data can be saved on hard drive of PC storage or either be transmitted to onshore shipping company office through internet connection.

3. Conclusion

Owing to rapid development in the shipping industry and maritime transportation, air pollution emissions from ocean-going ships are continuously increasing. Exhaust gases from ships contain CO_2 and many other harmful pollutants. The increased volume of air pollutant results in serious negative effects to environment, to human health and contributes to global warming. In order to control CO_2 emission from shipping, the Energy Efficiency Design Index requirement was adopted by IMO for newly-built ships. The EEDI expresses the amount of CO_2 emission on transport ability, assesses the energy consumption of a ship under normal seagoing conditions. The passage of EEDI regulation came with one important compromise that could affect the magnitude of benefits in developing more efficient ships to serve the demand.

The Energy-efficiency Design Index or Operational Indicator Monitoring System (EDiMS) was developed by DL-MMU in order to analyse and monitor EEDI on the base of results during the engine shop test trial and the actual monitoring of shaft power and ship speed. It is recommended for EEDI verification to use a compact software capable of measuring the shaft power and ship speed simultaneously. This software is a suitable tool for inventory and ship energy management plan. Not only EEDI, EDiMS can estimate and help to control air pollution source in exhaust gases such as SO_x, NO_x and PM. All of the energy-efficiency indexes can be displayed online continuously and transmitted to other server via internet connection. The software capability should be continually improved according to the expectations and participations from the ship owners and shipping companies with accurate advices from specialists.

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Diesel Engine Emissions/Performance of Emulsion Marine Fuels

Richard W. Kimball[1], **Brendyn G. Sarnacki**[2], **Scott J. Eaton**[3], **Joshua A. Henry**[2], **Travis Wallace**[2], **Thomas Lokocz**[2]

1. Professor, Maine Maritime Academy, kimball@mma.edu
2. Research Engineer, Maine Maritime Academy
3. Assistant Professor, Maine Maritime Academy

Abstract. The work of the Marine Engine Testing and Emissions Laboratory (METEL) at Maine Maritime Academy (MMA) in the area of emulsion biofuels is presented. An overview of METEL is discussed including its unique capabilities in the fabrication, characterization and engine testing of emulsion fuels. The engine emissions test facilities and protocols are discussed including state of the art emissions measurement techniques used to analyze stationary high speed diesel engines, on board vessel emissions and in METELs medium speed heavy fuel testing facility.

In this paper we describe the emissions of glycerol/diesel and glycerol/biodiesel emulsion blends on marine diesel engines. In addition, fuel physicochemical characteristics and handling issues for these fuels are discussed. Glycerol is an attractive fuel blending material as it is a waste product of biodiesel production with desirable combustion and fuel properties when emulsified into diesel and biodiesel fuels. The cost and carbon reduction benefits of glycerol also make it economically attractive as a fuel component. It is shown that glycerol emulsion fuels exhibit long term shelf stability and when burned can reduce the unwanted pollutants NO_X and THC. Particulate matter emissions are nearly equivalent by mass, but particulate number counts are significantly increased trending towards smaller particles sizes. CO emissions are shown to increase slightly with increasing emulsion concentrations. Data on the performance of emulsion fuels from both laboratory stationary diesels and on board the research vessel *Quickwater* are presented and the operational aspect of using these fuels on vessels is discussed.

Keywords*:* Glycerol, Glycerine, Glycerol/Diesel fuel, Emulsion fuel, renewable fuel, emissions, marine diesel engines, alternative fuels

1. Introduction

The health and environmental effects of emissions from combustion sources is an important focus of the scientific community [1-3]. Emissions from the marine industry account for approximately 3% of total global green house gas emissions while contributing 15% of global NOx, 13% of global SO_x, and 20% of global particulate matter emissions [4,5]. The International Maritime Organization (IMO) in 2005 through the International Convention for the Prevention of Pollution from Ships (MARPOL) implemented international regulations capping NO_x emissions from international vessels by category and build date along with particulate matter (PM) in Emission Control Areas (ECAs). Additional efforts by the United States included the Act to Prevent Pollution from Ships (APPS) which applied the MARPOL regulations to all applicable vessels operating in the navigable waters of the United States. EPA regulations further capped emissions of oxides of nitrogen (NO_x), total hydrocarbons (THC), carbon monoxide (CO), and total particulate matter (PM) from U.S. flagged vessels by engine category and build date. All above policies stipulate a 3-tiered structure of increasingly stringent emissions limits with the third tier generally taking effect between 2016 and 2018 in U.S. waters and other designated Emissions Control Areas (ECAs). As such, these impending emissions limits and any future policies identify clear openings in the market for drop in fuels, pretreatment, and after treatment technologies to reduce emissions from new engines or subsequent to major vessel conversions and overhauls. Drop-in fuels are appealing as they can be sourced from cost effective feedstock and require little-to-no capital investment by the end user. Glycerol is an attractive feedstock as it is an inexpensive waste product of biodiesel production with desirable combustion and fuel properties when emulsified into diesel and biodiesel fuels [6]. Eaton *et al.* showed that incorporating glycerol into diesel fuel as an emulsion retains many of the diesel fuels original flow properties, such as viscosity and surface tension, but can reduce THC, NO_x and PM emissions significantly. This allows for glycerol, a water-soluble energy source, to be compatible with diesel power applications without the need for engine modification. The use of glycerol has the potential to offset petroleum consumption, reduce diesel emissions and increase the economics of biodiesel fuel manufacturing. Despite these benefits, little is currently understood about the application of glycerol emulsion fuels in the marine environment and their durability across multiple engine platforms. This paper presents the production and test results of glycerol emulsion fuels in the laboratory and on board the research vessel *Quickwater*. Glycerol emulsion fuels containing both ULSD and biodiesel are considered.

2. METEL Overview: Facilities and Capabilities

The Marine Engine Testing and Emissions Laboratory (METEL), established in 2013, is a Tier I University Research Center under the U.S. Department of Transportation Research and Innovative Technology Administration as a collaboration between Maine Maritime Academy and the University of Maine. The focus of the laboratory is on environmental sustainability and is dedicated to research, development, and commercial implementation of viable technologies that improve heavy diesel engine emissions and efficiency. METEL conducts internal research and development projects, while also offering third party testing and evaluation services to industry. Engine test stands of various size engines are housed at METEL's facilities, including a 5.2 kW Hatz 1B30 single cylinder diesel engine, a 27 kW Caterpillar C2.2 marine diesel generator, a 186 kW Cummins QSB6.7, and a 246 kW John Deere 6081AFM75. METEL also operates an instrumented research vessel, the R/V *Quickwater*, a 41ft U.S. Coast Guard cutter outfitted with two 268 kW Cummins VT903 marine diesel engines. The unique research asset allows for testing of fuels, load cycles, and emissions in a real world environment. Construction of a new medium speed engine laboratory is currently in progress. The 1,020kW Wartsila 6L20 generator test cell will be capable of operating on heavy fuels and will simulate a marine support system with tankage, purifiers, and fuel changeover systems.

METEL has additionally developed capabilities and procedures to characterize fuels and blend various alternative fuels. METEL houses state-of-the-art continuous emissions monitoring equipment for both gaseous and particulate emissions including in cylinder monitoring equipment for analysis of fuel heat release. In order to characterize test fuels, METEL uses ASTM standards to determine the fuel's physical characteristics such as the heat content of the fuel, flash point, viscosity, conductivity, and filter plugging. In the case of emulsion fuels, METEL also employs optical particle sizing equipment to determine the size and distribution of fuel additive or emulsion particles.

3. Experimental Description

3.1 Fuel Composition and Preparation

Fuel components consisted of 2007 certification low-sulfur diesel (ULS) obtained from Chevron Phillips Chemicals (Lot 14GPUL701), waste vegetable oil-derived biodiesel blended between 0-50% (vol/vol), glycerol (99.7 wt% purity from KIC Chemicals, NJ), tap water, Span 80 and Tween 80 surfactants (99 wt% purity from Croda Chemicals). Emulsions were prepared batch-wise in a 50 gallon drum by combing components by weight as listed in Table 1. Glycerol and water were blended and added to the solution of diesel and surfactants. The batch was blended to create a macro-emulsion using a barrel mixer. A micro-emulsion was produced using a Model A dual-feed edge-tone resonant homogenizer (sonolator) manufactured by Sonic corp. The sonolator was operated in continuous mode at a feed rate of 6.7 kg/min using an orifice with a 1.8 mm (0.07 in.) slot width equating to a 206 bar (3,000 psig) line pressure. Emulsion fuel was produced in a single continuous run.

Table 1 Glycerol/ULSD emulsion fuel composition

Component	Weight (%)
2007 Certification ULS Diesel	61.9
Glycerol	28
Water	7
Tween 80	1.4
Span 80	1.2
Ethyl hexyl nitrate (cetane improver)	0.5

After emulsification, ethyl hexyl nitrate was added to achieve 5,000 ppm (wt/wt). The resulting fuel properties are shown in Table 2. The emulsion is considerably denser than the base 2007 ULS diesel due to the heavy components (glycerol/water), which follows a nearly linear proportion increase with increasing emulsion concentration. Conversely, kinematic viscosity is shown to follow a non-linear relationship with increasing emulsion concentration. For the emulsion fuel produced, the kinematic viscosity was determined to be 13.9 cSt indicating that fuel handling and injection operations should not require modifications for operations. The emulsion fuel also requires a lower stoichiometric air/fuel ratio indicating that diesel operation within stock engine configuration will be lean which should improve combustion efficiency.

Table 2 Relevant physicochemical properties of emulsion fuel and its primary components

Property	ASTM Method	2007 ULS Diesel	Glycerol	Emulsion Fuel
Specific Gravity @ 25°C	D4052	0.8423	1.251	0.9178
Derived Cetane Number (IQT)	D6890	47	--	31.5
Viscosity @ 40°C (cSt.)	D445	2.2	225.8	13.9
Net heat of combustion (MJ/kg)	D3338	42.9	16	32.1
Hydrogen (wt%)	D3343	13.2	8.8	11.7
Carbon (wt%)	(Calculated)	86.8	39.1	66.7
Oxygen (wt%)	(Calculated)	0	52.1	21.6
Air/Fuel Ratio (Stoich)	(Calculated)	14.41	7.45	11.63

A Malvern Zetasizer was used to determine the dispersion and droplet distribution of the resulting fuel. Stability is an important property for transportation fuels for storage and distribution. To determine the suitability for the emulsion fuel for transportation applications, the dispersion and droplet size was tracked over a period of 1 month to quantify aging kinetics. In these tests, 250 mL of sample was obtained off the production stream and stored in a glass jar. On a semi-weekly basis, the sample was re-agitated by hand and approximately 3 mL of sample was removed for dispersion analysis. Figure 1 compares the number distribution of emulsion droplets as produced and after 8 days and 30 days of aging. The freshly produced emulsion exhibits a multi-modal distribution with the first mode occurring between 200 and 700 nm and second occurring between 800 nm and 3,100 nm. The first mode is consistent with surfactant micelles while the second is consistent with micro-emulsion formation. The freshly produced fuel had a mean droplet diameter of 1,142 nm. The samples analyzed after 8 and 30 days of aging show the presence of ripening reaching a stable, single-mode distribution with 2,204 and 2,437 nm mean droplet diameters, respectively. This result indicates that equilibrium is obtained with droplets in the micrometer range.

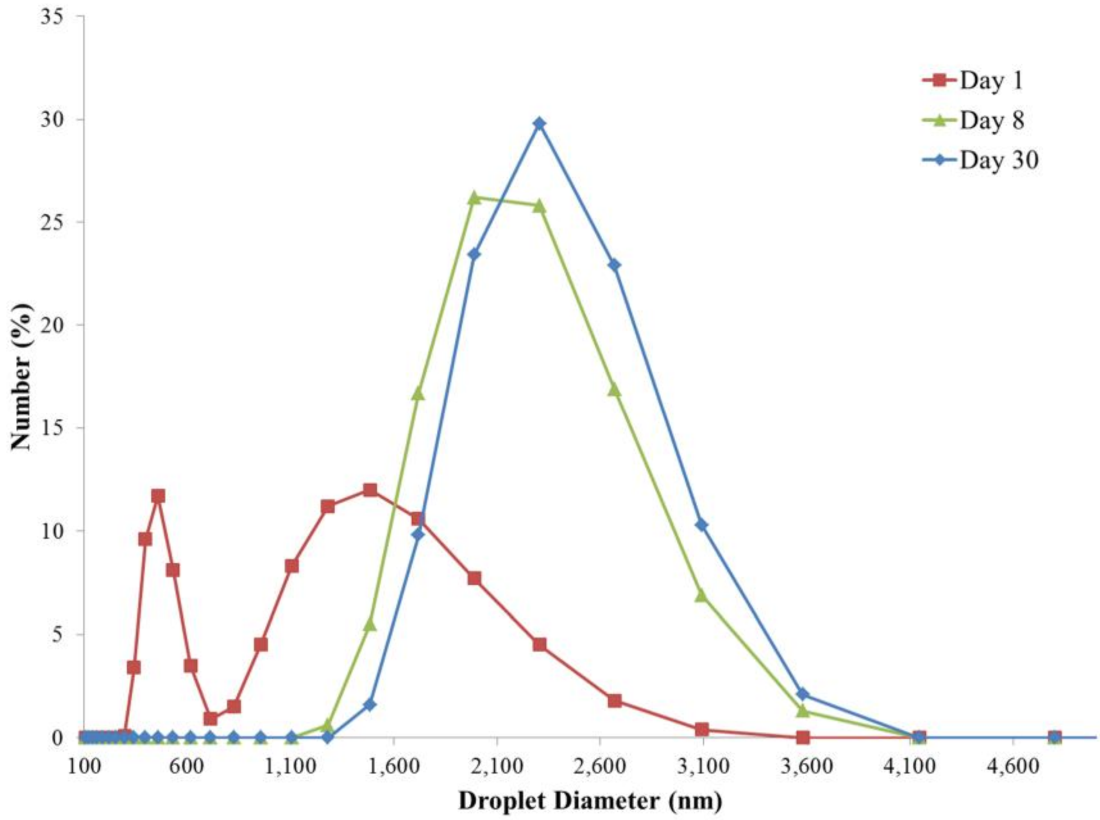


Figure 1 Number distribution of emulsion droplets measured with a Malvern Zetasizer as produced and after 8 days and 30 days of aging.

Figure 2 presents the growth of mean droplet diameter as a function of time. Average particles diameters are shown to increase over the first week of aging reaching a meta-stable droplet size exceeding 2,000 nm. The observations are well captured by a logarithmic rate. To quantify the rate of droplet ripening, the data was fit to a simple step-response model as shown in Equation 1.

$$S(t) = S_{\omega}\left(1 - e^{\frac{-t}{\tau}}\right) \qquad \text{Eq. 1}$$

where S(t) is the mean droplet diameter, S_{ω} is equilibrium droplet diameter (taken at 30 days) and τ is the time constant. The rate constant was determined by linear regression and found to be 12.4 days, which provided an adjusted coefficient of determination of 0.56. The fuel stability analysis provides strong support for the use of emulsion fuels in transportation applications.

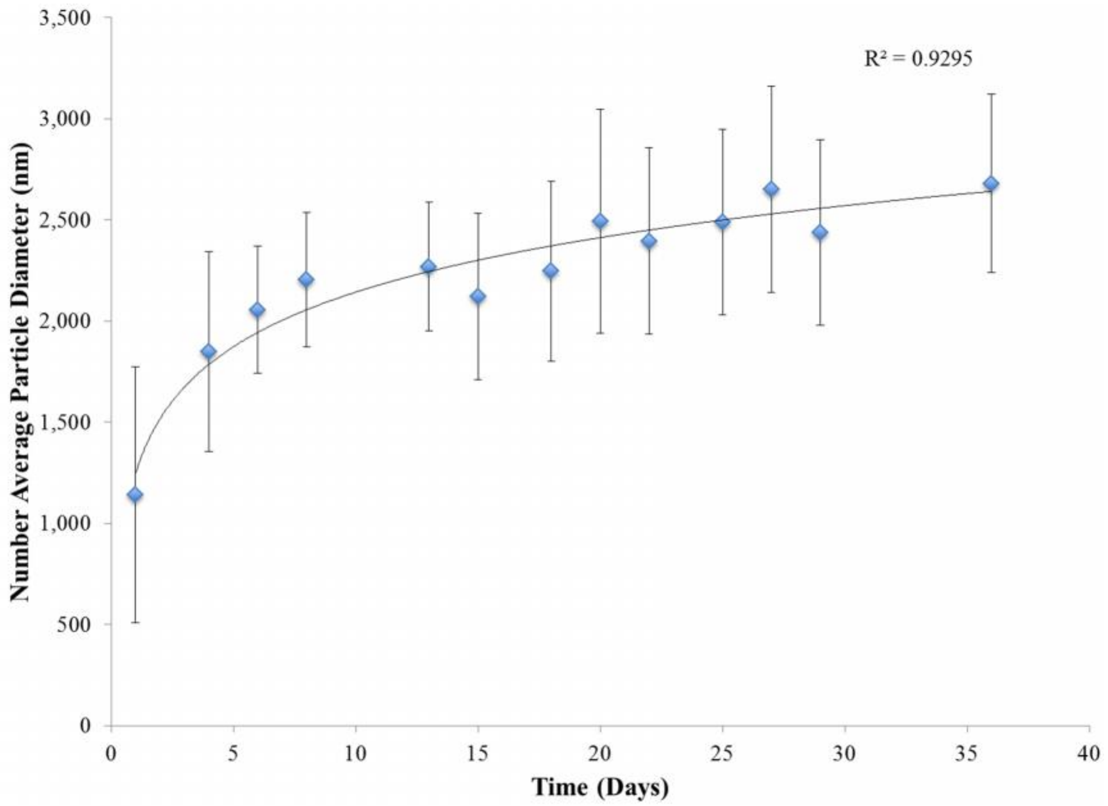


Figure 2 Growth of mean droplet diameter as a function of time.

3.2 Combustion Test Equipment

Stationary engine fuel testing and emissions measurements were conducted on a laboratory housed CAT C2.2 marine diesel generator test cell. The engine is a 4-cylinder indirect injection turbocharged diesel with a bore of 84 mm and stroke of 100 mm. The engine operates at 1,800 RPM with a maximum power rating of 27 kW. The engine test cell was instrumented with a variable frequency drive (VFD), resistive load bank, current, and voltage sensors to set and measure load on the engine. Fuel flow is measured gravimetrically via Omega LCR-50 load cells. Intake air mass flow rate and inlet air temperature are measured with a mass airflow sensor from PMAS with 0.25% measurement uncertainty and 0.4% repeatability. Exhaust emissions ports were located several pipe diameters downstream of the turbine housing of the turbocharger. The duty cycle utilized on the CAT C2.2 test cell conformed to ISO 8178 standards and consisted of starting at idle, 100% rated engine load, 75%, 50%, 25%, 10%, and back to an idle. All load settings were maintained for a sufficient duration to achieve steady state.

Marine environment fuel testing and emissions measurements were conducted on the research vessel *Quickwater*. The *Quickwater* is a 41ft. Coast Guard cutter-class workboat equipped with two VT903 360 hp (268 kW) Cummins marine diesel engines. The dual propeller shafts were instrumented with strain gauges and Datum Electronics shaft power measurement kits to measure shaft torque, RPM, and power. Fuel flow is measured via Kral OMX-20 flow meters. Intake air mass flow rate and inlet air temperature are measured with a mass airflow sensor from PMAS with 0.25% measurement uncertainty and 0.4% repeatability. The exhaust from the port engine of the vessel was outfitted with sampling lines for monitoring gaseous and soot emissions. The sampling ports were placed 0.6 meters after the turbine housing of the turbocharger and before the water-jacketed portion of the exhaust. The duty cycle utilized on *Quickwater* conformed to ISO 8178 standards and consisted of starting idle in gear, 100% rated engine load, 75%, 50%, 25%, and back to an idle in gear. All load settings were maintained for a sufficient duration to achieve steady state.

Dedicated emissions monitoring equipment used during all testing included a MKS 2030 FTIR with heated sampling equipment for gaseous emissions measurements, and a BMI 1710 Mixing Condensation Particle Counter (MCPC) for soot number concentration emissions measurements. The MCPC was additionally equipped with a heated dual stage ejector pump and calibrated critical flow orifice dilution system operating at 150 Celsius and a dilution ratio of approximately 1000. All emissions and engine specific performance monitoring equipment was controlled and recorded with LabVIEW.

4. Results

4.1 Glycerol/Diesel Emulsion

The glycerol/diesel emulsion fuel consisting of components outlined in Table 1 was tested for fuel performance and emissions in comparison to diesel fuel. Figure 1 illustrates gaseous and particulate emissions collected on the CAT C2.2 marine diesel generator test cell for diesel and the glycerol/diesel emulsion fuel. Figure 3a illustrates energy weighted emissions of NO_x + THC with a reduction in emissions evident for the emulsion fuel over all load settings. Figure 3b shows energy weighted emissions of CO significantly elevated for the emulsion fuel over all load settings. The significant variation in CO emissions may be due to incomplete combustion or changes in chemical kinetic pathways due to changes in molecular composition of the fuel [7]. Figure 3c illustrates energy weighted emissions of soot particulate count. The data depicts consistently elevated number concentrations of soot particulates for the emulsion fuel. Similar results were reported in literature for other oxygenated fuels [8]. Fuel consumption as a function of generator output power is illustrated in Figure 3d. The emulsion fuel exhibits a lower energy density and as a consequence results in an increase in fuel consumption. Thermodynamic efficiency exhibits little dependence on fuel type despite the change in fuel chemistry as shown in Figure 3e.

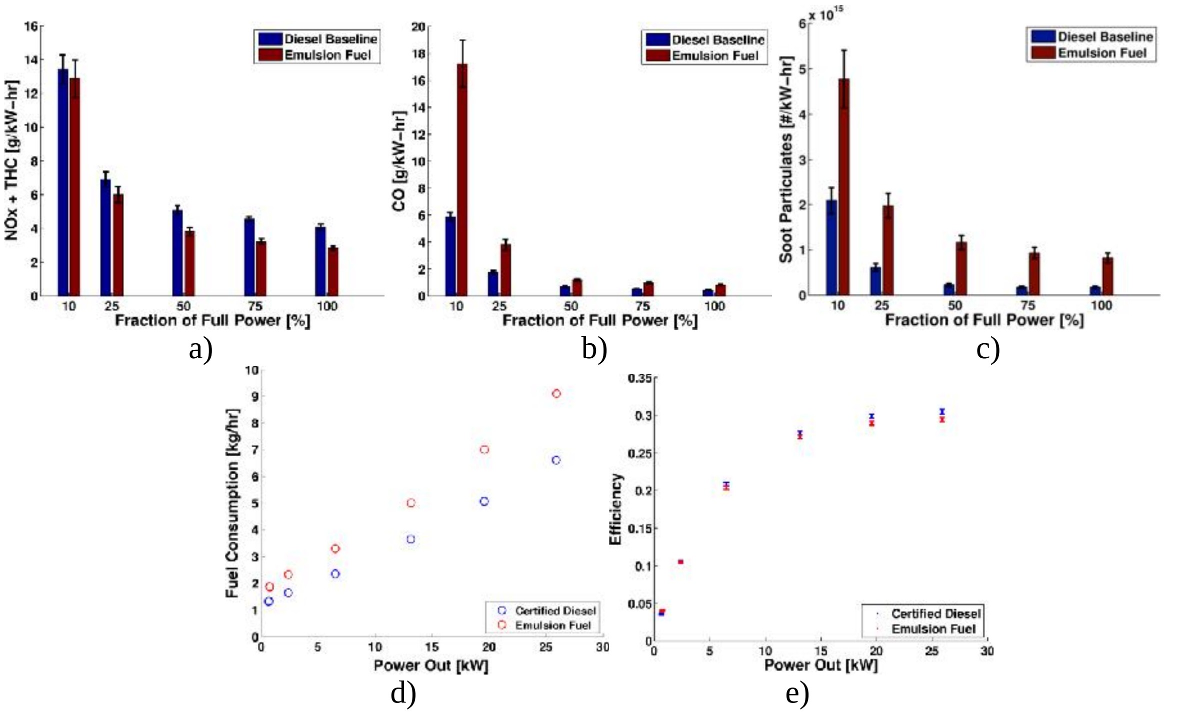


Figure 3 Emissions and fuel performance from certified diesel and glycerol/water/diesel emulsion fuel testing on a CAT C2.2 marine diesel generator over an ISO 8178 duty cycle. Energy weighted mass emissions of a) NO_x +THC and b) CO, energy weighted number emissions of c) soot particulates, d) fuel consumption as a function of power output, and e) fuel efficiency as a function of power output averaged over each load setting.

Additional testing conducted on board the research vessel *Quickwater* was found to be significantly different than results observed in the indirect injection diesel generator. Figure 4 illustrates gaseous and particulate emissions collected on board *Quickwater* for diesel and the glycerol/diesel emulsion fuel. The maximum load achievable with the emulsion fuel was approximately 87.5% of the maximum engine rating for diesel, as reflected in Figure 4, and attributed to the lower energy density of the emulsion fuel and a miss-matched engine fuel pump for the application. Figure 4a illustrates emissions of NO_x + THC remained unchanged over all load settings for the two fuels. Figure 4b shows CO emissions for the emulsion fuel were elevated at 25% load and reduced at all other load settings. In contrast, soot particulate number counts shown in Figure 4c are shown consistently elevated over the diesel baseline. Fuel consumption as a function of generator output power is illustrated in Figure 4d. Fuel consumption is again shown as elevated for the emulsion fuel due to the lower heating value of the fuel. Thermodynamic efficiency exhibits little dependence on fuel type as shown in Figure 4e.

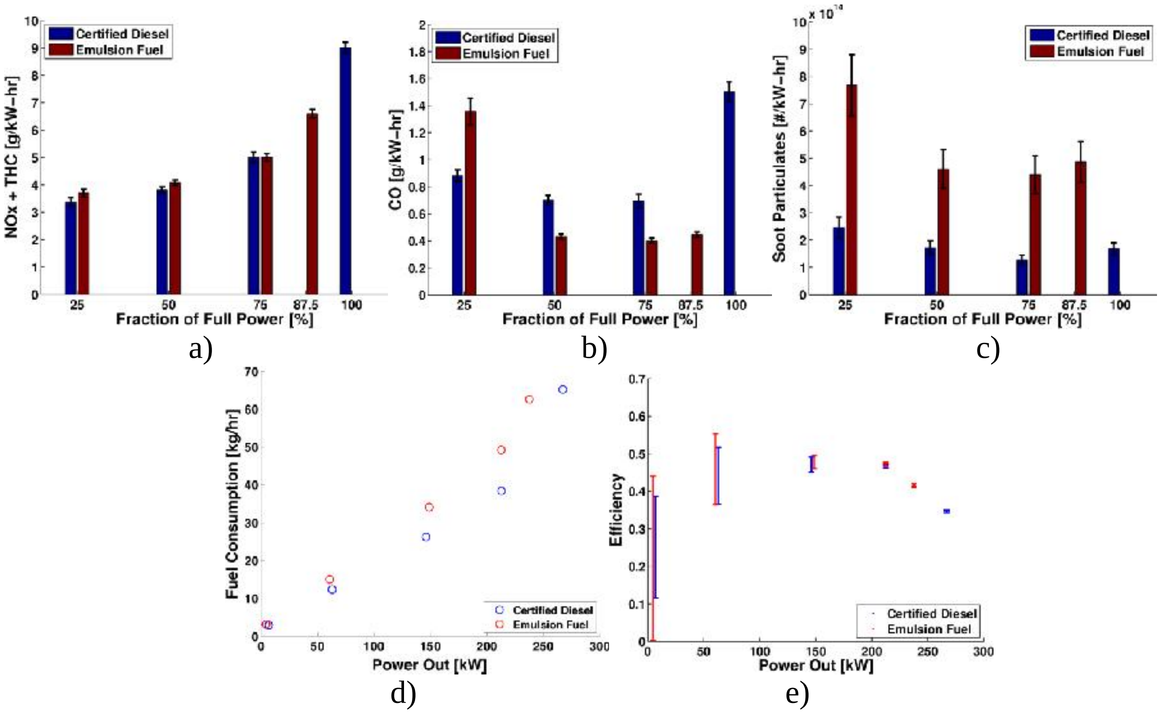
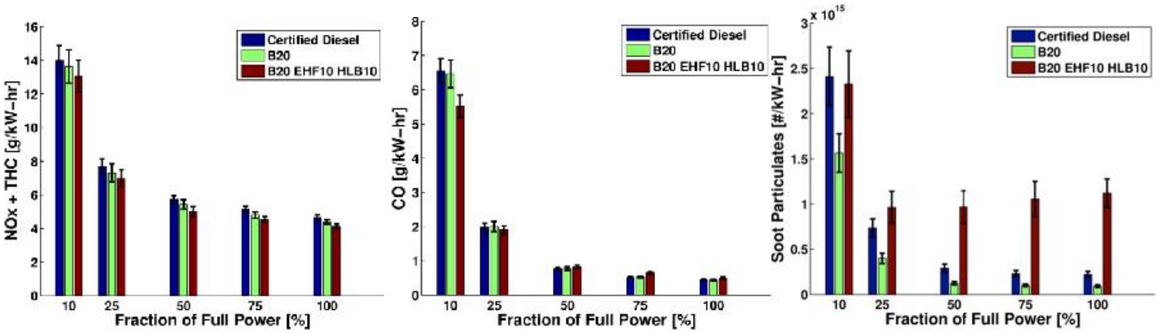


Figure 4 Emissions from certified diesel and glycerol/water/diesel emulsion fuel testing on the research vessel Quickwater over an ISO 8178 duty cycle. Energy weighted mass emissions of a) NO_x +THC and b) CO, energy weighted number emissions of c) soot particulates, d) fuel consumption as a function of power output, and e) fuel efficiency as a function of power output averaged over each load setting. Note the large error bars for fuel efficiency at low loads are due to entrained air in the fuel return line introducing considerable noise to the fuel flow measurement.

The persistent differences in soot number concentration prompted additional testing in the laboratory on the CAT C2.2 test cell. Additional tests were conducted via gravimetric soot sampling to determine total soot mass and thermophoretic soot sampling with transmission electron microscopy image analysis to determine particle size. The results indicate the emulsion fuel produced soot particulates of a smaller mean particle size with total soot mass equal to the diesel baseline fuel. The reduction in particulate size is consistent with other results reported in literature for oxygenated fuels with the cause likely due to a reduction in flame equivalence ratio and a suppression of soot precursor species [7,8]. However, the effect of decreasing particle size is typically associated with a reduction in total soot mass. With no evidence of a reduction in total soot mass, other additional effects may also play a role. Changes in fuel atomization due to variations in fuel viscosity and surface tension is a likely candidate that deserves further attention.

4.2 Glycerol/B20 Biodiesel Emulsion

The evolution of emulsion fuel development continued with an exploration of biodiesel blends. An experimental emulsion fuel blend of 8% glycerol, 2% water, 85% B20 biodiesel, 2.7% Tween 80 and 2.3% Span 80 by weight was chosen for optimum fuel stability and tested on the CAT C2.2 laboratory test cell using the procedures described above. The biodiesel was sourced from a local waste vegetable oil biodiesel producer and blended to B20 by volume with 2007 certification diesel from CP Chemicals. The biodiesel was produced batch-wise using base-catalyzed transesterification. The resulting fuel is refered to as B20EHF10 denoting the B20 base-fuel use and the 10 wt% emulsion in the mixture. It should be noted that the resulting HLB value of 10 used in the biodiesel containing fuels are the same HLB values used in ULSD only emulsion stabilization. We confirmed that stabilized emulsions can be made using this surfactant formulation with the stipulation that the relative amount be increased from 3 wt% (ULS-only case) to 5 wt% (B20 case). Figure 5 illustrates the gaseous and particulate emissions measured for diesel, B20 biodiesel, and the glycerol/water/B20 biodiesel emulsion fuel. A modest reduction in energy weighted NOx + THC emissions is observed in Figure 5a for the B20 biodiesel and biodiesel emulsion fuel in comparison to diesel with the emulsion fuel exhibiting the lowest NO_x + THC emissions. Energy normalized CO emissions shown in Figure 5b were unchanged for diesel and B20 biodiesel within uncertainty bounds. CO emissions for the B20 biodiesel emulsion fuel were slightly reduced at 10% load and slightly elevated at higher loads. Figure 5c depicts energy weighted particulate number emissions. Particulate counts are shown reduced on average for the B20 biodiesel in comparison to diesel and elevated on average for the B20 biodiesel emulsion fuel in comparison to the other two test fuels.

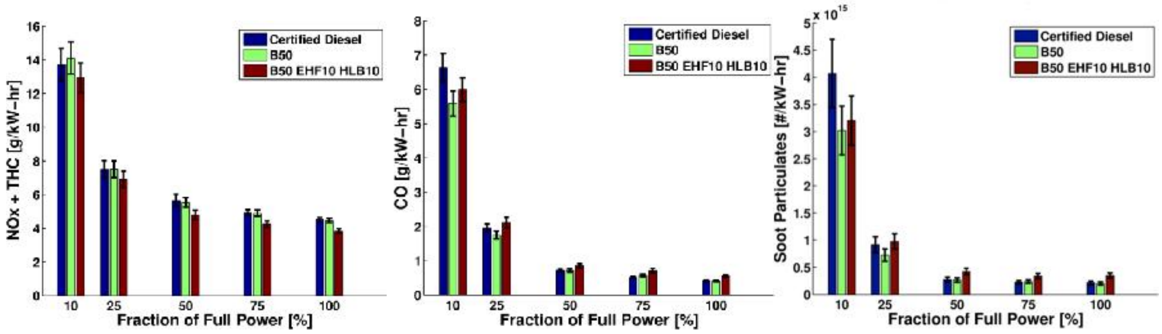


a) b) c)

Figure 5 Emissions from certified diesel and glycerol/water/B20 biodiesel emulsion fuel testing on a CAT C2.2 marine diesel generator over an ISO 8178 duty cycle. Energy weighted mass emissions of a) NO_x +THC and b) CO, and energy weighted number emissions of c) soot particulates averaged over each load setting.

4.3 Glycerol/B50 Biodiesel Emulsion

Lastly, an experimental emulsion fuel blend of 8% glycerol, 2% water, 85% B50 biodiesel, 2.7% Tween 80 and 2.3% Span 80 by weight was explored and tested on the CAT C2.2 laboratory test cell. Again, the resulting fuel was stabilized using the HLB 10 surfactant formulation as indicated above in B20 testing fuel composition. The resulting fuel is referred to as B50EHF10 denoting the use of B50 base-fuel and that the fuel is comprised of 10 wt.% emulsion. Figure 6 illustrates the gaseous and particulate emissions measured for diesel, B50 biodiesel, and the glycerol/water/B50 biodiesel emulsion fuel. A modest reduction in energy weighted NO_x + THC emissions is observed in Figure 6a for the biodiesel emulsion fuel with the diesel and B50 biodiesel exhibiting equal NO_x + THC emissions. Energy normalized CO emissions shown in Figure 6b were unchanged for diesel and B50 biodiesel within uncertainty bounds. CO emissions for the B50 biodiesel emulsion fuel were slightly reduced at 10% load and slightly elevated at higher loads. Figure 6c depicts energy weighted particulate number emissions. Particulate counts are shown reduced on average for the B50 biodiesel in comparison to diesel with near parity observed between the diesel and B50 biodiesel emulsion fuel within uncertainty bounds. The detailed chemical and physical mechanisms driving changes in particulate emissions are currently unknown. It is postulated that changes in chemical pathways along with changes in fuel atomization likely play a role and deserve further study.



a) b) c)

Figure 6 Emissions from certified diesel and glycerol/water/B50 biodiesel emulsion fuel testing on a CAT C2.2 marine diesel generator over an ISO 8178 duty cycle. Energy weighted mass emissions of a) NO_x +THC and b) CO, and energy weighted number emissions of c) soot particulates averaged over each load setting.

5. Conclusions and Future Work

The activities of METEL, at Maine Maritime Academy, in the area of alternative emulsion fuel development and testing were presented. An overview of METEL is discussed including its unique capabilities in the fabrication, characterization and engine testing of emulsion fuels. Glycerol is an attractive fuel feedstock as it is an inexpensive waste product of biodiesel production with favorable combustion characteristics. The emissions and performance of glycerol/diesel and glycerol/biodiesel emulsion blends on marine diesel engines in the laboratory and on the research vessel *Quickwater* are presented. Fuel characteristics and handling issues for these fuels are discussed.

Biofuel emulsions are a unique alternative fuel concept with demonstrated application to maritime operations. While considerable work in literature has focused on characterizing the combustion and performance of popular biofuel blends, the detailed chemical and physical mechanisms driving changes in NO_x, THC, CO, and particulate emissions for biofuel emulsions remain an open area of investigation. It is postulated that changes in chemical pathways along with changes in fuel atomization likely play a role and deserve further study.

Acknowledgements

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Validation and calibration of diesel engine model using DME

(Assoc. Prof. Luong Cong Nho, Dr. Nguyen Lan Huong)[1], (Assoc. Prof. Pham Huu Tuyen)[2]

1. Vietnam Maritime University, Email: nlhuongkdt@gmail.com, 484 Lach Tray street, Ngo Quyen district, Hai Phong, Vietnam
2. Hanoi University of Science and Technology

Abstract Diesel engines are utilized in most of heavy duty vehicles due to their high efficiency and performance. However, fossil fuel is being depleted currently, and emissions from diesel engine contains many toxic substances such as CO, HC, NO_x, PM…which effect adversely on environment and human health. Therefore, research and application of renewable alternative fuels are under consideration in many countries and Vietnam as well. Recently, Dimethyl ether (DME) has been considered as a potential alternative fuel for diesel engine. DME can be produced from a variety of raw materials such as biomass, coal and natural gas. It is also easy to liquefy and suitable to use in diesel engines. DME is not a nature product but a synthetic product is produced either through the dehydration of methanol or a direct synthesis from syngas. Using DME for diesel engine may reduce not only dependence on fossil fuel but also environmental pollution. Certain amounts of DME have been commercially produced as a propellant for spray cans because of its non-toxicity and suitable solubility and vapor pressure at room temperature. Some experimental investigations were conducted on diesel engine to clarify how DME injection characteristics affect the engine performance and exhaust emissions. Most of the results showed that emissions when fueled DME reduced significantly, especially CO and soot.

This paper presents a validation and calibration of diesel engine model fueled by DME. The engine was modeled by AVL Boost software and validated by experience. The parameters related to combustion process, for example ignition delay, combustion parameters, were calibrated and the effects of these parameterson performance of diesel engine fueled by DME were studied. Results show that in case of the same engine power the ignition delay calibration factor with DME can be chosen value of 1.37 while it is 1 with diesel.

Keywords: Dimethyl ether, engine simulation, combustion parameter, ignition delay calibration factor.

1. Introduction

Nowadays, research and utilization of renewable fuels in order to ensure energy security and reduce pollution emissions are of interest in many countries. Among these fuels, Dimethyl Ether (DME) is a friendly - environment fuel, easy to liquefy and suitable for use in diesel engines.

DME, chemical formula is CH_3-O-CH_3, is a colorless organic compound. DME is in gaseous form at ambient pressure and temperature. To increase the energy density, DME is usually stored in liquid form under compressed pressure of 7 to 10bar. DME can be produced from a variety of raw materials such as biomass, coal and natural gas and it is considered as a clean alternative fuel in near future. Using DME for diesel engine may reduce not only dependence on fossil fuel but also environmental pollution. DME is not a nature product but a synthetic product is produced either through the dehydration of methanol or a direct synthesis from syngas. Most of the results showed that emissions when fueled DME reduced significantly, especially CO and soot.

This paper presents a validation and calibration of diesel engine model fueled by DME. Diesel engine Kubota RT140 is modeled by using AVL Boost software and validated by experience.

2. Modeling theory

2.1 Combustion model

The combustion in diesel engine can be considered by two processes: premixed combustion and mixing controled combustion processes

$$\frac{dQ_{total}}{d\alpha} = \frac{dQ_{MCC}}{d\alpha} + \frac{dQ_{PMC}}{d\alpha}$$

Q_{total}: total heat release over the combustion process [kJ].
Q_{PMC} : total fuel heat input for the premixed combustion [kJ]
Q_{MCC}: cumulative heat release for the mixture controlled combustion [kJ]

Premixed combustion model:
A Vibe function is used to describe the actual heat release due to the premixed combustion:

$$\frac{\left(\frac{dQ_{PMC}}{Q_{PMC}}\right)}{d\alpha} = \frac{a}{\Delta\alpha_c}.\left(m+1\right).y^m.e^{-a.y^{(m+1)}} \quad , \quad y = \frac{\alpha - \alpha_{id}}{\Delta\alpha_c}$$

Q_{PMC} : total fuel heat input for the premixed combustion = $m_{fuel,id}$. C_{PMC}
$m_{fuel,id}$: total amount of fuel injected during the ignition delay phase
C_{PMC}: premixed combustion parameter
$\Delta\alpha_c$: premixed combustion duration= $\tau_{id}.C_{PMC\text{-}Dur}$
$C_{PMC\text{-}Dur}$: premixed combustion duration factor
m : shape parameter m=2.0
a : Vibe parameter a= 6.9

- Mixing Controlled Combustion process:
In this regime the heat release is a function of the fuel quantity available (f_1) and the turbulent kinetic energy density (f_2):

$$\frac{dQ_{MCC}}{d\alpha} = C_{Comb}.f_1(m_F, Q_{MCC}).f_2(k,V)$$

with

$$f_1(m_F, Q) = \left(m_F - \frac{Q_{MCC}}{LCV}\right).\left(w_{Oxygen,available}\right)^{C_{EGR}}$$

$$f_2(k,V) = C_{Rate}.\frac{\sqrt{k}}{\sqrt[3]{V}}$$

C_{Comb} : combustion constant [kJ/kg/deg CA]
C_{Rate}: mixing rate constant [s]
k : local density of turbulent kinetic energy [m^2/s^2]
m_F:vaporized fuel mass (actual) [kg]
LVC: lower heating value[kJ/kg]
V: cylinder volume [m^3]
α : crank angle [deg CA]
$w_{Oxygen,available}$: mass fraction of available Oxygen (aspirated and in EGR) at SOI [-]

C_{EGR} EGR influent constant [-]

$$k = \frac{C_{turb}.E_{kin}}{\dot{m}_{F,I}\left(1+\lambda_{Diff}\, m_{stoich}\right)}$$

E_{kin} : kinetic jet energy [J]
C_{turb} : turbulent energy production constant [-]
$\dot{m}_{F,I}$: injection fuel mass (actual) [kg]
λ_{Diff} : Air Excess Ratio for diffusion burning [-]
m_{stoich} :stoichiometric mass of fresh charge [kg/kg]

2.2 Heat transfer model

The heat transfer to the walls of the combustion chamber, i.e. the cylinder head, the piston, and the cylinder liner, is calculated from equation [3]

$$Q_{wi} = A_i \cdot \alpha_i \cdot (T_c - T_{wi})$$

Where Q_{wi} - wall heat flow, A_i - surface area, α_i - heat transfer coefficient, T_c - gas temperature in the cylinder, T_{wi} - wall temperature.

Heat transfer coefficient (α_i) is usually calculated by WOSCHNI Model, The Woschni model published in 1978 for the high pressure cycle is summarized as follows [6]:

$$\alpha_w = 130.D^{-0,2}.p_c^{0,8}.T_c^{-0,53}.$$
$$.[C_1.c_m + C_2.\frac{V_D.T_{c1}}{p_{c,1}.V_{c,1}}.(p_c - p_{c,0})]^{0,8}$$

Where $C_1 = 2.28 + 0.308.c_u/c_m$, C_2 = 0,00324 for DI engines, D - cylinder bore, c_m - mean piston speed, c_u - circumferential velocity, $c_u = \pi.D.nd/60$, V_D - displacement per cylinder, $p_{c,o}$ - cylinder pressure of the motored engine (bar), $T_{c,1}$ - temperature in the cylinder at intake valve closing (IVC) , $p_{c,1}$ - pressure in the cylinder at IVC (bar).

2.3 Modeling diesel engine Kubota RT140

Kubota RT140 Engine is a single horizontal cylinder, four-stroke, naturally aspirated, water cooled, DI. The engine specification is shown in Table 3, and the model is built by AVL Boost software (Figure 1)

Table 3 Specifications of the engine

Table. 3 Specifications of the engine	
Rating output	11kW at 2400 rpm
Maximum torque	42 Nm at 1500 rpm
Bore / Stroke	97/96 mm
Swept volume	709 cm^3
Compression ratio	18:1
Injection pressure	240 bar
Nozzle number x orifice diameter/ mm	4 x 0.30
Static injection timing	25 CA BTDC

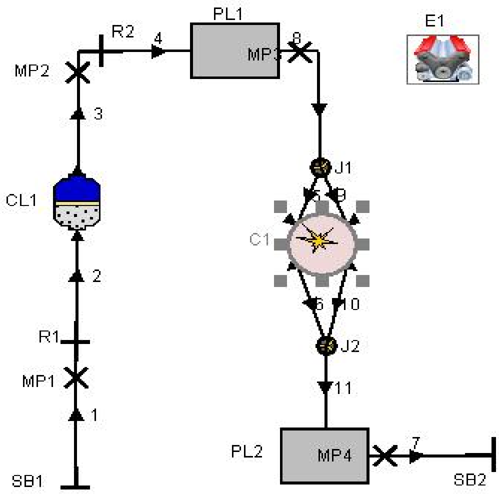

Figure 1 Diesel engine Kubota RT140 model

3. Simulation results and discussion

3.1 Validation and calibration of diesel engine model fueled by DME

Boost uses the Mixing Controlled Combustion (MCC) model for the prediction of the combustion characteristics in direct injection compression ignition engines. There are several factors relating to ignition delay period as: the ignition delay calibration factor, etc. The ignition delay calibration factor is a factor to assess the impact of the ignition delay.

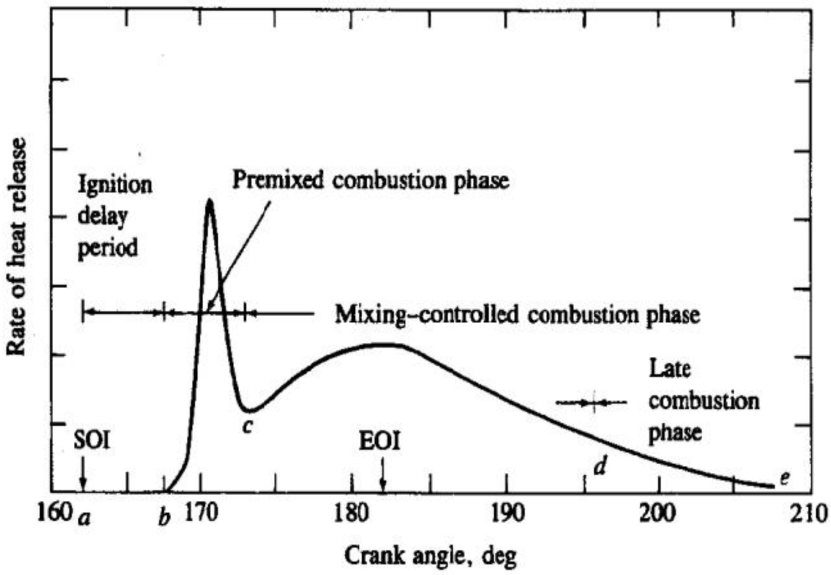

Figure 2 Rate of heat release of diesel engine

The ignition delay calibration factor with DME be adjusted lower than that with diesel, because DME is a clean fuel with good self- ignition charateristics. The ignition delay calibration factor with DME can be chosen value of 1.37 while it is 1 with diesel. The ignition delay calibration factor with DME is lower average 27% than that with diesel. (Fig 3).

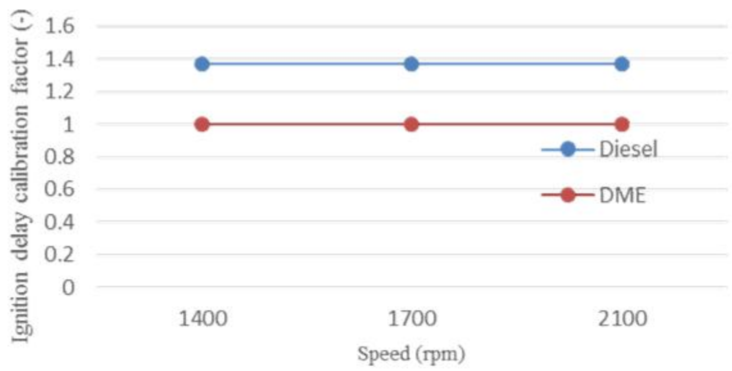

Figure 3 Ignition delay with diesel and DME

Addition, when the ignition delay calibration factor reduces, the pressure in the cylinder increases. When the ignition delay calibration factor reduces, that mean the ignition delay period is longer and premixed combustion phase is shorter, so the pressure in the cylinder increases.

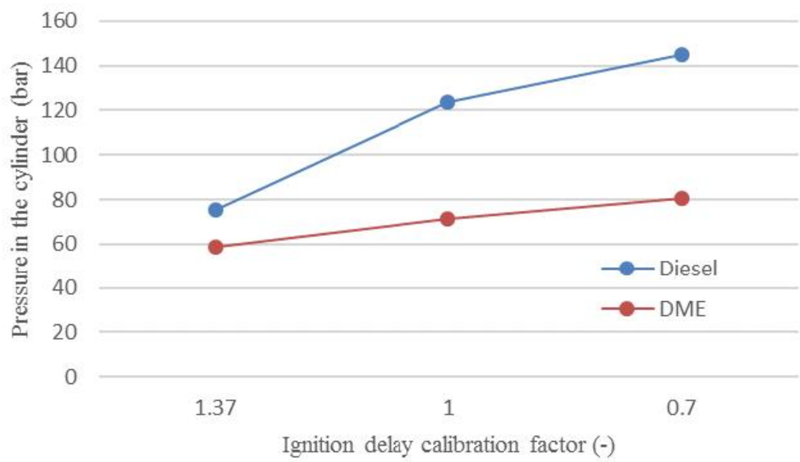

Figure 4 Pressure in the cylinder with diesel and DME

The combustion parameter coefficient is an important factor because it has the most impact on the rate of heat release graph. The value of this coefficient is more higher, and the combustion in the cylinder is more quickly. Cetane number of DME is high, so the combustion parameter coefficient with DME is lower than that with diesel and lower average 68.8%. (Fig 4)

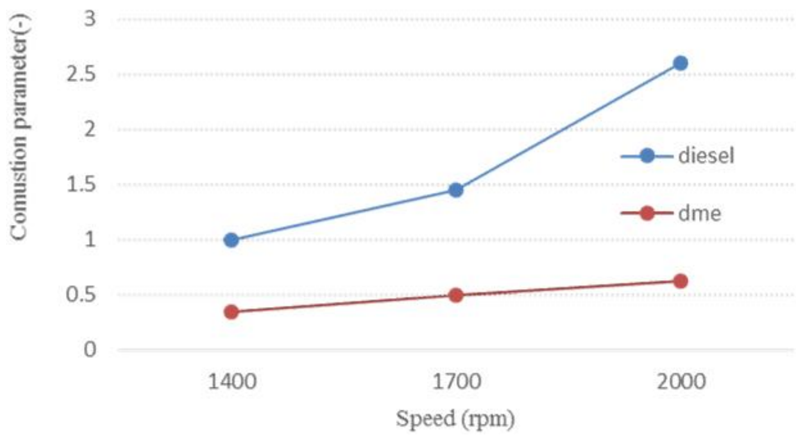

Figure 5 Combustion parameter with diesel and DME

The premix combustion parameter influences premixed combustion phase. The coefficient is determined by the amount of fuel in the ignition delay period and premixed combustion phase. The premix combustion parameter with DME is 1 while it is 0.7 with diesel.

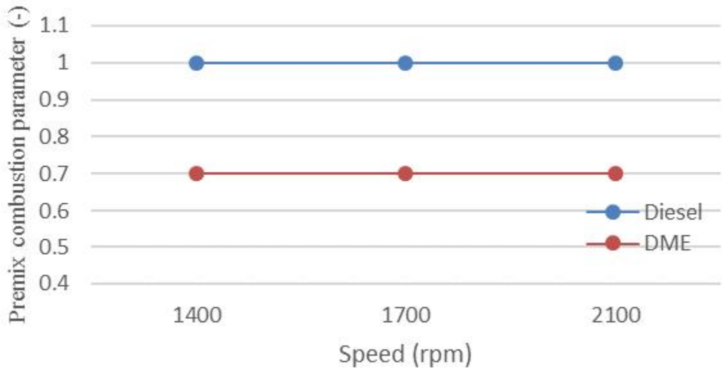

Figure 6 Premix combustion parameter with diesel and DME

3.2 Model validation

The model has been validated by experiment in case of using conventional diesel and DME. It showed that the torque as well as fuel consumption between simulation and experiment in case of diesel matched quite well: on average the difference in torque and fuel consumption was about 1.7 % and 1.9 %, respectively. Thus, it is possible to use this model to simulate the engine with DME fuel (Fig 5, Fig 6).

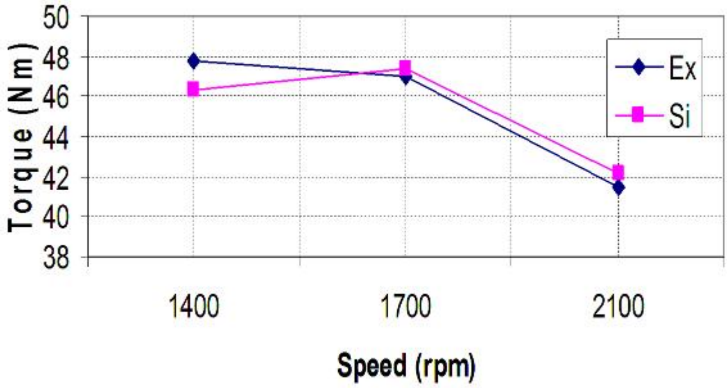

Figure 7 Torque with diesel

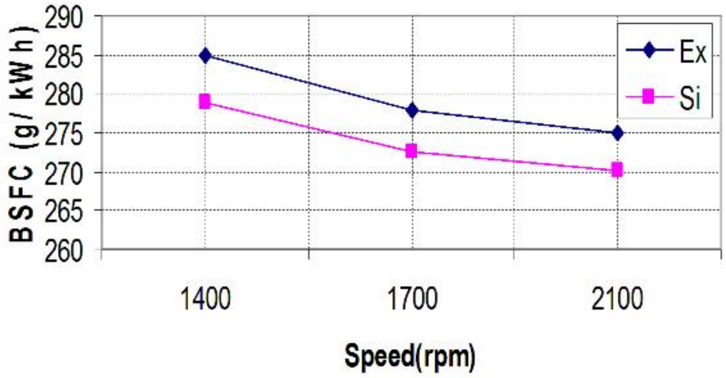

Figure 8 Fuel consumption with diesel

In case of DME, the torque as well as fuel consumption between simulation and experiment are similar, on average the difference in torque and fuel consumption was about 1.7 % and 3.1 % (Fig 7, Fig 8).

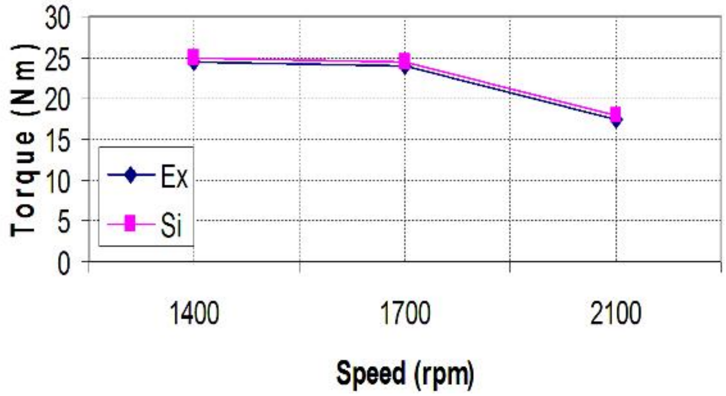

Figure 9 Torque with DME

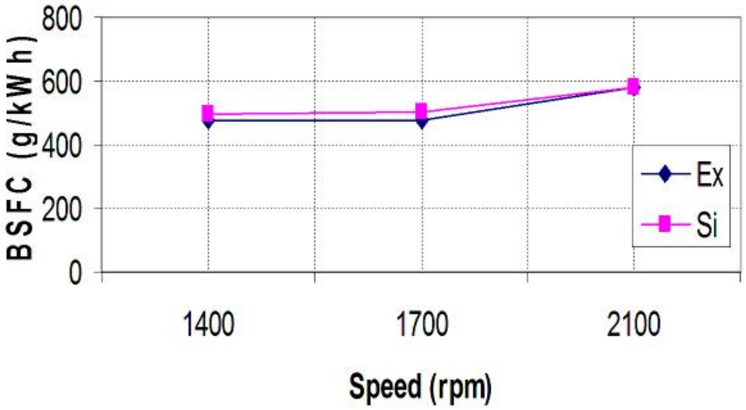

Figure 10 Fuel consumption with DME

4. Conclusions

The engine was modeled by AVL Boost software and validated by experience.

The ignition delay calibration factor with DME can be chosen value of 1.37 while it is 1 with diesel.

The combustion parameter coefficient with DME is lower average 68.8% than that with diesel.

The premix combustion parameter with DME is 1 and it is 0.7 with diesel.

Performance of DME fueled Kubota diesel engine are simulated by AVL Boost software. The model is verified by experiment: the torque as well as fuel consumption between simulation and experiment in case of diesel and DME matched quite well.

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Session 2A

MARITIME EDUCATION AND TRAINING

(No. 2)

Trends in the development of maritime education: prospects and proposals

Irina Makashina

DSc., Professor of the English Department, Director of International Education Center of Admiral Ushakov Maritime State University, Novorossiysk, Russia
e-mail: irmak@inbox.ru

Abstract. Maritime Education and Training is an essential factor for the contribution to the sustainable maritime development. The article reveals the basic trends in the development of maritime education. It is shown that the need to study and scientific understanding of the processes taking place in the space of maritime education, is determined by increasing the Convention's requirements, the new educational standards of professional maritime education, needs of society, the state and the merchant shipping industry. Maritime branch can be adequately updated and maintained only through effective maritime education and training.

This paper shows that a change in educational purposes causes a change in the content of the training, as well as methods of teaching and carrying out control and assessment procedures. In this regard, the system of technological criteria of professional training in maritime education is proposed and substantiated.

As an example of the expansion of educational opportunities the new educational project is offered. This Project implementation can be considered as an opportunity and platform for developing the mechanism for regular exchange and valuable discussion by maritime educators from different regions, who are ready to share and cooperate during workshops in favour of Maritime Education and Training, and Maritime industry.

The originality of the idea of the proposed Project corresponds with IAMU goal to invite new potential members, including different representatives of maritime industry and provide the opportunity not only to strengthen connections among IAMU Members, by enhancing the sharing of experience and knowledge, but also to promote the next step of maritime education evolution.

Key words: maritime education, educational space, poly-profiled and communicative competence, maritime transport.

1. Introduction

Maritime education is a complex, multilevel process, presuming the interaction of closely linked quantitative and qualitative transformations and at the same time the result of a long historical, economic, and spiritual coexistence and interaction of participants of the Global Maritime educational community.

The issues of Maritime education development do not cease to be urgent, as it covers the complex relationship of education, social and economic environment and society. Its unity has become essential, because there is a process of integration of all components of the Maritime transport sector at different levels. This process leads to the enrichment of each component in the existing system, to an appearance in it of new, integrative features. One of such components is marine education, with its new quality – poly-functionality.

2. Poly-functionality of Maritime Education

Poly-functionality of Maritime Education is both the process and the result acting as a resource of optimization of Maritime transportation industry. Level and quality of Maritime education in much determine the state of the sea industry. Maritime education at the present stage includes several functional tendencies: organizational, social, informational, communicative, preventive, analytical and predictive, etc.

The quality of implementation of these tendencies depends heavily on the diversification of maritime education, involving the organization of the learning process and the result of poly-functional, poly-profile training of future specialists for professional activity using of hierarchical training system [3, pp. 107-108]. This approach to the training process allows providing future specialist with extra opportunity of choosing personal and professional vector of their development.

Peculiarities of the multi-level system of marine specialist training in modern maritime university include: a high degree of unification of curricula in profiles and specialties of higher and secondary maritime professional education and a combination of broad basic training with subsequent specialization. At the same time, the global Maritime community imposes new requirements to the training of seafarers, and provides for new types of practical training that, in turn, necessitates optimization of the existing multi-level system of professional Maritime education.

When designing maritime educational space it is necessary to account the multisided nature of an activity of a maritime specialist. Analysis of the Manila amendments to the STCW Convention-78/95, adopted in 2010 showed that the standards of competence of all crew members introduced new competencies, knowledge and skills, providing different types of training caused by the introduction of modern new technologies and sophisticated equipment on ships. Also a step was made in the direction of development at sailors of non-technical skills, namely leadership features and ability to work in a team [1]. Such ability often becomes decisive in professional situations.

Such changes have already been reflected in the content of Maritime education, but not always at a proper level. In this aspect application of the poly-profile and communicative approach to the selection of content of maritime education can be useful and urgent. This approach presumes analysis of cognitive tasks, industrial and cultural characteristics of partners, including foreign ones, and organization of the communicative actions of all participants of solution and realization of set tasks [3, pp. 43-45].

Application of poly-profile and communicative approach to the selection and optimization of the content of education of future maritime specialists provides: systematic construction of the entire educational process; generalization and systematization of the training content, its components, reflecting poly-profile character of specialists' relations; continuity at all stages of lifelong learning; use of inter-subject links in the constructing of integrated training programs [3, p. 13].

At present the best maritime specialists are considered as complicated managers possessing poly-profile knowledge. The content of their education must be aimed at permanent accumulation at them essential professional features that adequately reflect the specificity of the nature of professionalism and formation of poly-profile and communicative competence, i.e. the integral abilities, consisting of number of competences of specialists of different professions, but included in the same professional field [3, p. 202]. Poly-functionality as a specialist's characteristic must be included in the content of education that further will provide him the different directions of development, depending on his abilities, desires and possibilities.

The development of poly-functional Maritime training assumes performing actions representing certain stages of its functioning and development. Each stage differs qualitatively by new state of the educational process and people included in it. Such actions include:

- career-guidance work, which allow attract to universities only concerned entrants, not those who are not interested in a specific specialty, but only the possibility of training on a budgetary basis (maritime education in Russia in much is on budget ground);
- investigating of factors influencing the Maritime education content and consideration of economic and legal conditions for the functioning of educational institutions and possible changes in the prospective period;
- implementation of innovative models of functioning of Maritime Universities and improvement of their departments management systems;
- introduction updated educational technologies in educational process; creation of digital, interactive textbooks and manuals in accordance with international and national requirements, as well as programs and integrated courses having poly-profile character, with subsequent organization of poly-profile practices at different companies in the industry or in different departments in accordance with the program;
- study and use of best experience, including international one with the aim of improving both the quality of education, and external academic mobility of students and members of teaching staff of Maritime Universities;
- creation of legal support of simulator training, and improving the organization of industrial practice and training on ships and at the shore companies, both national and foreign, providing regular financial support of this practice;
- providing conditions for increasing scientific potential of Maritime Universities and support the development of young scientific and pedagogical staff, and also attraction of students to performance of research work and the preparation of scientific projects;
- further development of the system of continuous education, reflecting the continuity of basic, secondary and higher professional education with the use of reduced terms of training, especially for graduates of the branch colleges in universities in their field, where they must undergo the full training period;
- formation and support of different forms of cooperation with employers (target training, seminars, conferences, involvement of customers in the structure of the University, for example, in a methodical Committees or boards of Trustees, development of proposals on improving the procedures of licensing of educational activity and state accreditation of Maritime universities engaged in Maritime specialists' training process;
- regular monitoring of the demand for Maritime specialists of any rank on domestic and international labour market and improving the planning of volume of their training for the Maritime industry;
- development and implementation of programs of support of cadets at the stage of their professional adaptation, the revival of mentoring and internship programs;
- raising the prestige of teaching activities and involvement employees working in the Merchant shipping branch in the educational process, etc.;
- wide extending of distance learning as alternative method of learning and teaching in MET. Implementation of these tools enables education institutions to provide a range of programs for seafarers. Successful delivery of distance learning provides more and more educational opportunities.

In this connection while developing content for distance learning the following factors should be taken into consideration: targeted competencies and outcomes; profiles of the different learning cohorts and their requirements and limitations; understanding the impediments to the learning; time and cost of developing the learning resources and the availability and access to the associated systems to deliver them, etc. [2, p. 210].

Networked learning, which allows connecting learning spaces, flexible learning programs and tools and hybrid learning, combining different methods of teaching have already enlarged existing learning opportunities and have further prospects.

3. Factors influencing quality of Maritime education

Consideration of the development trends in Maritime education involves the significant expansion of its diversification opportunities: different training period, forms, technologies, methods and means of teaching. But it is necessary to take into account external and internal factors that influence the quality of Maritime education, among which the following are:

1) changing of geopolitical and economic conditions of international integration with their determining influence on the competitiveness of specialists on the international labour market;
2) constantly increasing requirements of Federal Educational Standards of Higher Education to the level of marine expert training and Conventional requirements including the Manila amendments as well as current requirements, regularly published by the International Maritime Organization [1];
3) continued growth of accidents in the Maritime transport sector;
4) significant damage to the environment due to the increase of major disasters;
5) continuous development of technologies and their implementation on ships and in shore structures industry;
6) the best experience of Maritime universities, including foreign ones etc. [5; 7; 8; 9].

Accounting the external factors and specific conditions of implementation of marine education allows build a productive educating process, and plan and implement interaction with shipping industry. Internal factors, reflecting the nature of the industry are generated by combining the individual system elements. Their influence determines the operation and effectiveness of the poly-profiled training of future Maritime experts.

Change, or rather an adjustment of the educational purposes causes a change in the substantial part of the training and teaching methods, and conducting monitoring and evaluation procedures. Training of specialists working in a branch Universities is of particular importance. In this regard, we propose a system of technological criteria of quality of industry training of teachers (lecturers, instructors) working in the system of Maritime education. These criteria include:

– expediency, presuming the training corresponding to updated requirements of merchant shipping industry to the level of knowledge of Maritime specialists;
– poly-profileness, including not only knowledge of a certain specialty, but also profiles involved in the production of merchant shipping;
– diversification, supposing a variety of ways, methods and means of presentation of educational material;
– succession, namely, a) rationality of the choice of methods, forms and means of training; b) identification of the most effective teaching techniques; c) timely replacement of obsolete items of operational component of the learning process; d) maintaining of the above elements, which have stood the test of time and proven to be effective.
– coherence, involving continuous coordination of educational programs with accounting new model courses approved by the IMO and compliance with requirements of national and Conventional educational standards.

Accounting of technological criteria of industry training of lecturers, instructors, which train marine professionals, contribute to the definition of technology of acquiring of special subjects.

4. International cooperation as resource of development of maritime space

While considering tendencies of Maritime education development as a resource of industry optimization it is necessary to point out the international partnership as one of the important aspects. In Maritime education this component plays a special role that is stipulated by the international character of Maritime activities. It is well aware that international links in educational space of Maritime University are necessary to ensure the training of future marine specialists to contacts with foreign partners, coordination of related industrial activity and acquiring value orientations prevailing in the world, to preparation for inclusion in international programs, projects and etc.

In this regard, activities of such international associations as IAMU, IMLA, BSAMI, etc. are of great importance.
Admiral Ushakov Maritime State University (Russia, Novorossiysk) proposed some educational projects, the implementation of which contributes and will contribute in the further to the development of international Maritime educational space [4; 6; 7; 8; 9]. One of the latest projects is a Database of an innovative educational product. The idea of the Project is creating a free database of innovative educational products with a purpose to offer extra opportunities for educators from different countries to use them to improve the quality of Maritime education in Universities.

The urgency of the offered project is evidenced by challenges facing maritime education and training providers, and the Maritime industry and constantly growing requirements to quality and a level of future sea experts training. It also contributes to the implementation of new methods of teaching, development of technologies directed to the training of highly skilled sea professionals and development of cooperation among universities in promoting intercultural exchange and cooperation among professors, lecturers and instructors of the maritime educational space.

5. Conclusion

Maritime universities are focused on the principal issues of the maritime education, including the objectives to create a new competitive image of the merchant shipping industry, to support the industry through scientific and technological development. The result of set tasks first of all depends on specialists working in the branch, on their educational and cultural level. In this connection knowledge of trends in the development of maritime education and their accounting in the choice of new methods, forms and technologies of education would determine future success of educational process in maritime universities and success of maritime industry as a whole.

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Towards standardization of seafarers education and training

Professor Athanasios Karlis[1], Professor Margareta Lutzhoft[2], Neil Pereira[3]

1. Australian Maritime College/University of Tasmania, Swanson Building, Launceston, TAS 7250, Tel +61 3 6324 9593, Locked Bag 1398, *Athanasios.karlis@utas.edu.au*
2. Australian Maritime College/University of Tasmania, Margareta.Lutzhoft@utas.edu.au
3. Australian Maritime College/University of Tasmania, Neil.Pereira@utas.edu.au

Abstract: The shipping industry is the first and largest globalised industry. International seaborne trade is conducted by ships which in most part are manned by international crew. In addition ships offer services around the globe and thus many seafarers operate in waters other than the countries were educated, trained and certified. In addition, the crew is required to be trained following the STCW stipulations but application of the curriculum, training period and structure differs among the countries. Thus an interesting situation arises where the crew being certified and trained in one county serves and performs operation and application of his training in another.

The above situation is not in itself problematic. However, the need to assess compliance with the requirements of the STCW Convention (Standards of Training, Certification and Watchkeeping) is increasing. Thus, there is a need for greater standardization in the training processes and education of seafarers. And within this line a methodology should be created for comparing educational and training curricula and duration in order to move to greater standardization that will ultimately allow the quality improvement of the training and education of seafarers.

This paper examines the seafaring training systems in some of the leading maritime countries and in particular Greece, UK, China and Australia. The primary aim of the examination is to set up the basis for a methodology that will allow comparison of delivery of curriculum and training duration thus providing a basis for greater standardisation.

Keywords: Maritime education, Seafaring, STCW convention, training evaluation, standardization

1. Introduction

The shipping industry is the first and largest globalised industry [1]. It has been a globalised industry from the very early years when sea transportation was used for trade among civilisations. In these early years the training of seafarers started from a very early age through on-the job training schemes and ultimately competence of seafarers was evaluated on the spot by the captain-shipowner.

With the advent of steam propulsion and internal combustion engines, responsibility of seafarers' training slowly moved from the captain – shipowner to onshore management companies. The new administrative structure no longer had the possibility for on the job training and direct assessment of seafaring skills and competence. The training of seafarers is now being done before boarding the ship to ensure a minimum of skill, competence and certification.

In addition, in the last quarter of the twentieth century international trade grew with unprecedented pace and with it the possible damage and cost of an accident grew substantially. With these two parameters in mind the international community aiming to "promote safety of life and property at sea and the protection of the marine environment" [2] established STCW which came into force in 1984. The Convention was amended in 2010 with the Manila amendments that brought about changes to each chapter of the convention.

The STCW, together with MLC, SOLAS and MARPOL are the 4 pillars of global maritime regulation [3]. However an interesting difference exists. In the case of MLC, SOLAS and MARPOL application conformity of the agreed standards is examined on an ex-ante and ex-post approach. The application conformity is, or at least should be, monitored ex ante by the flag state and ex post by the Port State Control (PSC). International Registers also apply an ex post and ex ante monitor and examination. The case is different with STCW training courses where curricula offered by Maritime Education & Training (MET) institutions are approved and assessed by the Maritime Administrations of the countries that solely retain the privilege. It remains the ex-ante responsibility of the Maritime Regulator of the country of issue of certificates and of the flag state. This applies even in cases where refreshment of certificates is necessary.

As it is noted by the IMO [4] “The initial approval of a maritime training programme by a Maritime Administration might include **assessment of items … in order** to ensure that the training institute or training programme meet the appropriate STCW Convention standards:…”

It should be obvious with the above wording that there is considerable scope for diversification among METs and maritime training courses. This diversity is identified by the EU and a relevant policy application is adopted for a thorough enforcement of STCW requirements by all granting nations and thus METs [5]. This led to a list of recognised countries as regards the systems for training and certification of seafarers [6]. The recognition applies as criteria “…the inspection of facilities and procedures to evaluate whether the requirements concerning the standard of competence, the issue and endorsement of certificates and record keeping are fully complied with, and that a quality standards system has been established...” [7]. Therefore the primary focus of evaluation and recognition is on facilities, processes and systems and there is also a provision for assessment of MET. There is not relevant quality evaluation of training courses or providers or of training outcomes.

Indeed, despite the fact that STCW was entered into force almost 40 years now, there is agreement in the industry that considerable differentiation among training providers from different countries exists [8]. This potentially leads to a significant spectrum of differentiation of the training standards and therefore a methodology for assessing the quality of training in various METs is of significant importance.

2. Evaluation Methodology

According to Moss [9] “Programme evaluation is the process of attributing differences between actual and comparative outcomes to program characteristics under different conditions of student characteristics and other intervening influences, and making judgement about the value of the program characteristics”.

This above definition points to two important elements. The first is that evaluation must be **comparative**. The evaluation process aims at reaching a judgement of the training programme. This requires comparing outcomes with some other set of expected or actual outcomes. In the case of STCW related courses the expected outcome is “competence”. On a country level this training outcome is evaluated and affirmed through the provision of Certificate of Competency by the respective regulatory authority. With this in mind one might adopt a view that evaluation is already in place and from a certain perspective it would be true. Such an approach however would overlook the globalized nature of shipping. And as the shipping industry operates in a global competitive environment the training programs should be evaluated at transnational level aiming to standardization and homogeneous competence of seafarers. It is therefore suggested in our case that a comparative evaluation of STCW courses should be undertaken by evaluating the comparative outcomes of programmes of different countries. However, we also believe that a definition of the concept of “competency” needs to be operationalised. This may prove to be the largest challenge in this undertaking.

The second element of the definition is that any differences in programme outcomes must be **attributable to programme characteristics**. This task is quite tedious. The final programme outcomes are affected by student characteristics as well as other socio-economic influences rather than only the programme characteristics. Still however tedious the evaluation exercise needs to include the specification of evaluation parameters.

With the above in mind there are two tasks in hand. Identify the program outcomes that will serve as the evaluation criteria. Adopt a measure process for comparative assessment based on the identified criteria.

2.1 Evaluation parameters

The criteria by which instructional programs are to be evaluated must be the outcomes and the products of instruction. Program characteristics cannot be used as evaluative criteria, for, by so doing, we assume, rather than prove, that those characteristics are good. In the case of STCW related training courses the programme content and to some extend characteristics are directly or indirectly determined by the Convention itself and thus some degree of standardisation in curriculum exists. If only for this reason, programme characteristics and content cannot be the basis of comparison but rather programme outcomes must be the focus. By focusing on outcomes rather than processes or delivery methods, METs are able to apply innovative methods [10].

With the above in mind some of the most common criteria for evaluating educational and training results focus on learning outcomes, certification level and employment of graduates.

As far back as 1980 [11] a connection between time spent learning and increased outcome has been shown. Empirical studies indicate correlation between time spent and student's learning outcome [12]. Most of these studies [13] focus on the increase of learning outcome per increased time per class hour. The principle though is clear. There is a correlation between learning time and cognitive outcomes. Returning to the need for a definition of competence, from this follows that we also need to establish a connection between cognitive outcomes and competence. With that in mind, courses and of course STCW courses that provide ample time to students to absorb the educative content will provide for best learning outcome and will improve seafaring competence. Following this approach it is suggested that the length of academic studies is utilised as an evaluative parameter as increasing the MET learning outcomes is subject to the ample learning time provided by the MET institution.

Furthermore, research [14] shows that returns of individuals increase with higher degree qualification. In fact the higher the educational level the higher the returns and for the UK at least, returns on average of 27% for those completing some sort of Higher Education (HE) than anything else. The findings are consistent. The higher the degree compared to 16 year old school leavers the higher the returns. Educational attainment is rewarded with better employment conditions, higher employability and low unemployment [15], than individuals with lower levels of education. With this point in mind it is suggested that the degree level offered at the end of the training period to seafaring students should be the second evaluative parameter.

The quality and prestige of the degree is a key factor explaining the success to work transition. It has been suggested [16] that quality in higher education is based on three dimensions and specifically academic quality, administrative quality and relationship quality with "customers". These dimensions are important to measure academic quality but also very difficult to approach. However as suggested above quality of degree will be reflected in the employability and working conditions of graduates. In fact employability will increase or decrease based on perceived degree quality from companies that will evaluate the degree against expected productivity in order to make the hiring decision [17]. Although the literature suggests increased employability with higher degree, the crew market in shipping is globalised [18] and thus country specific employment records could be deceptive. On the other hand expected productivity which as was noted is linked with the degree quality is usually connected with salary rate. Therefore salary differences of equally ranked seafarers based on degree origin should be the third evaluative parameter.

2.2 Measuring Outcomes

The identification of evaluation criteria is one step of the assessment exercise. The adoption of a relevant measurement mechanism is also required and this task is not simple and can sometimes be as controversial as the choice of evaluation criteria. Nevertheless a proposed measurement mechanism is obviously necessary. The measurement mechanism should be appropriate to aim and the evaluation parameters.

In recent years there is a shift towards multidimensional indicators for measuring effectiveness [19] and composite indicators [20]. This methodology is increasingly applied in Higher Education institutions [21] and thus application to vocational training should be adapted rather than adopted. In any case it has been suggested that application in higher education should made coupled with sensitivity analysis [22].

3. Maritime Education & Training in various countries

With the above notes in mind and in order to obtain differences in processes in MET in various countries a choice of countries and METs was undertaken.

The countries chosen were, China [23], Greece [24], Australia [25] and the UK [26]. The first two were chosen as these countries hold two of the largest fleets [27] and the latter due to being significant destinations of students for seafaring training from other countries. The UK and Australia were also chosen aiming to evaluate whether educational systems with the same origin would produce similar training processes.

From the evaluation of the data researched it turns out that the four chosen METS differ in most of the elements of the training characteristics. Indeed the training processes differ in duration, certification result, sea time and class time, as can be seen in figure 1.

As can be seen in Table 1 the training period until CoC ranges from 144 weeks in Australia to 178 in China. Australia seems to follow the most balanced approach between sea time and lecture based training.

Table 1 Comparison of met durations in weeks to COC

Country	**GREECE**	**UK**	**AUSTRALIA**	**CHINA**
DURATION TO CoC	187	160	144	178
TOTAL SEA TIME TO CoC	97	82	72	88
TOTAL LECTURE TIME TO CoC	90	78	72	90
ACADEMIC QUALIFICATION	**Certificate**	**BSc**	**BSc**	**Diploma**
		52		
OPTIONAL ACADEMIC QUALIFICATION		**BSc(Hons)**	**-**	**-**

Source: Authors' elaboration with data derived from [9], [10], [11], [12]

Figure 1 Illustration of seafaring training stages at chosen countries. Authors' elaboration with data derived from [23,24,25,26]

It is interesting to note from the above data that the countries with the largest fleets from the sample support a longer sea training period compared both with the time at class as well as in comparison with the other countries with smaller fleets. This could be the result of the effort of the national training system to provide cadets to the national controlled fleets. It could also be explained from the fact that seafaring students in countries with considerable fleets can actually secure sea time in contrast with the other countries where limited fleets provide limited possibilities of sea time training.

On the other hand, both the UK and Australia provide a Higher Education degree at the end of the process, with the UK granting the higher level degree but also encompassing the longer training period. It should be noted though that the UK delivers a considerable period of blended learning where academic work is integrated with work based training at the last and final year.

With the above notes in mind it may not be difficult to reach the conclusion that maritime training in each country is adapted to the needs of the shipping or training policy of the country. The two countries with significant fleets tend to favour on the job training whereas MET in countries focusing on third party provision focus on degree outcome, see figure 2.

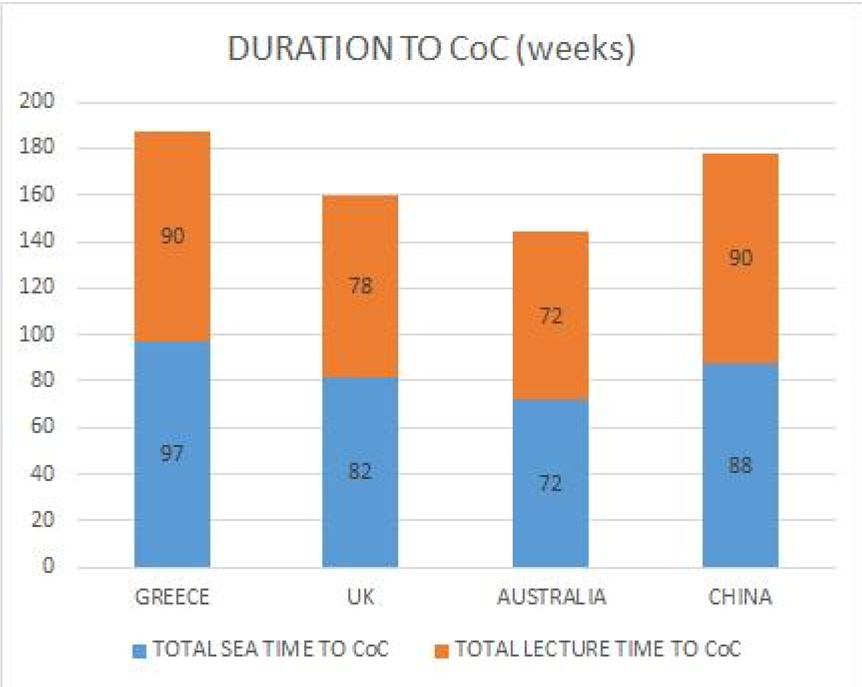

Figure 2 Duration to CoC for different METs
Source: Authors' elaboration from Table 1.

4. Conclusion & Discussion

The examination of the Maritime Education and Training institutions' programmes from four countries revealed that there are differences in duration, certification result, sea time and class time. Indeed it would be rather optimistic to aim for a proposed MET system that would be considered as one size fits all tool. This has not to date been achieved in any educational or training system. It is probably not an aim worth exploring as each training and educational system is adapted to each country's characteristics. Particularly, it seems that training systems operating in countries with large fleets tend to favour sea training time.

Despite the fact that training systems and programmes are not or should not be aimed to be identical, that shipping is a globalised industry and competence of crew trained and originated in one country might create a risk in another, which requires a higher standardisation of training schemes. With that in mind it is strongly contented that the evaluation of a maritime training scheme should be comparative and that outcome evaluation should focus on results such as employment of graduates, salaries or degree prestige that tend to be connected with market oriented results. Nevertheless, the evaluation should also be based on a multi-dimensional approach as well and to that end the use of composite indicators is proposed as a methodology for evaluation.

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Knowledge Management and itsInfluence on the Efficiency of Maritime Education and Training Institutes (A Case Study)

Capt. Amr Moneer Ibrahim [1] Capt. Eslam Mostafa Gaber [2]

Arab Academy of Science, Technology & Maritime Transport (AASTMT), amr.ibrahim@aast.edu
Arab Academy of Science, Technology & Maritime Transport (AASTMT), eslam.gaber@aast.edu

Abstract Knowledge Management (KM) had been one of the hottest topics in the last decade, especially in knowledge-intensive and highly competitive organizations. Admitting that knowledge is a key asset in any organization, any management should start planning how to manage the knowledge available in the organization represented in employees, and how to establish a method to utilize and maintain such knowledge in order to become skilled at creating, acquiring and transferring knowledge to support sustainable development of the organization.

The Maritime Education and Training (MET) is a vocational education in general; requires highly qualified and field-experienced individuals to serve as maritime teachers. This arises the research problem; that mostly used KM tools may be good enough to efficiently manage explicit knowledge but do not manage implicit knowledge to the same extent, especially when dealing with implicit-rich educational facility like marine simulators. Therefore, a system capable of concurrently managing both explicit and implicit knowledge is critically in need, in order to resolve the current problem.

From that perspective, this paper illustrates the introduction of KM concept into Maritime Education and Training, specifically in short courses delivered by the Marine Simulator Department in the Arab Academy for Science, Technology and Maritime Transport. An appropriate KM tool was introduced and implemented, managing both implicit and explicit knowledge simultaneously over a period of 14 months, over which continuous feedback were collected quantitatively and statistically analyzed.

The findings of the study were interestingly positive. The efficiency of education for the test subject have improved significantly after comparing Key Performance Indicators (KPIs) before and after adopting the KM system into the department. The paper finally recommends that due to the special nature of MET; a specified (MET related) Knowledge Management tool should be developed and generalized to all aspects of MET.

Key words: Knowledge Management, Maritime education and Training, Communities of practice, Implicit and explicit knowledge, Short Maritime Courses.

1. Introduction

Knowledge Management (KM) had been a hot topic in the last few years, it was found essential especially in knowledge intensive and highly competitive organizations. Admitting that the knowledge is the main asset in any organization, any management should start planning how to manage all the knowledge available in the organization represented in their employees, and how to establish a method to utilize and maintain such knowledge.

KM concept is important to enhance the understanding of how an organization becomes skilled at creating, acquiring and transferring knowledge to support sustainable development.

Therefore, this paper will discuss KM concept and its sub-theories, of Communities of Practice (COP) and different types of knowledge, and how a successful KM system could be established. Furthermore, to illustrate the functionality of these theories, an issue in a Maritime Education and Training Institute (METI) concerning a knowledge gap problem between teachers will be taken as a case study, proposing a KM strategy to address this problemillustrating the positive effect on the performance of Maritime teachers, demonstrating different aspects of implementations from all perspectives.

The main derive behind this research is the absence of an effective knowledge management tool in METIsand how it negatively affects the efficiency of educational services presented.

The research aims tohighlight the importance of Knowledge Management in METIs, manufacture and test a suitable knowledge management tool, and use this tool to manage knowledge assets within, in order to have sustainable development and efficiency in its education and training. In other words, the research should answer the following:

1. What is the importance of KM to METIs?
2. How to establish an appropriate KM tool to METIs and use it efficiently?
3. Does the application of KM concept improve the METIs performance?

1.1 Research Methodology, Research Plan& Paper Structure

McIntyre, Gauvin, & Waruszynski (2003) claims that KM is a "*multi-disciplinary*" field derived from theories in economics, sociology, philosophy and psychology. Information technology (IT) and data storage systems also contribute to the field of KM. Combining and applying multiple theories to practical problems within organizations has a pragmatic approach, concerning applicable solutions, not to add, the analyzing and measuring capabilities with high reliability.

Saying so, in the first part of this paper we will try to provide a structure for a KM solution appropriate to the special nature of METIs, in order to ensure its fruitfulness. In the second part, the efficiency of this KM tool will be tested through a research involving three Maritime lecturers (1 senior and 2 juniors). Where the senior lecturer will share his knowledge using different methods of the KM tool. Throughout the period of the research (14 months), feedback will be collected from trainees attending the subject course held by the three lecturers. Quantitative method will be applied to statistically analyze the efficiency/progress of the KM tool used.

In the end, the case study would present a suitable KM-MET tool, prove the importance of KM to METIs and that if well implemented, will affect the educational efficiency positively.

1.2 Literature Review

Literature provides hundreds of definitions of KM, many of them are related to the context of information being used or processed within the system. On the other hand, some definitions suit all types of information. One of the widely used definitions is offered by Davenport (1994) saying that Knowledge management "is the process of capturing, distributing, and effectively using knowledge", as simple as that.

A different definition touches the context of information used in a company is the one introduced by Karlsen & Gottxchalk (2004) "Knowledge management is a method to simplify and improve the process of creating, sharing, distributing, capturing, and understanding knowledge in a company".

The Gartner Group created yet another definition, but carries a detailed description suitable to an information intensive enterprise, expressed by Duhon (1998) "*Knowledge management is a discipline that promotes an integrated approach to identifying, capturing, evaluating, retrieving, and sharing all of an enterprise's information assets. These assets may include databases, documents, policies, procedures, and previously un-captured expertise and experience in individual workers.*"

In addition, there are definitions that introduce Information Technology (IT) systems as a major player in a successful KM system as the definition laid by Tan, Et al. (2007) "Knowledge management deals with the organizational optimization of knowledge through the use of various technologies, tools, and processes to achieve set goals".

At the same time, another set of definitions focuses on human factor and introducing the concept of *Communities of Practices (*COPs), like the one adopted by Swan, Newell, Scarbrough, & Hislop (1999) "Knowledge management is about harnessing the intellectual and social capital of individuals in order to improve organizational learning capabilities".

The latent set of definitions maybe suitable to be applied in an educational facility, although it will not cover the major aspects that characterizes the maritime education. Given the nature of the industry, an MET-related KM definition may still be required to be innovated.

Abundancein literature concerning KM concepts applied in corporates is clear, produced as early as the 1990s (Gupta & Govindarajan (1991), Hedlund (1994) & Wiig (1997). With the beginning of this century, the interest of applying KM concepts into education had been focused upon; it started with a trial to implement corporate-KM in education as did Kidwell et.al in 2000 & Bernbom in 2001. Then there were a huge studiousnesssurge into the matter when the Institute for the Study of Knowledge Management in Education (ISKME) were established in 2002, since then, there had been serious literature on applying KM in education, like what (Sallis & Jones) & (Serban & Luan) wrote in 2002, followed by Petrides & Nodine in 2003 and Metcalfe in 2006. It is fair to say that KM in education literature surged after the establishment of ISKME.

Education may be the same when it comes to philosophies and theories, but the application may differ when it faces a special nature of education, like the maritime education. Maritime education is a vocational education, derived largely from vocational-knowledge and experience, which is reflected greatly in the scarcity of experienced maritime teachers.

Applying KM in the maritime domain were greatly addressing the shipping industry either in running shipping companies like in articles and books of Fei in 2011,2013 or shipping logistics as written by Lee & Song in 2010, 2015; Radhika in 2014.A modest approach were made to the application of KM in METIs found in a few paragraphs in an article by Raicu & Niţă in 2008 and a research done by Kitada wrote about the application of KM techniques to improve online MET in 2015.

The absence of literature describing a serious long time testing of the application of KM concepts and techniques in METIs will be one of the motivation for the contribution of this research and future researches.

2. How to Establish a MET Related KM tool

2.1 KM and Communities of Practice (COPs)

COPs has proven to be the most important factor in any KM system, the core of knowledge is the people who hold this knowledge, extracting and sharing this knowledge is done easily and smoothly in a COP. Wenger (2006) defines COP as "Groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly".

According to Wenger (2006) any COP consists of three components:

The domain: A COP is not necessarily a network between people. It can be a unique identity defined by a shared domain of interest. This implies and produces some sort of a commitment to the domain.

The community: To form a COP, members engage in joint activities and discussions, help each other, and share information. Being in the same field of work and having the same daily tasks do not necessarily form a COP, a strong relationship must be built enabling them to share and learn within a circle of interest and trust.

The practice: A community of practice is not a community of interest. Members of a community of practice must be practitioners. They develop a shared reservoir of experiences, tools, and ways of dealing with problems.

> *"Nurses who meet regularly for lunch in a hospital cafeteria may not realize that their lunch discussions are one of their main sources of knowledge about how to care for patients. Still, in the course of all these conversations, they have developed a set of stories and cases that have become a shared repertoire for their practice." Wenger (2006)*

The concept of COP is applicable in all sort of human-interactive entities, like organizations, institutions, governmental/non-governmental associations, and most importantly, educational institutes, which is the core subject of this paper.

2.2 Implicit and Explicit Knowledge

As discussed, KM is all about sharing knowledge with others sharing the same interest, based on interactive and transmission processes between producers and consumers of knowledge. This knowledge is either implicit or explicit.

Schacter (1987) defines implicit memory by the limited control of conscious or intentional recollection of data. Reber (1993) on the other hand, defines implicit learning as "the acquisition of knowledge that takes place largely independently of conscious attempts to learn and largely in the absence of explicit knowledge about what was acquired".

The difference between implicit and explicit was expressed by Dienes & Perner (1999) in an illustrative example "They didn't say so explicitly; it was left implicit". Furthermore, a formal differentiation between implicit and explicit knowledge is introduced by Polanyi (1966):

> *"Explicit knowledge is that which is stated in detail and leaves nothing merely implied. It is termed "codified" or "formal" knowledge because it can be recorded. Implicit knowledge is that which is understood, implied and exists without being stated. It is informal, experiential, and difficult to capture or share. It is knowledge that cannot be expressed"*

Because of that contradiction, different KM methods should be used to deal with different types of knowledge says Fei (2011), IT for example has limited outcome when implicit knowledge is transferred, when face-to-face approach should be facilitated for better results.

2.3 How to Transfer Knowledge

Based on Nonaka & Takeuchi (1995) theory on organizational knowledge creation, where it says that the best results of flowing of information through an organizational KM system happens when the knowledge is converted from implicit to explicit continuously and dynamically, as illustrated in figure 2.1.

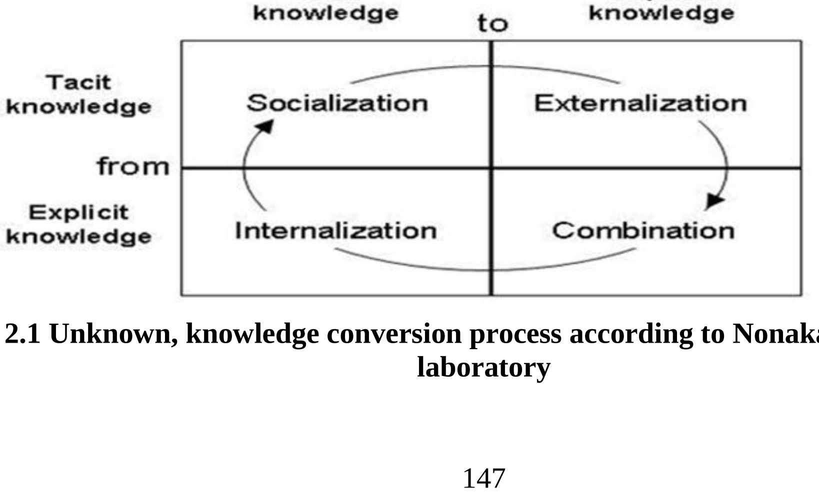


Figure 2.1 Unknown, knowledge conversion process according to Nonaka & Takeuchi, Hck laboratory

Educational knowledge is pretty much complicated; it is a strong mixture of implicit and explicit knowledge, to the extent that a decent education process cannot be built on one type without the other (Pazaver, 2013).

Therefore, it is important to manage the cycle of knowledge very carefully to ensure the complete beneficence of the information within. Nonaka & Takeuchi theory has four pillars; socialization, externalization, combination, and internalization.

Implementing Nonaka & Takeuchi cycle in METs as follows:

1. **Socialization** (implicit to implicit)

Experienced teachers share implicit knowledge with the new incomers based on the "share and learn" concept.
"The results of a recent study conducted by the IBM Institute for Knowledge Management found that even in a company with a well-developed infrastructure of knowledge management technology, people still turn first to other people as they seek solutions to problems and knowledge". Bartlett (2000)
This step is mostly done through formal/in-formal COPs, technology may also be used to support knowledge sharing and learning process.

2. **Externalization** (implicit to explicit)

McIntyre, Gauvin, & Waruszynski (2003) divided this step into two parts:
Capture and Acquire: where new teachers gain implicit information from the close socialization with seniors in a COP, then tries to converse it into explicit knowledge by recording it into the CMS, e.g., attending a lecture with an experienced teacher and trying to record notes of tactics used during the lecture, body movement, voice tone, analogies, metaphors etc…, the main challenge here is the ability of the new teacher to capture this implicit knowledge from his tutor.
Organize: After establishing a KM system that enables organizing and editing the context, a suitable CMS would be a useful platform for new teachers to upload their findings and recording the knowledge gained from their socialization. This platform can even be used by the management as an assessment tool to assess all teachers and quantify their performance as discussed earlier.

3. C**ombination** (explicit to explicit)

This is where the new explicit knowledge added by the new teacher is joined in the CMS with other explicit knowledge recorded from other teachers, resulting in a resourceful and enriched database. Now the information can be circulated, shared, evaluated, and (more importantly) accessed through a search engine using technological and statistical methods capable of retrieving the required content.

4. **Internalization** (explicit to implicit)

This is the process where teachers practice repeatedly what they have learned as explicit knowledge, either from the database, in training sessions, or in real classroom environment supervised by a senior staff member. This internalization period lasts until the new teacher accommodates a satisfying level of implicit knowledge, and only then, the management can end his training period and confirm his employment.
To that point, the cycle will have had completed its first round and starts a new round for additional knowledge building up in the data base, conditioned by the participation of senior/junior staff members under managerial supervision.

2.4 The Design and Structure of theMET Related KM System

Inspired by a research done by Haas, Aulbur & Thakar (2003), a MET Related KM system can (and was) established by doing the following:

1. Construct COPs from expert teachers in different subjects and specialties (representatives) to extract different expertise and different ideologies and backgrounds. COP of navigation teachers, COP of stability teachers, etc….

2. Encouraging the formation of formal &non-formal COPs of teachers and try to institutionalize these groups.
3. Establish a Content Management System (CMS)[1] suitable to deal with different types of knowledge (implicit–explicit).
4. Force/encourage teachers to participate in the formal/in-formal COPs and provide feedback.
5. Management may use CMS to monitor the progress of junior teachers and evaluate accordingly.
6. Teachers who will not participate in the system will be sanctioned or may even get their contract terminated, depending on their progress verses time allowed.
7. May be used in calibrating the performance of senior teachers, through evaluating the data recorded by the juniors explicating the knowledge they gained from them.

3. Case study & Research Framework

After constructing the KM system, a COP of three Maritime Lecturers were constructed. They all shared the same interest in simulator based training. The COP consisted of one senior lecturer with long experience in teaching the subject simulator course; where the 2 junior lectures were new to the subject course teaching.

The current research includes 1053 trainees attending a Short (5 days) Simulator Course, tested over a period of 16 months, from 4th of January 2015 to 24th of April 2016, subdivided into three groups:

Group No.1 (G1)
Feedback from 346 trainees were collected, representing 32.9% of the population, over a period of 6 months. During this time, the KM system and the CMS were established and in progress but the receiving instructors were not contributing to teaching in the classroom, the senior instructor was still in full command of the complete course being the sole instructor. This group is considered a control group validating the hypothesis of the research.

Group No.2 (G2)
Feedback from 175 trainees, representing 16.5%, collected for the period of one month. At this time of research, the senior instructor allowed the receiving instructors to contribute in actual teaching under his direct supervision and intervening when appropriate; as a part of the Knowledge transfer plan.

Group No. 3 (G3)
532 trainees, representing 50.5%, of which feedback were collected for the period of 7 months. In this period of time, the senior lecture had stepped down handing over the full responsibility of the course to the junior lecturers. As a final step in the research.

As the main idea of the research is to find out if the implementation of the Knowledge Management (KM) model introduced was effective or not, the research will compare the periods under study by comparing different responses to the research statements in different periods of implementation. Also, the overall performance in the three groups will be constructed and compared. Accordingly, the research hypothesis could be stated as follows:

H_1: There is a positive change in the overall performance as we proceed in the steps of KM implementation.

All trainees were subject to a survey of 9 questions and the answers were collected and entered on SPSS – version 22 to be analyzed. The analysis includes a descriptive analysis for the statements under study. Also, data testing using validity and reliability tests will be applied to check the validity of data for the

[1] CMS are systems that enable adding, editing, formatting, publishing and maintaining data. These systems can also be integrated into more sophisticated programs that have the ability to extract more information statistically and knowing which individual has what information, e.g. METADATA (Bolmsten, 2013).

analysis and to be able to construct the Performance as a variable out of the questionnaire statements assigned to the mentioned variable. In addition, ANOVA testing will be used to show if there is a significant difference in the data under study between different periods of implementation. Finally, a focus will be done on comparing the performance of the two periods of implementation; G1 and G3, where an independent samples t-test will be used to show if there a significant difference in the data under study.

The tools of ANOVA and t-tests are used to examine the difference between different groups within the same variable. A t-test is used if the testing variable consists of two groups. So, it can be used to determine if two sets of data are significantly different from each other. If the testing variable contains more than two groups, the Analysis of Variance (ANOVA) will best fit rather than the t-test (Farrell, 2006). This means that the t-test will be used to test if there is a significant difference in the research statements, as well as the overall performance according to different periods of Knowledge Management implementation; as the latter is the testing variable consisting of only two groups; No1 & No. 3. On the other hand, the ANOVA test will be used to test if there is a significant difference in the research statements as well as the overall performance according to different periods of implementation, as the latter one consist of three groups.

3.1 Data Analysis& Testing

In this section, data testing and analysis will be presented using the above mentioned tools to figure out a response of the hypotheses under study.

3.1.1 Descriptive Analysis

Table 3.1 Descriptive Analysis for the Statements under Study

Research Item	Frequency														
	Poor			Average			Good			V. Good			Excellent		
	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3	G1	G2	G3
Q1:Rate the course overall	1	1	0	6	5	2	101	15	81	134	71	211	104	83	238
Q2:Rate the course duration	13	2	18	30	14	52	105	38	100	105	56	174	93	65	188
Q3: To what extent was the course content compatible with course objectives	4	0	0	9	6	14	92	26	112	139	61	198	102	82	208
Q4:Rate the course knowledge added value	4	1	0	15	6	12	94	30	111	138	71	211	95	67	198
Q5:Rate the practical gained skills during the course	5	1	1	28	9	34	108	29	105	109	70	208	96	66	184
Q6:Rate the course lecturers' performance	1	0	0	12	4	1	111	15	28	95	42	161	127	114	342
Q7: How was the interaction between you and the lecturer?	4	0	0	14	5	2	99	19	47	124	57	187	105	94	296
Q8: How useful was the discussions held during the course?	5	1	0	19	3	8	84	27	95	134	70	214	104	74	215
Q9:Rate the simulators' familiarization period	10	1	7	37	10	33	95	31	118	101	68	189	103	65	185

The descriptive analysis shows a summary about the simple features of the data under study. It could be observed that most of the overall opinions lie in the zone of Excellent and very good, indicating an overall satisfaction regarding the simulation training course performance. Moreover, some of the responses lie in the neutral zone. On the other hand, there is a relatively very low number of responses lying in the zones of Average and Poor, indicating very few number of trainees who are not actually happy regarding the course provided.

Also, it could be observed that the periods of G2 and G3 enjoy better opinions of Very Good and Excellent zones from trainees than the period of G1, as the percentages of trainees in the zone of disagreement decrease while the trainee's percentages in the zone of agreement increase.

3.1.2 Data Testing

Validity and Reliability of the data under study are two important conditions that have to be satisfied to start using the data available in responding to the research hypotheses. In the current research, the variable; Performance is the variable that is supposed to be improved among different periods of Knowledge Management implementation.

3.1.3 Validity Testing

Validity means the extent to which an instrument measures what it supposes to measure correctly (Sekaran & Bougie, 2005). Convergent validity tests the data using factor analysis (multivariate technique) that confirms whether or not the theorized dimensions are applicable (Sekaran & Bougie, 2005). Convergent validity was essential to ensure that the items measuring the same construct are highly correlated (Hair et al., 2003).

In order to test the convergent validity, the average value extracted for each of the scales should be calculated, which represents the average community for each latent factor. In an adequate model, AVE should be greater than 0.5, which means that the factors should explain at least half the variance of their respective indicators (Garson, 2011; Hair et al., 2003).

Table 3.2 represents the items having adequate factor loading, which means that all dimensions under study have convergent validity, as AVE is greater than 50% and Factor Loadings are greater than 40%.

Table 3.2 Average Variance Extracted and factor Loadings of Research Items

Variables Under Study	Number of Items Entered	AVE	Items	Factor Loading of Items
Performance	9	60.666%	Q1	.694
			Q2	.504
			Q3	.629
			Q4	.688
			Q5	.684
			Q6	.469
			Q7	.607
			Q8	.622
			Q9	.562

3.1.4 Reliability Analysis

For the purpose of evaluation of measures of concepts, any multidimensional scale should be reliable and valid. In order to test reliability of the study, Cronbach's Alpha, as the most commonly used test of reliability, was applied. Alpha coefficient ranges in value from 0 to 1 and may be used to describe the reliability of factors extracted from dichotomous (that is, questions with two possible answers) and/or multi-point formatted questionnaires or scales (i.e., rating scale: 1 = poor, 5 = excellent). The higher the score, the more reliable the generated scale is. It was indicated that 0.7 is an acceptable reliability coefficient but lower thresholds are sometimes used in the literature (Hair et al, 2003).

Cronbach's alpha coefficient was applied to estimate the reliability of studied variables. The results are shown in Table 3.3 below and the results showed that all alpha values revealed the reliability and the internal consistency between the selected items of the studied variables. It can be shown that the value of Cronbach’s Alpha for the variable under study exceeds 0.7, which is an acceptable level for the reliability of the variable.

Table 3.3 Reliability Test for Variables under Study

Variables	Number of items	Validity Indicator
Performance	9	0.915

3.1.5 Normality Test

It is verified to determine if a data set is normal or well-modelled. An assessment of the normality of data is a prerequisite for many statistical tests because it is an underlying assumption in parametric testing. ANOVA and t-tests are one of the parametric tests requiring data to be normal.

Two common methods are identified to check this assumption:

a) ***Kolmogorov-Smirnov test of normality:*** It tests the normality assumption for samples greater than 50 observations.

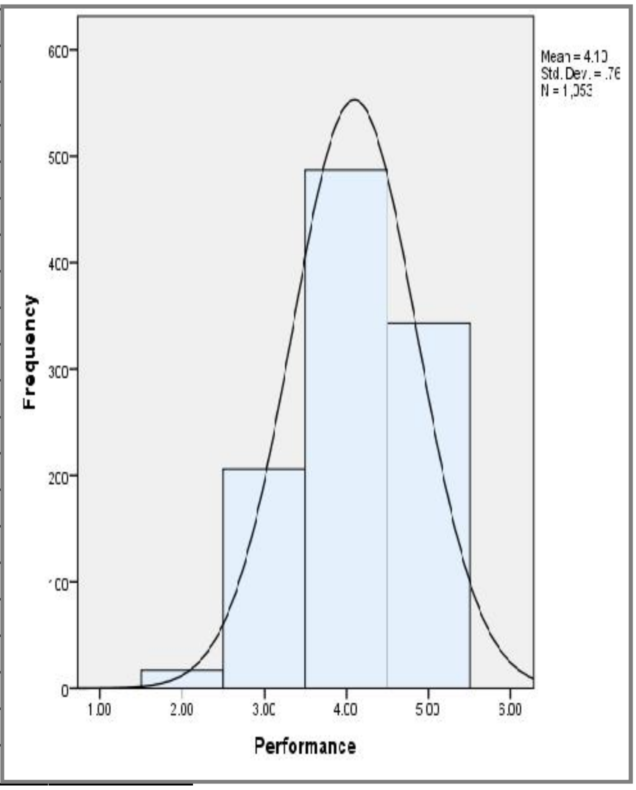
Table 3.4 Normality Test for the Research Items

	Kolmogorov-Smirnov[a]		
	Statistic	**Df**	**P-value**
Q1	.255	1041	.000
Q2	.213	1041	.000
Q3	.232	1041	.000
Q4	.222	1041	.000
Q5	.220	1041	.000
Q6	.341	1041	.000
Q7	.288	1041	.000
Q8	.229	1041	.000
Q9	.217	1041	.000
Performance	.236	1041	.000

b) ***Skewness and Kurtosis:*** It claims that a variable is reasonably close to normal if its skewness and kurtosis have values between –3.0 and +3.0 (Kleinbaum et al, 2008). The skewness and kurtosis of Performance is illustrated in figure 3.1, where the skewness is shown in the left side, indicating negative skewness value as shown in table 3.5:

Table 3.5 Skewness and Kurtosis Values for the Research Items& Figure 3.1 Normality Curve of Performance

		Statistic	Std. Error
Q1	Skewness	-.608	.076
	Kurtosis	-.305	.151
Q2	Skewness	-.672	.076
	Kurtosis	-.278	.151
Q3	Skewness	-.569	.076
	Kurtosis	-.357	.151
Q4	Skewness	-.585	.076
	Kurtosis	-.150	.151
Q5	Skewness	-.582	.076
	Kurtosis	-.360	.151
Q6	Skewness	-1.033	.076
	Kurtosis	.174	.151
Q7	Skewness	-.912	.076
	Kurtosis	.345	.151
Q8	Skewness	-.712	.076
	Kurtosis	.128	.151
Q9	Skewness	-.656	.076
	Kurtosis	-.230	.151
Performance	Skewness	-.391	.076
	Kurtosis	-.555	.151



3.2 Results & Discussion (Hypotheses Testing)

In this section, a response will be figured out for the hypotheses under study. ANOVA test (table 3.6) is applied to find out if there is a significant difference in the response towards the statements under study as well as Overall Performance according to different periods of implementation.

Table 3.6 ANOVA Testing for the Research Items

	N				Mean				Std. Deviation				P-value
	G1	G2	G3	Ttl	G1	G2	G3	Ttl	G1	G2	G3	Ttl	All
Q1	346	175	532	1052	3.9681	4.3143	4.2876	4.1873	.82942	.79407	.73004	.78890	0.000
Q2					3.6812	3.9600	3.8684	3.8222	1.07688	1.00779	1.10536	1.08434	0.008
Q3					3.9449	4.2514	4.1278	4.0884	.87596	.83369	.83170	.85303	0.000
Q4					3.8866	4.1257	4.1184	4.0438	.90121	.85512	.81134	.85523	0.000
Q5					3.7645	4.0914	4.0150	3.9458	.99551	.89230	.90394	.94108	0.000
Q6					3.9710	4.5200	4.5865	4.3736	.92402	.74925	.59978	.79615	0.000
Q7					3.9017	4.3714	4.4605	4.2621	.92102	.79096	.66973	.82017	0.000
Q8					3.9072	4.2171	4.1955	4.1046	.94166	.80853	.77832	.85064	0.000
Q9					3.7331	4.0629	3.9624	3.9046	1.09372	.91069	.96770	1.00830	0.000
P					3.8757	4.1886	4.2124	4.0978	.76453	.78337	.71702	.75956	0.000

It could be observed that the P-values of the statements; Q1 to Q9 and Performance (P) are all less than 0.05. This means that the mentioned statements show a significant change in their values with different periods of KM implementation.

Also, it could be noticed that the mean values of G1are the least, while the mean values of G2 are the highest. For more clarification, it is found that the mean value for Q1 in G1 is the least (Mean = 3.97), while the mean value for Q1 in G3 comes in the second rank (Mean = 4.29). The mean value for Q4 in G2 was shown to be the highest one (Mean = 4.31).

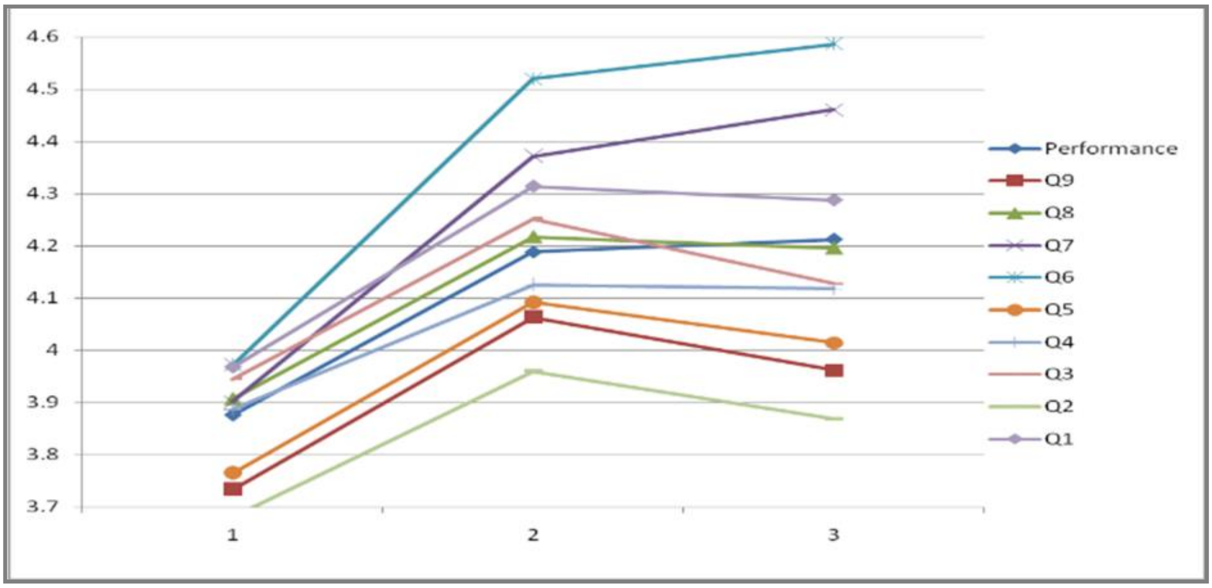
Regarding Q2, it could be noticed that the same rank between periods of implementation is found, where the mean value for Q1 in G1 was shown to be the least (Mean = 3.68), while the mean value for Q2 in G3 comes second in rank (Mean = 3.87). Also, the mean value for Q2 in G2 was shown to be the highest (Mean = 3.96). In the same way and rank, it was found that the mean values for the research statements Q3, Q4, Q5, Q6, Q7, Q8, Q9, as well as the Performance (P) were found to be the highest in the period of G2, while the second in rank is the period of G3. The period of G1 was found to have the least mean values among the three periods of Knowledge Management implementation.

The above result is illustrated using Figure 3.2, where it could be observed that mean values of all the research statements show an increase in their mean values when the junior instructors started contributing in teaching (G2). After that, a slight decrease happened after the senior instructor stepped down (G3), but yet it is shown to be still higher than the period when there was a sole instructor (G1).

The result above leads the researcher for further investigating the two periods; G1 (Control Group)& G3. Thus, an independent samples t-test is constructed to test the change in the mean responses of trainees towards the research statements and overall performance according with changing the periods from before to after implementation.

Table 3.7 shows the results obtained from the t-test, where it could be observed that there is a significant change in the research statements; Q1 to Q9, and Performance with changing periods of implementation from G1 to G3, as all corresponding P-values are less than 0.05.

Figure 3.2 Research Statements Mean Response for the Periods Under study



Also, it could be observed that the mean values of the research statements in G3is higher than that of G1. For example, the mean value of Q1 in G1 was 3.97, while in G3 increases to be 4.29. Also, the mean value of Q2 was 3.68 in G1, while increases to 3.87 in G3. In the same way all mean values of the research statements show an increase in its values from G1 to G3.

	N		Mean		Std. Deviation		P-value
	G1	G3	G1	G3	G1	G3	All
Q1	346	532	3.9681	4.2876	.82942	.73004	0.000
Q2			3.6812	3.8684	1.07688	1.10536	0.013
Q3			3.9449	4.1278	.87596	.83170	0.002
Q4			3.8866	4.1184	.90121	.81134	0.000
Q5			3.7645	4.0150	.99551	.90394	0.000
Q6			3.9710	4.5865	.92402	.59978	0.000
Q7			3.9017	4.4605	.92102	.66973	0.000
Q8			3.9072	4.1955	.94166	.77832	0.000
Q9			3.7331	3.9624	1.09372	.96770	0.001
P			3.8757	4.2124	.76453	.71702	0.000

Table 3.7 T-test for the Research Items according to Data from G1 and G3

In summary, the case study had shown that KM as a concept is important to the efficiency of education in a METI; where a mixture of implicit and explicit knowledge should be retained and shared within the institution. The case study also proves that when a well-designed KM Model is developed and wisely implemented, the results will be in favor of improved educational quality and surly reflected in the competency of its graduates.

4. Conclusion& Recommendations

In conclusion, knowledge management systems are an essential managerial tool used in any knowledge intensive organization. Believing that the knowledge of its employees is the most important asset in any successful competitive organization; top management should always utilize its resources in the most beneficial way. In order to do that, this paper had illustrated different aspects of knowledge management and its subsidiary theories. In addition, the concept of communities of practice have been discussed and how it is considered a major player in the successful flow of information and knowledge, conditioned by the participation of the knowledge producers and consumers. Also, discussed Nonaka & Takeuchi theory on the flow of organizational knowledge and how this theory would successfully be integrated throughout the educational system backed by strong formal and non-formal COPs and a powerful functional CMS.

Furthermore, a knowledge management case study had been introduced, describing how the establishment of a knowledge management system in a Maritime Education and Training Institute can simply solve the matter and reduce the educational gap between teachers. By statistically analyzing KPIs collected over a period of more than one year. where a CMS KM tool where introduced to a group of Simulator instructors and the result investigated the change happening in the responses of trainees regarding their opinions of the training courses provided in different periods of Knowledge Management application. It was observed that there is a significant change in the mean responses of trainees along the research period. The change proved a better response of trainees with time, which support the idea that appropriate methods of sharing knowledge leads to the improvement of educational services provided by any METI.

Therefore, this research recommends that all Maritime Education and Training Institutes shall construct / develop a Knowledgemanagement model / system and implant it in its quality management system where all employees would obligatorily contribute in. In this way, knowledgewill be retained within the institution, and as proven by this research, the overall performance of the Institute would surly magnify.

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Captain´s duty – The constant and continuing changes of captain´s legal position. How can we ensure that Masters are on map?

Senior Lecturer, Captain Ninna Roos[1]
Senior lecturer of Maritime and Commercial law
Peter Ivar Sandell [2]

[1]*Satakunta University of Applied Sciences, ninna.roos@samk.fi, Suojantie 2, 26100 Rauma, Finland.*
[2]*Satakunta University of Applied Sciences, peter.sandell@samk.fi, Suojantie 2, 26100 Rauma, Finland.*

Abstract The aim of this article is to examine the ship master's legal position and his rights, responsibilities and obligations. The idea is to find out what the ship master's role is with respect to the ship owner and ship's charterer and to what extent the master is allowed and expected to make his independent decisions. In addition, the purpose of this thesis was to clarify the general view of the master's roles and tasks in legal and contractual context and to examine how different changes in the transport industry over time have affected the development.

The ship master's role has changed over the time especially through development of technical means of communication and increase of internalisation of legislation and contract practice. The focus of the article is to describe the present situation predict some of the coming changes in horizon. Shipping is controlled by various international and national laws which impact the master and ship's crew. The changes in laws and regulations create new challenges for the master to maintain his/her knowhow and legal knowledge. This creates a constant challenge for the maritime Universities, but it also offers possibilities and need for further education. Some models for further educating the Masters will be offered.

The master works in close cooperation with different authorities who look after the safety of vessels. In this article, different methods of educating the authorities together with the Master Mariners have been found useful. Further education of the authorities and Master Mariners in co-operation with the Maritime Universities influences the ship safety and the protection of marine environment.

The article also focuses on the seaworthiness of ships, which is a significant issue when it comes to the charter party. It is in the best interest for both the master' and ship owner' to be concerned with seaworthiness. This is considered a serious issue, the breach of which may lead to the cancellation of the charter party. Marine insurance and charter parties are essential topics which are based on international development and which can be taught for Master Mariners on a global basis.

The final section of the article focuses on accidents at sea and general average decision making from the master's point of view.

Keywords: Captains legal position, safety and security, maritime environment, seaworthiness, education, further education, maritime accidents, general average.

1. Introduction

The ship master's role and status are exceptional compared to many other managerial duties ashore. On board the vessel he /she controls global operation of many matters and advantages of the different interest groups. His / her duty is to act behalf of the ship owner and the charterer.

When operating a vessel in the international traffic, the master has to act under several different legislations and be aware of and to take into account laws and rules which are valid in different sea areas and harbours.

The ship master's essential role is to manage risks which are related to safety of the ship, crew, passengers, cargo and environment. The master should always be authorised to make independent decisions and perform whatever acts are necessary for the safe prosecution of the voyage.

2. The ship master’s role today and in the future

2.1 Master’s role today

The ship master’s role has changed over the time especially through development of technical means of communication and increase of internalisation of legislation and contract practice. Various international and national laws control shipping and impact the ship operation. [1]

The master is the agent of the ship owner and the bailee of the cargo and he/ she has to act like the ship and cargo were his/her own uninsured property so as to complete the voyage with the minimum of delay and the minimum of expense. [2] According to most time-charter parties, the master and the vessel's crew have to give " customary assistance" to charterers, which means that, they have to give the same assistance to the time charterers as they would give to ship owners if they were trading for their account. [3]

The ship master is responsible for implementing ISM code on board the vessel and motivating the crew in the observation of shipping company's safety and environmental-protection policy. According to ISM Code, the master has " *the overriding authority and responsibility to make decisions with respect to safety and pollution prevention and to request the Company's assistance as may be necessary*." On the other hand, the Shipping company's obligation is to make sure that master and other personnel are qualified and trained for their tasks. [4]

Sometimes position of the master as an employer of the shipping company and as trustee of the charterer can be challenging, for example under the circumstances which are related to both safety/seaworthiness and time/economic issues. The threshold to settle against the employer can be high if priorities differs.

2.2 Challenges of the master in the future

The ship master's role has changed within time with development of a technology and society. Increasing international and national legislation and rules challenge both seafarers and shore operators to update their knowledge and competence. The essential feature for masters and supporting organisations ashore is that most decisions at sea need to be taken fast if not immediately. Courts of law can weigh the facts of the case even years while the master has to act often in minutes based on the existing knowledge and often without possibility for consultation. The ever growing amount of legislation and technology creates challenges also for education and further education during the careers at sea and in supporting roles of those ashore in shipping companies and in maritime administrations.

Before we turn into the problem of preparing the masters for these challenges through education we take up some issues which describe more closely the challenges the masters meet and what kind of decisions they have to make in modern seafaring. We take a closer look at the issues of seaworthiness and general average situations.

3. Seaworthiness

The seaworthiness of the vessel and cargo is one of the highest priorities of the ship master's duties.

Many parties have their own interests involved in vessel's seaworthiness – insurance companies, classification societies, charterers and investors.

There are many aspects how to define a vessels seaworthiness. In one circumstance a ship can be seaworthy and in an another not. Because of new technological advantages, what was earlier considered to be a seaworthy ship may not be that anymore. The simple definition for the seaworthiness, - a vessel is seaworthy when it's reasonably fit for its intended purpose.[5] Other requirement is that a vessel has to be able to meet the ordinary perils contemplated for the voyage.

The demand of seaworthiness can be roughly categorised to three different layers. First of all, the vessel has to meet the demands of relevant authorities like flag state, classification societies, authorities of countries where the ship is intended to visit while its journey.

The second layer is the insurance companies and the demand of seaworthiness described in the insurance contract and insurance legislation. Most marine insurance is still based on the warranty of seaworthiness of vessels, but some insurance contracts have taken another view: Nordic Marine Insurance Plan has since 2007 (at that time still carrying the previous name “Norwegian Marine insurance Plan”, which was changed to Nordic Marine Insurance Plan 2013) been based on the idea that insurers are not able to deny cover based on seaworthiness of the ship but only on a basis of breach of safety regulations. [6] Many ships are however nowadays insured with several different insurance conditions and have to follow both of these demands. Typical combination is to insure a vessel with German or English conditions for hull insurance and with Nordic conditions for loss of hire.

The third layer of seaworthiness is the guarantee offered by the ship owner´s in charter parties where they give a guarantee that the vessel is offered for chartering in seaworthy condition and is to remain seaworthy at all times during the charter party period [7]. This requires that the vessel remains seaworthy in relation to all loaded cargoes and combinations of cargo. For masters this demand is the most difficult as the cargoes need to be well planned and their positioning in especially container vessel´s causes headache as the loading should also meet the tight time constraints. Far too often the cargo inside the containers is not what was announced in the documents or the properties of the carried substances are not in order. Especially this is endangering the vessels seaworthiness when dangerous goods are carried in containers.

Seaworthiness is also a matter of human error which causes most accidents at sea. Lack of education or induction to the vessels safety measures or technical specifications still causes accidents even though the education levels have been harmonised through STCW convention.

Obligation to make the ship seaworthy lies foremost with the master of the vessel. He must ensure that the vessel is seaworthy before the vessels leaves port and this must be done by stages every time when leaving a new port during the voyage. The owner´s role is also crucial. The owners need to make everything at their disposal to guarantee the master a seaworthy vessel. The owner´s must take into account the masters opinion and demand of maintaining the seaworthiness of the vessel. The last thing the master can do is to decline leaving port if the vessel is not maintained in a seaworthy state in every respect or if it not possible to meet the demands of every safety regulations.

4. General average

When at sea, the master is the master of the ship. Despite modern communication equipment the master still has authority to make independent decisions and he/she is expected to act accordingly in matters of urgent danger. The most important issue in this regard are the acts which are formulated in order for the master to be able to protect the ship and cargo in imminent danger and to make continuation of the voyage possible despite urgent measures which need to be taken fast.

The general average act is an issue which has existed in seafaring since the times of Rhodian maritime law. At that time according to the Rules the master was able to decide that cargo will be thrown overboard and sacrificed for interest of common safety for all to safe the “common adventure” from total destruction. Another rule from those ancient times was that if a broken mast has to be cast into sea in order to save the rest of the vessel and its cargo, the value of the mast will be compensated for the owner by the cargo owners whose cargo was saved by that action. The Rule of General Average was formulated to divide the risk in GA situations between all contributing interests whose property was saved by sacrificing the others property in danger.[8]

In the modern world the same basic rules are in heart of seafaring – Only in much more complicated form covering many different kinds of perils of the sea. The rules of General Average have existed in all seafaring nations in all times since the Rhodians. The law on General Average was diversified since the fall of Roman empire but the Rule were again unified in York 1864 and again in Antwerp 1877. Since then they have been called York-Antwerp Rules. The newest version of the Rules was accepted 2016 in New York and is called York-Antwerp Rules 2016. BIMCO gave its acceptance to the new rules on following Tuesday after the acceptance of the new rules by CMI on previous Friday.[9][10]The Rules are expected to be incorporated in Bills of Ladings and Charter parties as soon as new versions of them are implemented.

According to York-Antwerp Rules the master is able to decide on matters like stranding the ship when necessary in order to prevent it from sinking, he/she can make the decision on extinguishing fire on board even though this would mean destroying the containers above the containers on fire, he/she can drop the cargo like in ancient times, he/she can enter into a salvage contract on terms which are commonly accepted in maritime community or he/she can deviate to port of refuge and the costs of getting and staying there in order to be able to continue the voyage will be divided according to the York-Antwerp Rules.

5. Models for education

Learning rules and legal issues can be boring. Reading rules by heart seldom makes sense if they are not visualised from practical point of view. This applies to all students but especially seafarers as they are often practically orientated persons. The lecturers in law in law schools are too often lecturing just by referring to legislation or cases just briefly explained. Quite often when a new convention in maritime world enters into force, this method is used also when masters are taught to understand the new rules. This is sometimes caused by cautiousness of the lecturers who do not want to guess how the law will be implemented in practical life. This is the specific problem in a situation when something totally new is implemented in maritime community. We have good and recent examples of this: Many of us have been sitting and hearing about the implementation of the ISM code and later the ISPS code.

Also when conventions like ISM and ISPS are taught for the first time before they are implemented and taken into practise, they should be put to life for the masters. Problems which lead to the very existence of the new rules should at least be opened up. But as soon as the implementation is started and the practical examples are available, they should be used. In Finland the Maritime Universities worked together to educate the masters in both these conventions. Combining the forces and experiences was made not only together with the Universities teaching in Finnish language but also together with the Finnish maritime administration. The whole maritime industry in the country was taught systematically. This is the first example of national co-operation which combined all the best resources in a situation where all masters needed to be updated at the highest possible speed to meet the deadline by the implementation.

In the beginning of 21st century the maritime administration and shipping companies as well as the Maritime Trade Unions started to discuss the problem of ageing of the workers in the maritime management professions ashore. Finland like many other countries had seen the growth of maritime sector after the second world war and persons who had been born before or immediately after the war and had been recruited to maritime professions were ageing fast. The need for persons working ashore who had maritime experience from sea were vanishing and retiring rapidly. Master Mariners education was based on a lower University degree. With strong support from the maritime industry a new Master degree was established and developed starting 2006 in Satakunta University of Applied Sciences.

The Master of Maritime Management- degree programme in Satakunta University of Applied Sciences was based on the idea that Master Mariners –bachelor degree programme was the basis for further education supplemented first by reasonable amount of working experience at sea (minimum three years) and then supplemented by theoretical and practically oriented studies on maritime economics, maritime law, marine insurance, charterparties, shipbroking, safety of ships etc. The Master of Maritime Management program has since then produced tens of Master Mariners now also holding a higher degree in Maritime Management. The program was developed and built up in close co-operation and with support from the industry. The degree programme has been beneficial for those still working at sea but especially for those who wanted to develop their careers ashore. There we have been able to fulfil a hole in education and respond to the need of professionals with seafaring experience in shipping companies and maritime administration. The careers after the education in general have been quite successful.

These successes however need to be followed by the next steps to be taken. The Master of Maritime Management programme is now starting 2017 in English language and has been enlarged also to cover Marine Engineers Master-level education. Not all Master Mariners want to take a higher University degree with a demanding thesis to be written during and in the end of the studies. The problem based methods developed for the Master program can however be applied to also further education for Master Mariners in general. Keeping the Masters on map on legal issues should be explored on the basis of the needs explored during the development of the Master programme. This cannot be done by Maritime Universities only. There we need again co-operation. Some models for co-operation are already under observation and development.

Seminar activities together with maritime administration and the alumni organisation has already been established. The growing number of alumni's are also further educating in their respective organisations. They have been allowed to use the materials for in-house education for free of charge. They need to be further educated and updated. The idea of meeting the alumni´s once a year and using this meeting for updating has already been tested and found useful.

Maritime law, Law of charter parties, law of marine insurance and General Average are topics which are heavily based on development on case law. Master Mariners are dealing mostly with English law beside their national legislation. Case studies are used in Satakunta University of Applied Sciences in both levels of mariner's education on bachelor and Master degree programmes.

Using the case studies also for further education is an idea that could be even tested as an international co-operation together with Maritime Universities. One possibility for financing these activities and mobility of teachers could be using the existing teacher exchange programmes. The other possibility could be financing it with fees from the students whose employers would participate in travel costs and fees.

6. Conclusions

Master Mariners role is constantly changing and they are required increasing amount of information. At sea google doesn't help much. And often there is no time to search information as the decisions are made fast. As Maritime University we should take care that the Masters have enough knowledge when they graduate and help them to maintain the essential skills and knowledge. All Maritime Universities need to do or cover everything. From legal point of view our Maritime industry is unique – there is no other field of education where harmonisation through international conventions and case law of one single country makes it possible for us to unite education and work together. It's time for co-operation and specialisation. At least it´s time for developing and dividing teaching and learning methods and best practices – Time for ensuring together that the Master Mariners are on map globally.

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Standardization and Simplification for Teaching the International Collision Regulations [72COLREGS]

Douglas A. Hard, Master Mariner, Captain, USMS (Ret.) & USNR (Ret.)
Professor (Ret.) of Navigation Law

U.S. Merchant Marine Academy, hardd@usmma.edu
120 Newmarket Road
Garden City, NY 11530, USA

Abstract - The *International Regulations for Preventing Collisions at Sea, 1972* [72COLREGS] provide the standard by which every description of water craft is to be operated on COLREGS waters. In many instances the COLREGS, or *The Rules* as they are more commonly known, are the standard to which various appropriate authorities around the world have created their own special rules for the waters under their jurisdiction, an example being the Inland Rules of the United States. According to Rule 2 of both the COLREGS and U.S. Inland Rules, "*Nothing in these Rules shall exonerate any vessel, or the owner, master or crew thereof, from the consequences of any neglect to comply with these Rules* . . . " That fiat is a worthy and uncompromising objective designed to ensure that all vessels, commercial, public or private, are operated in accordance with the mandates of *The Rules*. The underlying corollary, however, is that *The Rules* are unambiguously clear and understood by all who operate vessels; unfortunately, that is not always the case. *The Rules* as presently written are <u>not</u> perfectly clear and in various places are confusing, ambiguous and even contradictory. Such uncertainty is frustrating enough for the professional mariner, to say nothing of the consternation experienced by the student or recreational mariner. But what is of overwhelming and paramount concern is the danger posed by the various uncertainties contained in *The Rules* which could lead to collisions, loss of life, pollutions and other undesirous results. This paper highlights some of the uncertainties and inconsistencies contained in *The Rules* as presently written and suggests changes that are intended to make *The Rules* clearer and easier to understand by the mariner (professional, recreational or student) as well as by members of the legal profession.

1. Introduction

- It is in the best interests of every inhabitant of our planet that vessels be operated as safely as is possible on the waters upon which we all depend. One critical aspect of such concern is the prevention of collisions and allisions, loss of life, pollutions, etc. and to this end the international maritime community has agreed upon a code of conduct embraced in the *International Regulations for Preventing Collisions at Sea, 1972* [72COLREGS]. For almost two centuries the signatory nations have endorsed and enforced these and prior similar regulations, one of the earliest examples of international cooperation of which the maritime community can take great pride!

To ensure that the safe operation of vessels is achieved, mariners must be taught (and comply with) *The Rules* and, as stated in Rule 2 of those regulations, "*Nothing . . . shall exonerate any vessel . . . from the consequences of any neglect to comply with these rules* . . ." However, in order for the mariner to comply correctly, the meaning and intent of *The Rules* must be perfectly <u>clear</u> and <u>unambiguous</u> which, unfortunately, is not always the case.

In many instances *The Rules* are confusing, inconsistent or contradictory. This is troublesome enough for those conversant in English, but it is especially vexing and difficult for the majority of the world's mariners whose native language is not English. Therefore, if the maritime community is going to hold the mariner to the high and unalterable standard of Rule 2 . . . that is, that *nothing exonerates* the mariner from non-compliance with *The Rules* . . . then it is incumbent upon the maritime community to ensure that what is meant and intended by those very same *Rules* be absolutely and incontrovertibly clear to all concerned!

The vast majority of vessels encountered out on the water today are not operated by professional mariners, yet the courts of law are going to hold these same individuals to the high standards of Rule 2; therefore, it is imperative that *The Rules* be presented in clear, unambiguous language in such a way as to be absolutely clear to every reader, whether they be judge, attorney, student, recreational boater or professional mariner.

To that end, this paper will highlight some of the confusing, ambiguous and contradictory aspects of the COLREGS as presently written and offer suggestions for resolving the shortcomings noted in order to facilitate both the teaching and the learning of this most important aspect of overall maritime training.

2. Examples of Confusion and Suggested Remedies

Rule 1. The very first paragraph of *The Rules* [i.e., Rule 1(a)], commences with an unintentionally misleading statement: "*These Rules shall apply to all vessels upon the high seas and in all waters connected therewith navigable by seagoing vessels.*" Since every sovereign nation (and any other appropriate authority) has the right to make its own *Rules* for its own waters, as a stand-alone statement Rule 1's paragraph (a) is just not true and is very confusing to the average reader, especially students. This confusion can easily be eliminated (as was made clear in *The Rules* previous to the 72COLREGS by the use of the word "except") by adding at the end of the present wording of Rule 1(a) the phrase "**except as provided in Rule 1(b)**." By doing so the intent of Rule 1(a) is made perfectly clear.

One of the questions most frequently asked by students relates to lights and shapes, and is generally stated in a manner such as this: *May vessels exhibit <u>signals</u> in addition to those specifically required?* Such uncertainty could easily be resolved, for each and every rule, by inserting a paragraph in Rule 20 similar to that which presently appears in Rule 26, *Fishing Vessels.* Rule 26(a) states, "*A vessel engaged in fishing . . . shall exhibit <u>only</u> the lights and shapes prescribed in this Rule*". A similar assertion in Rule 20, "*Application*" [of Part C - *Lights and Shapes*] . . . for example, an additional paragraph reading, "**The vessels of the categories addressed in Part C shall exhibit only the lights and shapes prescribe in Rules 23 through 31**" . . . would eliminate any uncertainty.

Another source of confusion is the use of the phrase "in a vertical line" (especially when pertaining to a *power-driven vessel when towing* [PDVWT]). To the professional mariner it is clear that the rule (24) intends for the masthead lights, which specifically indicate a towing operation, be mounted directly above or below each other; that is on the same supporting structure or the same *vertical axis*. However, for the student or non-professional, this vague wording is problematic because that which constitutes a "vertical line" depends on one's aspect of view and can be very misleading. For instance, when viewed from dead ahead a *power-driven vessel* [PDV] exhibiting both a forward and an after masthead light appears to be exhibiting, "in a vertical line", the same arrangement of masthead lights as a PDVWT that is less than 50 meters in length exhibiting both masthead lights on the same supporting structure which, of course, is not the case at all. It is suggested that wherever the phrase "in a vertical line" occurs it be replaced by the words "**in the same vertical axis**".

3. Examples of Ambiguities and Suggested Remedies

Throughout *The Rules*, there is no greater source of ambiguity or consternation than the use of the word "*restricted*" (or its variants) because its specific meaning and/or interpretation is dependent on the topic of the particular rule or the context of the conversation in question. Since the use of the word is so prevalent, the number of suggestions that would be required for clarifying each appearance goes far beyond the scope of this paper. Suffice to say, however, that an expansion of the *Interpretive Rules* chapter of the COLREGS may offer the most efficient method for providing the precise interpretation to be made of the word "*restricted*" each time it appears.

Rule 3 - *Definitions*, contains several ambiguities. For example, both 3(f) and 3(g), which define vessels *not under command* [VNUC] and *restricted in ability to maneuver* [VRIATM] respectively, state that the vessels in question are "*unable to maneuver*" which, of course, is not necessarily the case at all; such an inaccurate blanket statement is the cause of much confusion, consternation and frustration, especially among students.

For example, the VNUC: To begin with, the vessel must have encountered some unplanned for or unexpected event (i.e., encountered an *exceptional circumstance*). In addition, unless it has actually lost its rudder or the use of its propelling machinery (and therefore cannot physically maneuver), addressing the actual exceptional circumstance incurred may very well require extremely accurate *maneuvering* on the vessel's part. For instance, a vessel attempting to recover someone who has fallen overboard must be maneuvered very precisely in order to return to the exact spot in the water where the individual was last seen. Clearly, and contrary to what one is lead to believe as per the definition contained in Rule 3(f), this VNUC is not *unable to maneuver*; in fact, it must maneuver to handle the exceptional circumstance encountered.

The definition of a VRIATM presents a similar ambiguity. In carrying out the very work which justifies its claim to VRIATM status, a VRIATM may have to maneuver very precisely to perform its work. For instance, a buoy tender's placing of a buoy requires extremely accurate shiphandling; an aircraft carrier engaged in launching or recovery of aircraft; vessels involved in underway replenishment, all classified as VRIATM, of necessity must be maneuvered with great precision and are, by no interpretation, "*unable to maneuver*" as stated in the Rule 3(g) definition.

To eliminate the ambiguities associated with the definitions of both VNUC and VRIATM, it is suggested that the respective definitions be reworded (as in the following **bold** print) to state:

3(f) – "The term *vessel not under command* means a vessel which through some exceptional circumstance is **relieved of the maneuvering obligations of the Steering and Sailing Rules for the duration of the exceptional circumstance and, therefore, will not keep out of the way of other vessels in a traffic encounter**."

3(g) – "The term *vessel restricted in her ability to maneuver* means a vessel which from the nature of her work is **relieved of the maneuvering obligations of the Steering and Sailing Rules for the duration of its work and, therefore, will not keep out of the way of other vessels in a traffic encounter**. The term . . . shall include but not be limited to:"

"*Restricted Visibility"* - The lack of a clarity in Rule 3(l)'s critical definition of *restricted visibility* is extremely problematic. What actually constitutes the concept of *restricted visibility* is not clear until arriving at Rule 19 (*Conduct of Vessels in Restricted Visibility*) and even then clarity is due the rule's name rather than the actual wording of the rule itself.

To ensure the correct understanding of the *restricted visibility* concept, its meaning should be unquestionably clear from the very outset (i.e., in its Rule 3(l) definition). Therefore, the following rewording of Rule 3(l) is suggested: "**The term *restricted visibility* means any condition in which meteorological conditions (such as fog, mist, falling snow, heavy rainstorms, sandstorms or any other similar cause) prevent the observer from actually seeing the risk of collision**." It is extremely important that it be made crystal clear, in the simplest of terms, that the mere presence of rain or snow, etc. is not, in and of itself, sufficient to constitute *restricted visibility*! Rather it is the inability (*due* to the meteorological conditions present) to actually see the potential risk of collision that determines which of the Steering and Sailing Rules apply at any particular time and place.

4. Examples of Contradictions and Suggested Remedies

A contradiction of a subtle nature appears in Rule 9, specifically in paragraphs (d), (e) and (f). Each of these paragraphs calls for the use of various whistle signals from Rule 34. The contradiction arises from the fact the Rule 9 is contained in Section One [Rules 4-10] of the *Steering and Sailing Rules* and, as per Rule 4, is to be followed in any condition of visibility. However, the Rule 34 whistle signals called for in Rule 9 are to be employed only when vessels *are in sight* of one another; thus the signals called for by Rule 9 are not to be employed in *restricted visibility* and, therefore, aspects of Rule 9 do not, as per Rule 4, "apply to any condition of visibility"!

In order to counter the existing contradictions in Rule 9 and prevent any further misinterpretation of the use of the whistle signals referenced therein, it is suggested the following be added as an additional paragraph (h) to Rule 9: "**The Rule 34 whistle signals referenced by this rule are to be sounded only when in sight of the other vessel and not in restricted visibility.**"

There are other similar contradictions throughout the rules, but the most glaring – and potentially most dangerous – arises with Rule 8(f) which addresses the concept *not to impede*.

The invented concept of *not impeding* was introduced with the 72COLREGS without definition or explanation. It had no maritime tradition or precedence, thus mariners were at a loss as to its meaning or implications. Therefore, in order to clarify its intentions, the IMO Subcommittee on Safety of Navigation issued "*guidance"* as to the meaning of the concept that, in effect, stated that a vessel so burdened (i.e., ordered not to impede) should take action so early in a potential traffic encounter that risk of collision would never develop and, therefore, the responsibilities of a stand-on vessel and a give-way vessel would never evolve. Although not nearly as specific as some of the other maneuvering mandates (e.g., Rule 14, the *Head-on Situation*), the *guidance* did explain what was intended and expected of the vessel which was ordered *not to impede*.

However, in 1989 the IMO decided that the "not to impede" guidance should become a formal part of *The Rules* themselves and, therefore, as an amendment to the COLREGS, a new Rule 8(f) was added. The new rule, 8(f), was (and still is) composed of three subparagraphs (i), (ii) and (iii). Subparagraph (i) clearly explains the intention of the previously issued guidance although it does not explain what is intended by "early action"; however, the general concept is explained clearly enough for the mariner to understand the IMO's intent. Had that been the entirety of the new Rule 8(f), few questions would have arisen; however, the additional paragraphs (ii) and (ii) are completely contradictory!

Rule 8(f)(ii) mandates that a "*vessel required not to impede . . . is not relieved of this obligation . . .* [when in] *risk of collision and shall, when taking action, have full regard to the action . . . required by the rules of this part.*" This part is Part B (*The Steering and Sailing Rules*), and the mandate of Rule 17 is absolutely clear stating that a Stand-on Vessel "*. . . shall keep her course and speed*." Therefore the critical question arises, what if a Stand-on Vessel is also required *not to impede*? How, at the same time, is a vessel to comply with Rule 17 - and "keep her course and speed" - while simultaneously mandated to take action (i.e., maneuver) so as not to impede? This is a blatant contradiction; a vessel cannot Stand-on and maneuver at the same time!

The confusion generated by 8(f)(ii) is further compounded by the following subparagraph (iii) which specifically states that a "*vessel . . . not to be impeded remains fully obligated to comply with the rules of this part* [Part B] . . . [when in] *risk of collision*." What if, as required by one of the other rules of Part B (e.g., Rule 12- *Sailing Vessels*, 13-*Overtking*, 15-*Crossing Situation* or Rule 18-*Responsibilities between Vessels*), a vessel not to be impeded is mandated to give-way? How is it expected/required to maneuver? Or is it expected/required to maneuver at all?

At the very least the intent and/or expectation of Rule 8(f) is not clear, and it is the opinion of the author that Rule 8(f)'s second and third subparagraphs are unquestionably contradictory and, as a result, very dangerous! Therefore, it is recommended strongly that **subparagraphs (ii) and (iii) of Rule 8(f) be eliminated**.

5. Conclusion

If the international community is going to hold the mariner to the worthy high standards of Rule 2 (i.e., that nothing exonerates the mariner from failure to comply with *The Rules*), then those same rules must be absolutely and incontrovertibly clear to the student trying to learn the rules as well as to the professional or recreational mariner! There should be no doubt whatsoever on anyone's part as to what is required of a vessel when in risk of collision with another vessel.

Session 2B

MARITIME SAFETY & SECURITY

Calculation and simulation of the current effects on maritime safety in Haiphong fairway, Vietnam

Prof. Dr. Luong Cong Nho[1], Prof. Dr. Pham Ky Quang[2], Dr. Vu Van Duy[3], PhD. Student Bui Van Cuong[4], PhD. Student Co Tan Anh Vu[5], PhD. Student Nguyen Thanh Nhat Lai[6].

1. Vietnam Maritime University, luongcongnho@vimaru.edu.vn
2. Vietnam Maritime University, phamkyquang@vimaru.edu.vn
3. Vietnam Maritime University, duyvv.vck@vimaru.edu.vn
4. Faculty of Navigation, Vietnam Maritime University, bvcuong1964@gmail.com
5. Faculty of Navigation, Vietnam Maritime University, vucotananh@gmail.com
6. Ho Chi Minh City University of Transport, nhatlai_hh@hcmutrans.edu.vn

Abstract: Haiphong is the biggest port in the Northern region, with 80 million tons of cleared goods passing through it in 2015. Haiphong fairway with 85 km length with high density of the maritime transports, plays the vital role in the Vietnam Northern waterway system. Moreover, in this one-direction fairway still remain complicated natural features such as many bends, branches, shallow spots and strong current and these factors are the potential causes for maritime accidents.

One of the reasons leading to these accidents in this channel (mainly grounding and collision) is the direct effect of the current on the process of ship course control which is pre-programmed.

With the features mentioned above, this paper focuses on analyzing the areas which potentially have maritime risks, as well as reasons for maritime accidents involving current effects such as: Interaction between rudder and propeller; impact on vessel's shell when altering course; rudder cavitation problems.

According to these facts, the authors built a research model and a mathematical one by basing on the BEM method and simulating them by the Fluent-Ansys software. Then, results of simulated calculation of the current effect on controlling ship course in the Haiphong fairway are presented in order to improve the safety of navigation in this channel.

To prove research outcomes, authors conducted an experiment and visually monitored the process of ship course control on M/V TAN CANG FOUNDATION in the Haiphong fairway.

***Keywords*:** current effect, ship course, Haiphong fairway, rudder and propeller, rudder cavitation.

1. Analyzing some potential risk areas of maritime accidents in Haiphong fairway

Currently, the task of guiding the vessel through navigational access channels to Hai Phong port is taken on by pilot or the ship's captain. The average number of vessels passing through the channels daily is 60, and at times, as many as 80 vessels do. Hai Phong fairway is one-direction with several avoiding spots, along the channels, there are areas where river branches meet, and the crooked channels consist of several areas with restricted depths and narrow parts. In addition, the hydrometeorological particulars of these channels can cause difficulties to navigation, for example, the current at some places can be as strong as 4.5 knots [4].

On average 45 maritime accidents occur annually (mainly collision and grounding). Some of them are extremely serious and cause both severe damage to property and loss of human life [4]. The main causes to maritime accidents are the ability of the captain and pilots when handling vessels. In addition, the effect of strong currents on vessels' maneuverability, deviating the ships from their planted tracks is also another cause to these.

Maritime accidents occur mainly in four areas (which are numbered by order of their locations, starting from Hai Phong main port to the buoy № 0, as shown in figure 1), as following [4]:

Area I: The confluence of the Cam and Ruot Lon rivers. This is a very narrow area, with floodplains near the mouth of Ruot Lon river on one side and the main berths of Hai Phong port on the other. The channel depth is low and the current is strong in this area, especially at high water. Furthermore, small vessels and watercrafts usually cross between the Cam river and the Ruot Lon river and this can easily create the risk of collision with vessels moored to berth or being aground at Ruot Lon river bank.

Area II: The confluence of the Cam and the Bach Dang rivers. There are many floodplains near the mouth of Bach Dang river. The traffic density in the area is extremely high, and the Rules of the Road are not very well observed. With the tide, the current always tends to the direction of motion of the ship to the shore of Thuy Nguyen district. Therefore, there are very high risks of collision and running aground in this area.

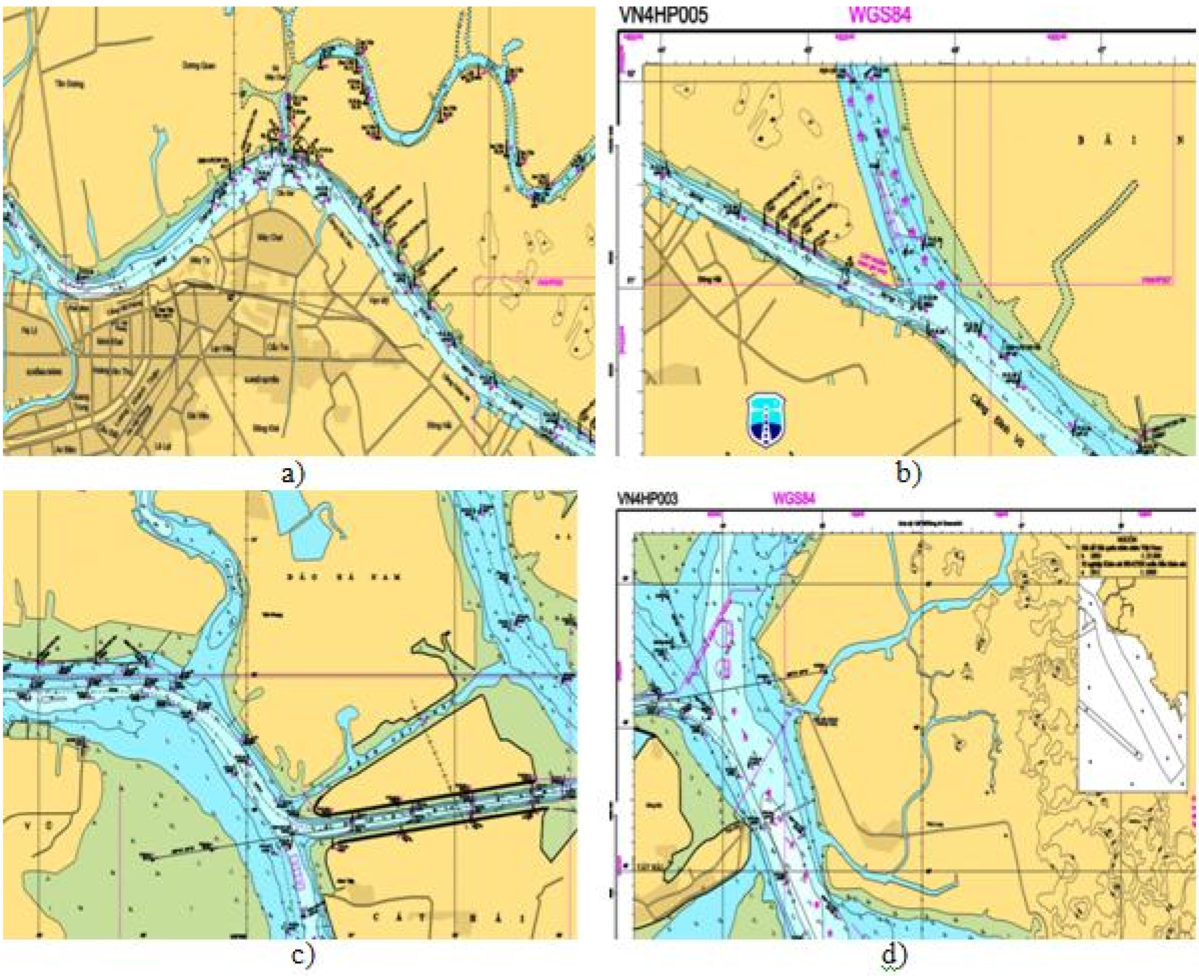


Figure 1 Four potential risk areas of maritime accidents in Haiphong fairway
a) Area I; b) Area II; c) Area III; d) Area IV

Area III: The junction of the Cam river, Nam Trieu, Cai Trap and Ha Nam channels. There are many shallow areas at the water near Dinh Vu peninsula and the mouth of the Bach Dang river. The traffic density is high and the nature of traffic is complicated in this area, especially between buoys № 30 and № 32. In addition, this area is known to be with strong and unstable currents, along with several anchorage areas and ferry terminals.

Area IV: The junction of Ha Nam, Cai Trap channels and the inland waterway leading to Quang Ninh provice. Many inland ships, barges and water crafts cross the channel to enter Cai Trap channel, especially around buoys № 19, № 21 and № 23. Furthermore, the area where larger vessels enter Lach Huyen chanel is accompanied by extremely strong and unstable current. The large number of both seagoing and inland waterway vessels passing through Cai Trap and Ha Nam channels makes the risk of maritime accidents in this area more serious.

Summary: In order to assist the captain and pilot in deciding the optimal routes to guide their ships through the above - mentioned areas, which will enhance the safety of navigation in the area, the authors have carried out the calculation and simulation of the current effects on the course keeping ability of vessels navigating in the fairways of Hai Phong port by calculating three problems, namely: Impact on vessel's shell when altering course; Interaction between rudder and propeller; Rudder cavitation problems, based on the results of field surveys, by analysizing values and evaluation practice received, with the experimental data are performed on the M/V TAN CANG FOUNDATION operating on the navigational access channels to Hai Phong Port.

2. Research models and mathematical principles

2.1 The model ship for research

Our research object is the effects of current on the course keeping ability of vessels navigation in Haiphong fairway. In order to facilitate the field surveys and collect experimental data for calculation and simulation, the authors used a congruent model of M/V TAN CANG FOUDATION (figure 2) (this is a container ship with the capacity of 420 TEU operating in the route between Hai Phong port and Sai Gon port) [1, 2, 4, 7].

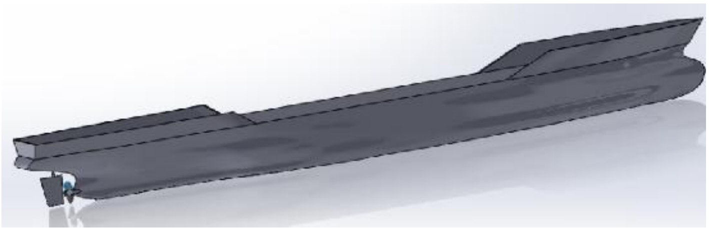


Figure 2 The model congruent of M/V TANCANG FOUNDATION

The first problem: When the ship alters her course, the current impact on vessel's shell will make additional forces (not considering the effects of the wind). To determine the additional force as well as to analyse its effects on the ship's maneuverability, we gave a research model according to figure 3 [3].

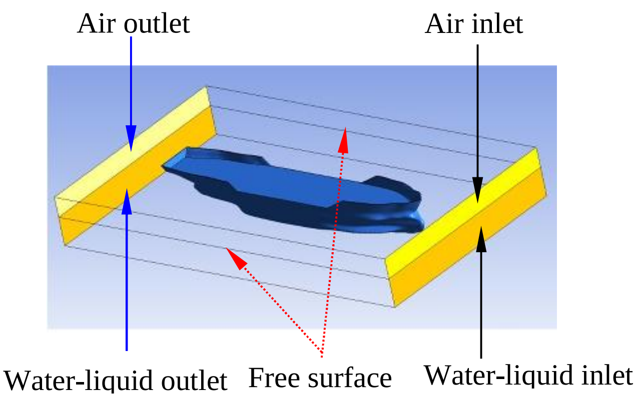


Figure 3 The research model with conditions as described in the situation of the first problem

The second problem: The interaction between rudder and propeller with different combinations of propeller rotation and rudder angle, as illustrated in figure 4 is researched and the result of which is analysed to find the optimal combination to keep the vessel on the pre-programmed orbit [2, 5, 6].

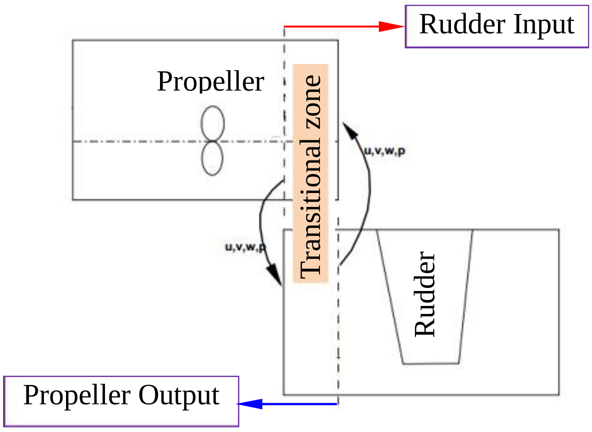


Figure 4 The research model for solving the second problem

The third problem: Calculating and stimulating the effects of cavitation rudder (figure 5) can help determine the steering forces of ship during this period. The results will be used to assess the effects of cavitation rudder on course keeping abilities of vessels navigating in Haiphong fairway.

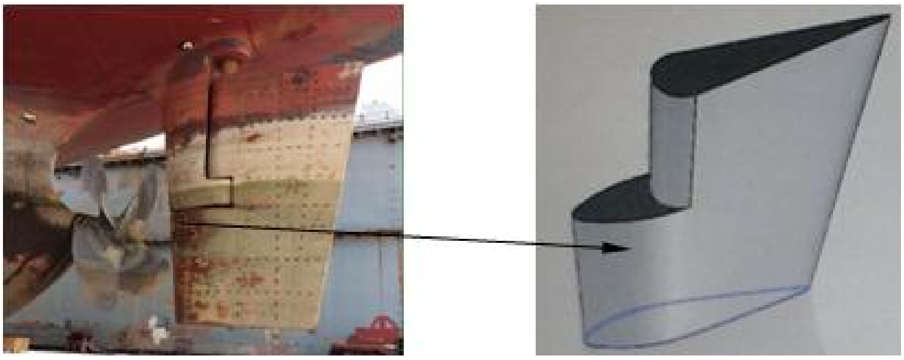


Figure 5 The research model for solving the third problem

2.2 Mathematical principles

We apply CFD in researching the effects of current on course keeping abilities of vessels navigating in the area. For three proposed problems, the VOF (volume of fluid) model, mixture for cavitation problem and others models, such as [1, 2, 3, 9]: k-ε, k-ω,... are used.

- The method of VOF for solving differential equations with various phases, by adding the value of volume fraction, if α_k is the volume fraction of the number k phase, then:

$$\sum_{k=1}^{n} \alpha_k = 1 \tag{1}$$

If ρ_k is the density of the number k phase, the density of the mixture will be:

$$\rho = \sum_{k=1}^{n} \alpha_k \rho_k \tag{2}$$

Then, we solve major differential equations to determine specific values:

$$\frac{\partial \alpha_k}{\partial t} + \nabla\left(\alpha_k \vec{v}_k\right) = \frac{1}{\rho_k}\left[s_{\alpha_k} + \sum_{k=1}^{n}\left(\dot{m}_{pk} - \dot{m}_{kp}\right)\right] \tag{3}$$

The value of volume fraction is determined by time step:

$$\frac{\alpha_k^{n+1}\rho_k^{n+1} - \alpha_k^{n}\rho_k^{n}}{\Delta t} + \sum_f\left(\rho_k^{n+1} U_k^{n+1} \alpha_{kf}^{n+1}\right) = \left[s_{\alpha_k} + \sum_{k=1}^{n}\left(\dot{m}_{pk} - \dot{m}_{kp}\right)\right] V \tag{4}$$

In the equation: n - the previous time step; (n+1) - the current time step; α_{kf} - the representative value of volume fraction of the number k phase; V - the volume of the calculating element; U_f - the volume of water flowing through the surface according to linear methods; $\dot{m}_{kp}$ - the mass transferred from phase number p to phase number k; $s_{\alpha k} = 0$.

The velocity distribution and energy can be determined by momentum equation and energy equation:

$$\frac{\partial}{\partial t}\left(\rho \vec{v}\right) + \nabla\left(\rho \vec{v}\, \vec{v}\right) = -\nabla p + \nabla\left[\mu\left(\nabla \vec{v} + \nabla \vec{v}^{\,t}\right)\right] + \rho \vec{g} + \vec{F} \tag{5}$$

$$\frac{\partial}{\partial t}\left(\rho E\right) + \nabla\left(\vec{v}\left(\rho E + p\right)\right) = \nabla\left(k_{eff} \nabla T\right) + s_h \tag{6}$$

T - temperature; E - energy and the value of E can be determined according to (7):

$$E = \sum_{k=1}^{n} \alpha_k \rho_k E_k \Big/ \sum_{k=1}^{n} \alpha_k \rho_k \tag{7}$$

The standard equation describes the flow and turbulence effect in the mixture model. The vapor transport equation determines the vapor mass fraction f_{vap} by the following equation.

$$\frac{\partial}{\partial t}\left(\rho . f_{vap}\right) + \frac{\partial}{\partial x_j}\left(\rho . f_{vap} . u_{vap_j}\right) = \frac{\partial}{\partial x_j}\left(\Gamma . \frac{\partial f_{vap}}{\partial x_j}\right) + R_e - R_c \tag{8}$$

In which: R_e, R_c dependent on the values of static pressure p and saturation vapor pressure p_{vap}:

If $p < p_{vap}$:

$$R_e = C_e \frac{v_{ch}}{\sigma} \rho_l \rho_{vap} \sqrt{\frac{2\left(p_{vap} - p\right)}{3\rho_l}}\left(1 - f_{vap}\right) \tag{9}$$

If $p > p_{vap}$:

$$R_c = C_c \frac{v_{ch}}{\sigma} \rho_l \rho_l \sqrt{\frac{2\left(p - p_{vap}\right)}{3\rho_l}} f_{vap} \tag{10}$$

In which: v_{ch} - characteristic velocity (m/s); C_e, C_c - empirically constants ($C_e = 0.02$; $C_c = 0.01$) [8,10].

3. Analysing results

3.1 The result of the first problem

Due to the limitation of the article, we calculate two situations with input parameters as following:
- Situation 1: The ship's true course is 000^0, the speed V_s is 5 m/s, wind speed V_w is 0 m/s.
- Situation 2: The ship's true course is 015^0, the speed V_s is 5 m/s, wind speed V_w is 0.

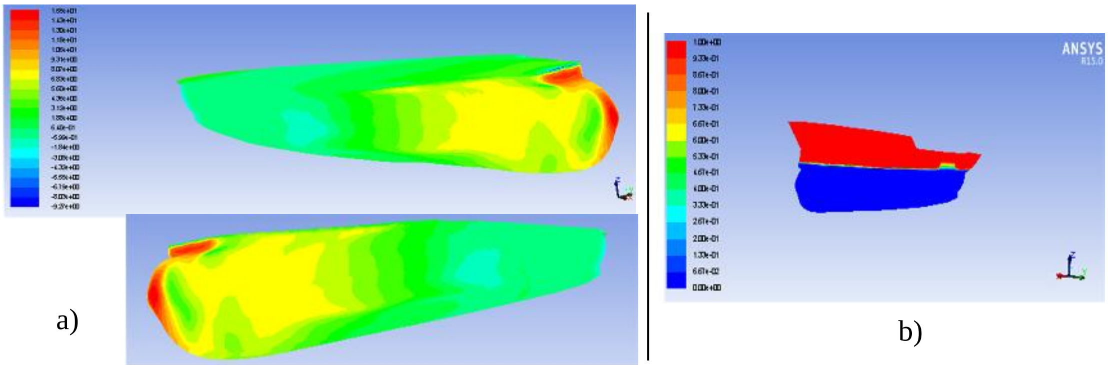


Figure 6 The simulation results of the distribution of static pressure on both sides of the vessel (the submerged area only) (a) and contour of volume fraction (air) (b)

In situation 1, the distribution of static pressure on both sides of the ship is nearly symmetrical. In order to have a more detailed look, we can analyse one waterline as following:

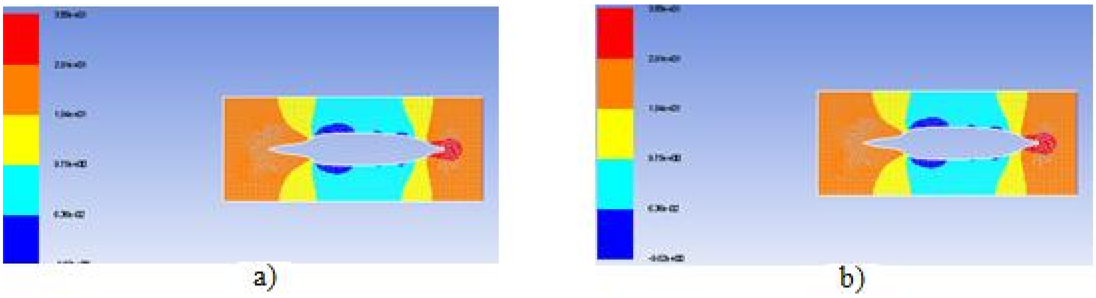


Figure 7 The simulation results of the distribution of static pressure (a) and pressure coefficient along the surveyed waterline (b)

Based on the result shown in figure 7, we come to the verdict: The distribution of static pressure on both side of the waterline is symmetrical and the pressure distributing coefficient along the waterline on both side of the vessels are near equal. There is no additional force impact on the ship's hull in this situation.

When the ship alters her course to 015^0 (situation 2), this situation can be considered as if the current flew around the ship's hull with an angle of 15^0 to the ship's center line. The simulation result is measured on the same waterline as in situation 1.

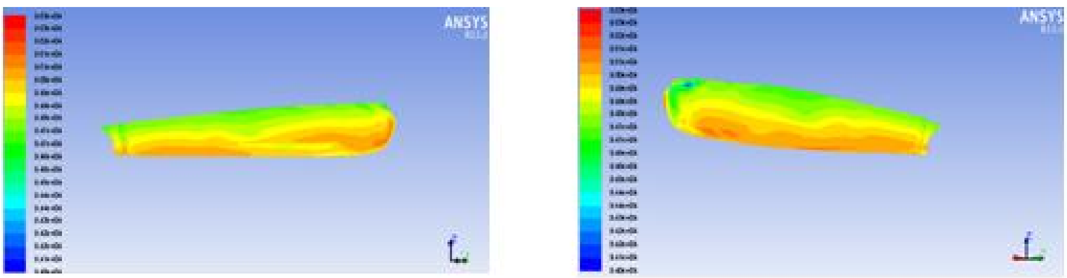
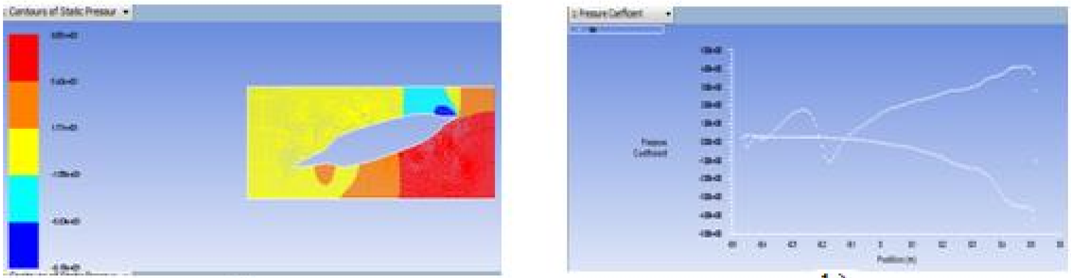


Figure 8 The simulation results of the distribution of static pressure on both sides of the vessel (submerged area only)



a) b)

Figure 9 The simulation results of the distribution of static pressure (a) and pressure coefficient along the surveyed waterline (b)

Based on the result shown in figure 9, we come to the verdict: The distribution of static pressure on two sides of the vessel is not symmetrical. Specifically, the pressure coefficient C_p is divided into two lines with noticeable difference, which indicates the presence of additional force impact on the ship's hull. In this article, we do not carry out qualitative calculations for different specific situations but rather introduce the procedures and expanded possibility for the research problem.

3.2 The result of the second problem

The simulation results are the contours of axial velocity and contours of turbulent viscosity on the transitional zone when experiencing two situations with different propeller rotation, the first time with $n_1 = 90$ r.p.m and the second with $n_2 = 150$ r.p.m (which correspond with the lowest and highest r.p.m of M/V TAN CANG FOUNDATION when operating in the fairway).

Situation 1: $n_1 = 90$ r.p.m (figure 10).

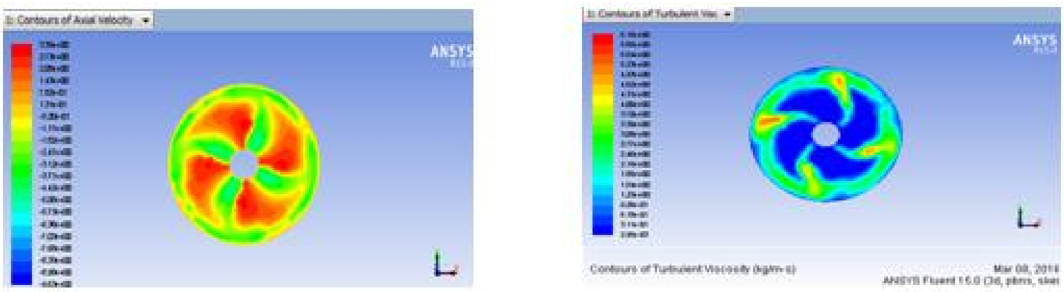


Figure 10 The simulation results of contours of axial velocity and contours of turbulent viscosity

Situation 1: $n_2 = 150$ r.p.m (figure 11).

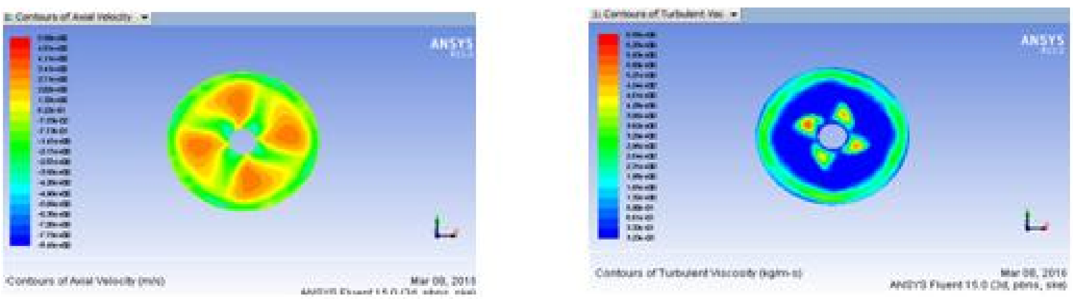


Figure 11 The simulation results of contours of axial velocity and contours of turbulent viscosity

Based on the received results as illustrated on figure 10 and figure 11, it is clear that the steering forces correspond with various combinations of r.p.m and the rudder angle can be determined in order to find the optimal combination to keep the ship on the pre-programmed orbit. The outcome of this research will be published on sequence reports.

3.3 The result of the third problem

In case of the rudder angle of α = 35^0 (the maximum permitted rudder angle) and the input parameter of speed is 7,5 m/s (the highest permitted speed for vessels navigating in the fairway), with profil in the midship position of the rudder, the calculated results with specific values are displayed on the coloured column on the left of each figure, specifically: The distribution of water-vapor phase, pressures coefficient and pressure distribution on figure 12.

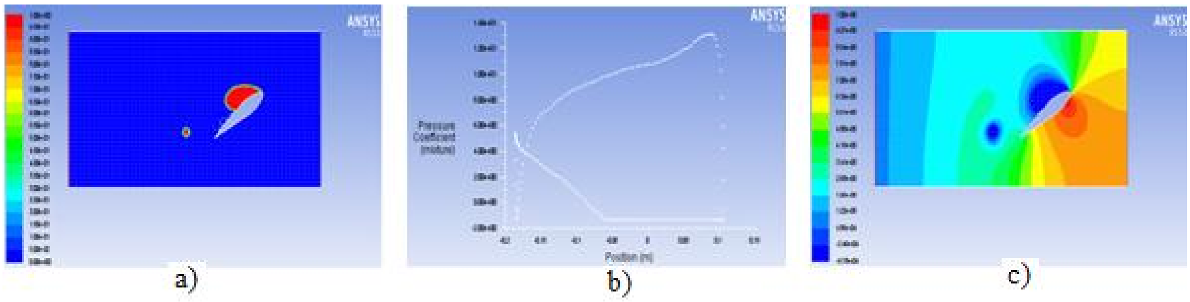


Figure 12 The simulation results of water - vapor phase (a), pressures coefficient (b), pressure distribution (c)

This is the situation where the cavitation can be seen most clearly, because, as the input parameters of current speed and rudder angle are of the highest values.

On figure 12a, it is clear that the size of the cavitation area reaches 100% in water-vapor phase, starting from the edge to profil and enclosed on profil with the length of the cavitation area on profil is 0.175 m. According to the classification of cavitation, this is partial cavitation.

In addition, there is also a cavitation area on the edge of profil, which is shown on figure 13.

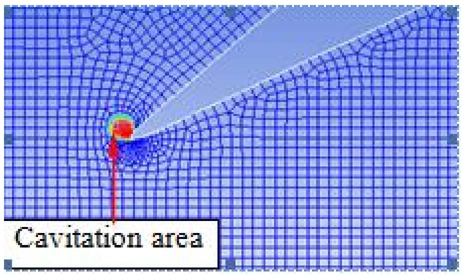


Figure 13 The simulation result of cavitation area on the edge of profil

The pressure coefficients and the pressure distribution on the profil are shown in figure 12b and figure 12c. The cavitation area will have the value of static pressure equal to the saturation vapour pressure of water, which is 3540 N/m^2. This explains why the pressure coefficient in this area is of horizontal type (it is called the cavitation length l). With different input parameters of speed, the values of l will vary and the cavitation area on the edge of profil will change accordingly.

Moreover, the type of cavitation in this area is partial cavitation, which is a type of unstable cavitation that forms, grows, and disappears in certain cycles. This makes the value of steering force to fluctuate while maintaining speed and steering angle and causes difficulties to maneuvering of ship. The calculated results of partial cavitation area in one cycle are shown below:

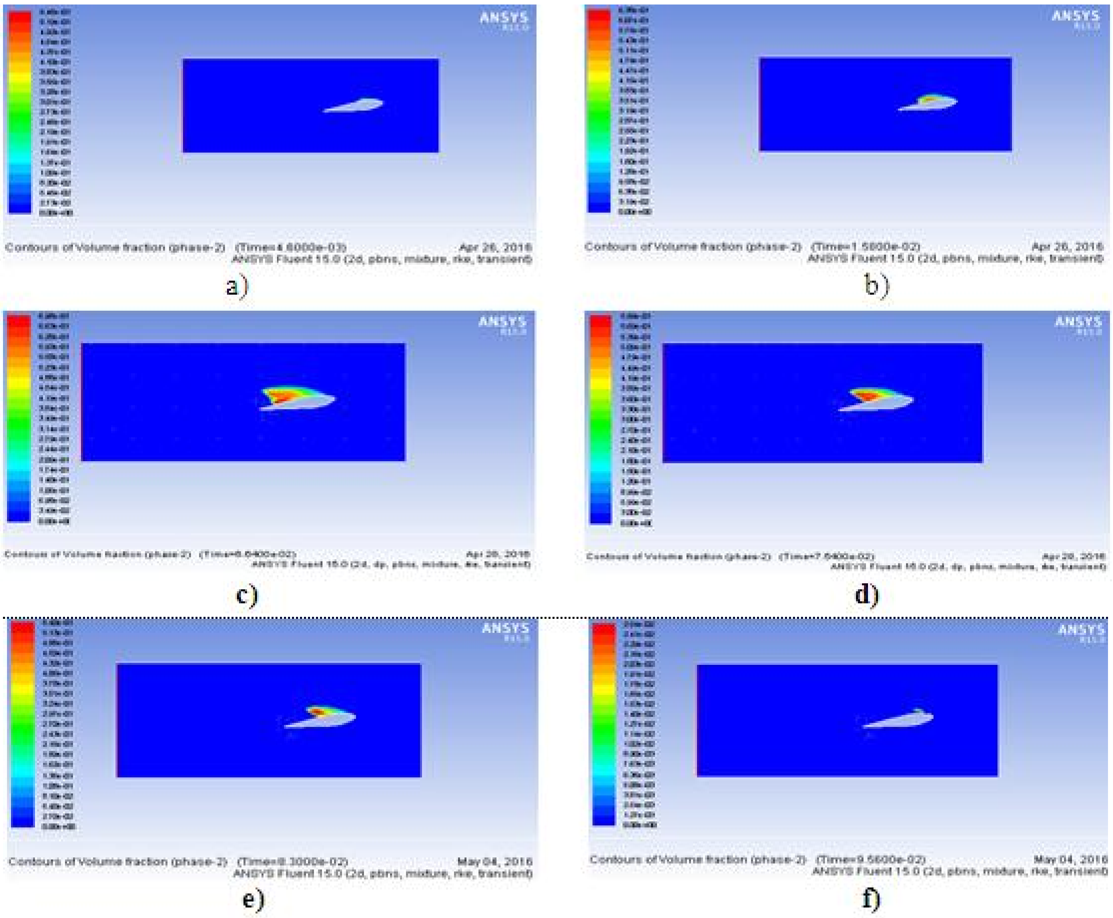


Figure 14 Contours of volume fraction (water-vapor phase): a) time = 0.0046s; b) time = 0.0158s; c) time = 0.0664s; d) time = 0.0754s; e) time = 0.083s; f) time = 0.0956s

Based on the result shown in figure 14, we come to the verdict: the cycle of partial cavitation in rudder profil in this situation is: T = 0.0956s - 0.0046s = 0.091s.

With 3D calculation, the cavitation area can be calculated according to true conditions. The calculation and simulation results with the conditions of rudder angles $\alpha = 0^0$ and $\alpha = 30^0$ at the ship's speed of 7,5 m/s are shown in figure 15.

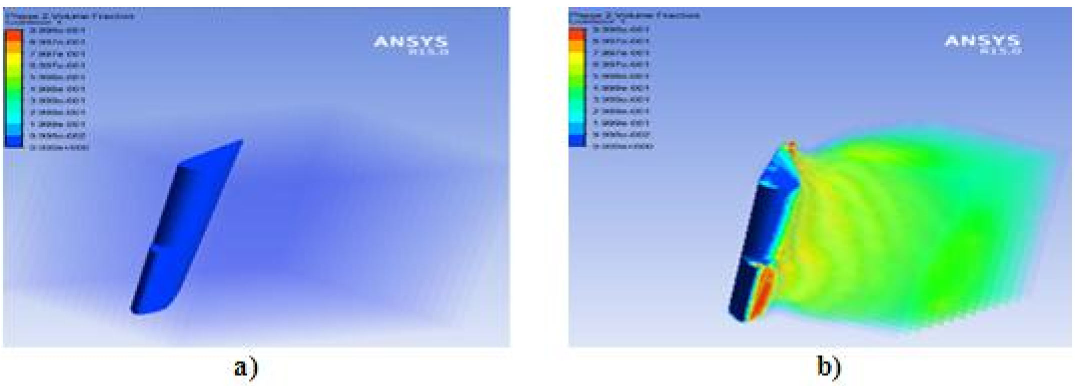


Figure 15 The simulation results of the proportion of water - vapor phase: a) $\alpha^0 = 0^0$; b) $\alpha^0 = 30^0$

By analysing the results shown on figure 15, we come to the verdict:
- When the rudder angle $\alpha^0 = 0^0$, the proportions of water - vapor phase on the rudder and the surrounding are nearly zero;

- When the rudder angle $\alpha^0 = 30^0$, the proportions of water - vapor phase are high and reach nearly 100% on the edge of rudder, then decreases in the surrounding areas.

4. Conclusion

We apply CFD in researching the effects of current on the course keeping ability of vessels navigation in Haiphong fairway, through analysing three problems: The effects of additional force when the ship alters her course; the interaction between rudder and propeller on keeping the ship on proposed orbit; the effects of rudder cavitation on steering force. The results of these researches show the procedures to calculate and steps needed to be taken to quantify research result for each type of ship.

In the following steps, the authors will analyse and assess the effects of the mentioned-above factors on the manoeuvrability of vessels navigating in Hai Phong fairway. Therefore it will help the captain or pilot decide suitable actions to keep the vessels on pre-programmed orbit, and thus, enhance the safety of navigation, especially for vessels navigating through the danger areas in Haiphong fairway.

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Confined space operations

Lecturer, Philip Mackrill[1], Associate lecturer, Lyndon Gabites [2], Lecturer, Anthony Beckett [3]

1. Australian Maritime College, P.Mackrill@amc.edu.au , University of Tasmania, Launceston 7250, Australia.
2. Australian Maritime College, Ian.Gabites@utas.edu.au
3. Australian Maritime College, Anthony.Beckett@utas.edu.au

Abstract The intent of this paper is to further stimulate a global approach to managing the risk exposure for seafarers working in, on or around confined spaces. Whilst this requires a holistic approach, this paper focuses on the standards of training and competence, in an effort to enhance the human and confined space operations interface within maritime specific training, drills, equipment and regulatory aspects. The ultimate aim being to mitigate the rate of injury and fatal incidences.

It is widely accepted in the maritime industry workingin, on or around confined spaces has its risks. Whilst these risks are controllable, incidents resulting in serious injury and fatalities are nothing new, thecontinued loss of seafarer lives must be addressed.

In an effort to improve safety, the International Maritime Organisation (IMO) released its revised recommendations for entering enclosed spaces aboard ships in 2011. However incidents listed by maritime investigation bodies since the adoption of the IMO's revised recommendations, suggest more needs to be done. The introduction of mandatory entry & rescue drills are certainly a move in the right direction; question is, are they enough to positively influence safety and reduce incidents? Or do they simply provide a mechanism to tick the compliance box.

Why is it, in this day and age, seafarers are still succumbing to the hazards and risks of these spaces? Investigative reports often cite the cause of fatalities, as atmospheric, this being the most common hazard. What is contributing to these lethal situations? Is it a combination of error inducing factors at individual, job or organisational levels?

More needs to be done in developing and embracing standards, including operational, equipment and training to enhance human reliability and reduce error inducing factors and those fatal consequences that follow. Could part of the answer be the introduction of confined space training under the mandatory Standards of Training, Certification and Watchkeeping (STCW) structure?

Keywords: Competence, standards of training certification and watchkeeping, confined space operations, fatalities, error inducing factors, relevant.

1. Introduction

'Seafaring has always been one of the world's most dangerous occupations' [25]. The maritime industries guidelines and regulations have been developed and enhanced in response to many incidents over the years. In 1912 when the RMS Titanic collided with an iceberg tearing a hole in her, many lives were lost. This event prompted the creation of the International Convention for the Safety of Life at Sea (SOLAS) with the first convention enacted in 1914 [26]. Standards for training, certification and watchkeeping were introduced in 1978, through the implementation of the International Convention on Standards STCW.

Prior to this, standards were set by the governments of each country, subsequently the standards across the global maritime industry proved inconsistent. [27].

Across the globe, countries/flag states have various regulatory frameworks and guidance documents, along with recommendations from the IMO and yet, fatalities continue to occur.

Standards for training associated with enclosed/confined space currently remains under the control of governing countries with a wide range of standards. The vast differences in approaches to confined space is supported by a global survey conducted in 2011 by Enhesa, anenvironmental, health and safety consultancy firm, specialising in supporting business to meet regulatory requirements. Enhesa found, of the sixty countries surveyed, “no two countries used the same regulatory approach”. [16] As the maritime industry has a diverse multicultural workforce, would it not make sense to standardise this training under the STCW.

2. Background

Incidents resulting in fatalities in, on or around confined spaces aboard ships are nothing new; sadly this ‘unnecessary and avoidable loss of seafarer’s lives’ [3] is a theme that has been continuing for many years. For the ill-informed or ignorant seafarer, confined spaces may be likened to aniceberg. Whilst the top of the space can be clearly seen, they may not appreciate orbe aware of what may lay beneath the surface. In this day of age it is reasonable to expect seafarers to have a heightened level of knowledge and awarenessof the risks whichmay be associated with confined spaces.

Whilst the loss of lives attributed to confined space work on vesselsshould not occur,it does!According to Patraiko D[1] this remains‘a deadly serious issue, and one which the marine industry has to come to grips with,’this is further echoed by Lloyd and Allan’s view that the maritime industry ‘have reached a critical situation with more people injured and dying in enclosed spaces than through any other related on-board work activity.’[2] Surely the time has come for change of mindset, withmore needing to done to address the continued loss of seafarer’s lives.The international maritime community must become more proactive and move to develop, embrace and enforce standards, whichaddress the harsh realities of confined space operations within the industry. It is time to getserious about this deadly issue.

It is the opinion of the author’s that forward progress to reduce the rate of incidences can only be achieved throughaholistic approach addressing aspects such as; ship design, safety culture, procedures, appropriate equipment &most importantly seafarer competence.

3. Confined space fatalities

In 2007 the Maritime Accident Investigators International Forum (MAIIF), identified the rate of incidence, resulting in fatalities and serious injuries across the maritime industry on global scale was increasing [4]. In 2008 the Marine Accident Investigation Branch (MAIB) of the United Kingdom, releaseda global safety bulletin, highlighting the issue of fatalities as a result of spate of confined spaces incidents. Contained within, the MAIB released details that the MAIIF had received responses from eighteen flag states at this time identifying “120 fatalities and 123serious injurieshad occurred since 1991”. [4]

The industry as a whole should be horrified by these figures derived from such a small percentage of flag states, particularly when one considers what the magnitude of the true figures could be, if all flags states data had been included. It is fair to say that we may never know or appreciate the true magnitude of seafarers who have sustained fatal injuries, serious injuries, minor injuries and/or near misses. This is a significant challenge for the maritime industry, but it is one that must be undertaken. The time for change has come.

Confined space fatalities and serious injuries are not restricted to international shipping alone. It affects all of the maritime industry regardless of; the ship’s country of origin, seafarer’s nationality, or the position one holds in the crew compliment. People are dying in these spaces unnecessarily, fromcadets starting their careersto thechief officer and all that come between. No singular vessel type is exempt; it occurs on them all, tankers, bulk cargo, containerships, passenger liners, roll on roll off, trawlers, barges, cruise vessels, research vessels and the list goes on.

4. Continuing incidents

The incidence of seafarers sustaining injury when interacting with confined spaces are continuing, the following incidents represent a brief overview: March 2014 a first mate, died from asphyxiation after entering a hold containing zinc concentrate. During the rescue the space was found to have an oxygen concentration of 2.8%. [5] May 2014 two crewmen and a chief officer lost their lives during preparation to unload a vessel with a cargo of sawn timber and the rescue party narrowly escapeddeathduring the rescue. [6] August 2013 during an attempted recovery of a broken oil sampler, a master lost his life and a cadet sustained injuries. Prior to their entry atmospheric testing established the following readings 20.6% oxygen, with HC at 26% of LEL. [7] June 2011a chief officer and a crew member, peeredthrough a hatch and saw thebosun lying motionless. Theyraised the alarm, prior to the emergency team arriving, the chief officer entered the space to assist he collapsed, the other seaman entered to help he collapsed. All three were recovered from the space, the chief and seaman recovered in hospital however the bosun died. [8] November 2009, a chief mate on a chemical tanker lost his life after entering a cargo tank containing hydrocarbon vapours and deficient in oxygen. [9] May 2009 a chief officer and an able seaman went to the aid of other crew member who was overcome bya toxic cocktail ofhydrogen sulphide, volatile organic compounds (VOCs) and mercaptans vapours. The chief officer was overcome as they had no respiratory protection; luckily they made a full recovery [10]

The following incidents highlight that one does not need to be in the space, to be impacted by it: November 2001, eight seafarers lost their lives as a result of a ballast tank explosion that occurred during the painting, of the eight only one crew member was in the space. [11] July 1996, three seafarers lost their lives and six sustained irreversible medical conditions, when anengineer opened a refrigerated seawater tank's side door. The engineer was quickly overcome, two seafarers who came to his aid were overcome and six others in the vicinity were injured. [12] These examples are a small sample of death and injury associated with confined spaces and without serious interventionincidenceswill continue to growand seafarers will continue to die.

5. Contributing factors

After a serious incident investigationsare conducted to ascertain the root cause and determine how similar incidents can be prevented. The contributing factors can often be referred to as 'human factors which fall into three basic categories, individual, job & organisational' [22]. Investigative reports will identify a range of factors that may have contributed to a fatalityor serious injury. Common themes re-emerge time after time. They are: lack of competence, acting on impulse or emotional decisions (rescuer), inability to identify confined spaces, complacency and failure to follow confined space entry procedures including: poor preparation and planning, inability to identify hazards, risks and suitable control measures. The list continues withineffectivesafety management system procedures, lack ofequipment which is fit for purpose, or inappropriate use of equipment and training in the use of equipment. If these 'factors are not managed they are known as error inducing factors'. [22]

'Often the concept of human error leads to the conclusion that the intervention should be directed towards the human operator e.g. more training, better education'etc. [21] and while this conclusion is not always the cause, there can be no better argument for better skills and knowledge development for those likely to be affected by confined spaces.

6. Who needs to address this?

The International Maritime Organisation (IMO) principal function is to facilitate the development, implementation and maintenance of international regulatory frameworks that support international shipping. One of these areas is safety, which is addressed through the Safety of Life at Sea (SOLAS) convention. [13] The SOLAS convention is considered to be one of most important conventions, the first convention coming about after the sinking of the Titanic. Since then there hasbeenmodifications, updates, amendments and subsequent release of consolidated versions.

There is no disputing that the IMO has achieved much in the area of safety, for example the regulatory framework surrounding the prevention of fire through the Fire Safety Systems (FFS) code and the levels of training to prevent and respond to fireaddressed by the Standards of Training & Certification for Watchkeepers (STCW) issound. However! Compared to the likes of fire little has been done to stem the wake of fatalities and injuries, which continuesaboard ships when working in, on or around confined spaces.

In 1997 the IMO provided guidancefor the entering of enclosed / confined spaces through the introduction ofthe Resolution A.864 (20) Recommendations for entering enclosed spaces aboardships. [28] Sadlysince the adoption of the resolution andup until 2009there 'have been at least 101 incidents, resulting in 93 deaths and 96 injuries'. [14] November 2011 saw the adoption ofrevised recommendations through Resolution A.1050(27). These recommendations provide sound guidance, however they are not mandatory. They 'are intended to compliment national laws or regulations'. [15] Whilst it seems feasible to use such recommendations to compliment national laws and regulations, national laws and regulations are typically orientated to the land and not necessarily designed for confined space work in remote and isolated situations such as shipping. It has previously been stated that, the regulatory approaches found across the countries of the world are very different. This in turn impacts on how a confined space is defined and as a result how confined space work is approached.

In January 2015 a new resolution came into force, bringing change to SOLAS chapter three regulation nineteen (Emergency Training & Drills). This requires seafarers with roles and responsibilities relating to confined space entry & rescue, to participate in drills at least once every two months [17]. This resolution refers to 'revised recommendations for entering enclosed spaces aboard ships', [18] These mandated entry & rescue drills are certainly a move in the right directionthe question is, are they enough to positively influence safety and reduce incidents? Or do they simply provide a mechanism to tick the compliance box? Anecdotal evidence suggests that there is room for improvement at all human factor levels, with particular emphasis on individual factors.

In general terms the maritime industry tends not to use the term 'confined space', instead continuing to use the term 'enclosed space', which the IMO "defines asa space which has limited openings for entry and exit; inadequate ventilation; and is not designed for continuous worker occupancy".[18]This definition fails to bring to the attention of seafarers working in on or around confined spaces the potential, and foreseeable risks; furthermore many hazardous areas are only partially enclosed.Could the IMO's definition contribute to seafarer's not recognising areas that are potentially life threatening.

Whilst the requirement to conduct drills for confined space entry and rescue isacknowledged, a question remains, what standards underpin the training, procedures and equipment requirements of those drills? Could substandard knowledge, skillsand acceptance of inappropriate equipment be inadvertently perpetuated?

7. Time to change the mindset

All too often when discussions occur, procedures are written or legislation is drafted the term confined space "entry" is used. Entry being: *"the act or instance of entering, a point or place for entering"* [19] Use of the term entry might also lead people into a false sense of security, i.e. if we are not actually entering the space, there is minimal or no risk! Rather than thinking about the entire operation at hand or indeed acknowledging the high casualty count of people affected by confined spaces without entering them. E.g. Eight seafarers died when a ballast tank exploded, only one had entered the space. [11] Three seafarers died and the six sustained irreversible respiratory damage, no one had entered the space. [12] It is the opinion of the author's that the term confined spaceshould be used rather than enclosed space. This allows for a broader and more risk based definition, such as the one used by the Australian regulatory framework as listed below:

‘A confined space means an enclosed or partially enclosed space that:

- is not designed or intended primarily to be occupied by a person; and
- is, or is designed or intended to be, at normal atmospheric pressure while any person is in the space; and
- is or is likely to be a risk to health and safety from:
    - an atmosphere that does not have a safe oxygen level, or
    - contaminants, including airborne gases, vapours and dusts, that may cause injury from fire or explosion, or
    - harmful concentrations of any airborne contaminants, or
    - engulfment’. [29]

If the maritime industry enforced the adoption of a more holistic approach and used terms like confined space operations*:* operations being ‘a process, method or series of acts especially of a practical or mechanical nature’ [19] instead of enclosed space entry, could this lead to greater awareness, increased safety, supporting a reduction in the rate incidents and unnecessary loss of life.

As the broader maritime industry is a truly global industry, it makes perfect sense that an international maritime standard for confined space operations aboard ships be developed. In doing so all regulators, shipping companies, operators and seafarers across the maritime industry could consistently address the issues associated with these high risk operations.

The industry as a whole needs to change itsmindsettowards how work in, on or around confined spaces is conducted. The starting point for this change must rest with the International Maritime Organisation by laying down mandates followed by a collaborative approach amongstindustry stakeholders to reduce the risk. This holistic change should include, but not be limited to, ship designers, safety culture, procedures, equipment, and competence.

7.1 Designers

Wherever possible during the design process and subsequent manufacturing of ships, attention should be given to remove thenecessity to enterconfined spaces. Where elimination is not a realistic option, spaces should be designed in a manner to reduce the risks associated when entering and working in the space. Consideration needs to be given to ease of access, exiting, retrieval and emergency extrication from such spaces.

7.2 Safety Culture

Most would be aware of situations were errors of judgement or complacency and the outright ignoring of procedures have led to serious injury and/or the loss of life. Some might assume this is the junior seafarers unfortunately this is not the case, even chief officers that should know better, but probably don’t, are making these fatal errors. If senior personnel are exhibiting a lack of knowledge, know how, or promote cutting corners, what message does this send to other crew members.

It is the opinion of the authorsthat in order to support an industry wide improvement in safety culture, there needs to be more specific regulatory frameworks in place underpinned by standards of training and competence levels. A good foundation to support such change is the development and implementation of sound confined space management plans, an outline of which was published in 2013 in the maritime journal Seaways. [20]

7.3 Procedures

Each vessel should have confined space management plans complete with checklists embedded within the Safety Management System that outlines a clearly defined processthat seafarers can work through to safely undertake work in on or around confined spaces. Theplan should highlight what is required to done; before work commences, during occupancy, upon exiting and what to do in the event of a confined space emergency. These procedures should be supported by realistic and relevant training drills and auditing system to validate and monitor compliance on board.

7.4 Equipment Use

Anecdotal evidence identifies in some cases crew members are entering spaces without personal atmospheric detection, leaving them vulnerable and unaware of atmospheric changes. Whilst many vessels have atmospheric detectors of sort, it is as of 1st July this year ‘a new SOLAS regulation XI-1/7 on Atmosphere testing instrument for enclosed spaces, to require ships to carry an appropriate portable atmosphere testing instrument or instruments, capable of measuring concentrations of oxygen, flammable gases or vapours, hydrogen sulphide and carbon monoxide, prior to entry into enclosed spaces’ [30].

Thereshould be a minimum standard of equipment defined by the industry and specific training in the use of the equipment should be mandated. Having the right equipment is one thing knowing how to use it is another, which brings us back to competence of the seafarer.

8. Competence

The definition of competence has been argued for many years and is not the subject of debate in this article, for the purpose of this paper competence will be referred to as the ability to complete a job task efficiently and safely (trained) which is different to knowing how to do it (educated).

‘Education and training are not the only two factors affecting individual competences. Other factors should also be considered. For example, personal characteristics such as ability, experience, cognitive capacities, receptiveness, behaviour, knowledge background etc. Also the environment to which individuals are exposed to; whether in their personal environment or in the organisation environment that they work in are important factors.’ [31]

The citation above supports the concept that competence is an ability based measure which is achieved through the practical application of knowledge and skills over time in a range of circumstances to enhance, maintain and fine tune initial training or education. To this end, someone who has completed a formal training course, is able to apply the principles of that learning back to their work place and able to adapt those principles to the unique nature of the jobunder initial guidance should be able to work more safely, efficiently and effectively into the future.

It can be argued that personal characteristics, like abilities, change over time based on the opportunity to apply learned knowledge and skills. This trait is often accelerated when similar past experiences are used to support the evolution of those particular work abilities. However, it needs to be acknowledged that workplace guidance from colleagues and supervisors can act as both positive and negative influences on the development and maintenance of initial training based on the attitude, practical skills and level of knowledge that they hold. This raises the question, are the supervisors competent to supervise confined space entry procedures?

9. Recommendation

Current evidence overwhelmingly suggests that something needs to be done and soon. A valuable support mechanism would be the adoption and implementation of an IMO model course with mandatory training outcomes to be agreed at an STCW convention with mandatory refresher training as is the case with other safety based courses.
A three days course that covers at least the following, should form the basis of the mandatory STCW course for confined space operations.

Day1: the basic knowledge and skills required by an individual to participate as part of a confined space work team including but not limited to: Defining a confined space, roles and responsibilities, hazard identification, risk assessment, control measures, isolation practices, entry and retrieval equipment, permit requirements, stand by attendants, planning for emergencies.

Day 2: gas detection and the use of atmospheric detection equipment and respiratory protection, including self-contained breathing apparatus (SCBA) and airline systems; &

Day 3: theoretical and practical aspect of confined space rescue, specific to shipboard environments.

10. Conclusion

At present there are substandard procedures and practices being undertaking in the maritime industry with devastating effect, which are leading to the loss of seafarers lives. The maritime industry as a whole including: maritime institutions, shipping companies, associations, unions all need to step up and become more proactive in addressing this issue.

There is a clear need to mandate standards of training for confined space operations on board ships/vessels. Training needs to be rigorous enough to ensure that course outcomes achieve what they say they will, and that subsequent assessment of competence is clearly aligned. It is important that seafarers truly understand, what is needed to work safely in, on or around confined spaces and it is especially important that those embarking on their careers have a plan to develop their knowledge and skills beyond routine day to day tasks and to have their knowledge and skills challenged from time to time with appropriate refresher training.

Seafarers invariably leave maritime education facilities with a foundation of knowledge and skills that will almost always need to be developed and adapted to fit a vessels operations and design, let us all make that foundation as strong and resilient as we can.

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Research on accuracy increase of the process of avoidance of the vessels collision in congested waters

Capt. Dmytro S. Zhukov, Senior Lecturer

National University Odessa Maritime Academy (NU “OMA”)
8, Didrichson str., 65029, Odessa, Ukraine
Telephone: +380 67 247 94 59 / +380 48 777 57 74
E-mail: d_zhukov@mail.ru

Abstract Rapid development of computer aids and modern navigation equipment for the merchant vessels gives possibility for navigators to solve complex problems for collision avoidance of the vessels during the sailing in congested waters.

When vessel sailing in congested waters the decision making about vessels maneuver based on navigators’ experience only may cause the problem for navigation and increase risk of collision. Installation of the shore navigation equipment and Vessel Traffic Services (VTS) plays important role for increasing the navigational safety. But despite this the risk of collision still exists.

The task of the research of the process of the vessels collision avoidance remains relevant and accident rate level documents it.

Moreover the levels of vessels axiomatization cannot exclude the human factor error in navigation.

Research and development of the method for accuracy increase of the parameters of the ship's maneuver for collision avoidance is very relevant.

Key words: Maritime Transport, Safety of Navigation, Collision Avoidance, Risk Assessment, Ship's Maneuvering

1. Work's Relevancy

Rapid development of computer aids and modern navigation equipment for the merchant vessels gives possibility for navigators to solve complex problems for collision avoidance of the vessels during the sailing in congested waters.

Figure 1 Collision of the vessels in the congested waters

With recent performance improvement of observation devices and introduction of new information systems, VTS is expected to play larger role in supporting the officers onboard. According to IMO Resolution A.857 (20), Vessel Traffic Service is implemented to improve the safety and efficiency of vessel traffic and to protect the environment. VTS are shore-side systems that evolved as a response to the increased complexity of shipping and the need to prevent congestion by maintaining a safe traffic flow. The services are basically of two types; one is predominantly found in coastal areas or straits that are characterized by congested shipping lanes, while the other type is used to control the traffic movement in and out of ports. VTS are designed to provide support to vessels by services that range from the provision of simple information messages, such as position of traffic in the vicinity, to extensive management of the traffic flow. In general, vessels entering a VTS covered area report to the authorities by radio, and are tracked by the VTS control centre. The vessels keep watch on a specific frequency for navigational or other warnings, while they may be contacted directly by the VTS operator if there is risk of an incident or, in areas where traffic flow is regulated, to be given advice on when to proceed.

However, an increase in the volume of available information demands higher skills in critical situation awareness and operational decision-making in complex situations. Assessment of collision risks and evasive maneuvers still to a degree depends on human individuals. Practical solutions so far include training and acquiring experience, although long-term experience does not guarantee that the right decisions will be reached. The task of the research of the process of collision avoidance of the vessels remains relevant and accident rate level documents it. Moreover the level of vessels axiomatization cannot exclude the human factor error in navigation. Research and development of the method for accuracy increase of the parameters of the ship's maneuver for collision avoidance is very relevant.

2. Purposes and tasks of the research

The purpose of the research is to increase the safety of the ships maneuvering for collision avoidance by development the methods for accuracy increase of the ship's maneuvering parameters in congested waters.

2.1 Research goals

Research object is the ships maneuvering process. Research subject is accuracy of determination the parameters of the ships maneuver for collision avoidance.
For achievement of the research goals the following tasks were set:

- analysis of the existing and development of new methods of the assessment of the risk of collision;
- development of the method and decision algorithm for safe actions of the collision avoidance maneuver;
- development of the algorithm of calculation the range of the vessels safety courses during the collision avoidance maneuver;
- development by the various ways of the algorithm of determining an error in calculation of the parameters of the vessels closest point of approach (CPA).

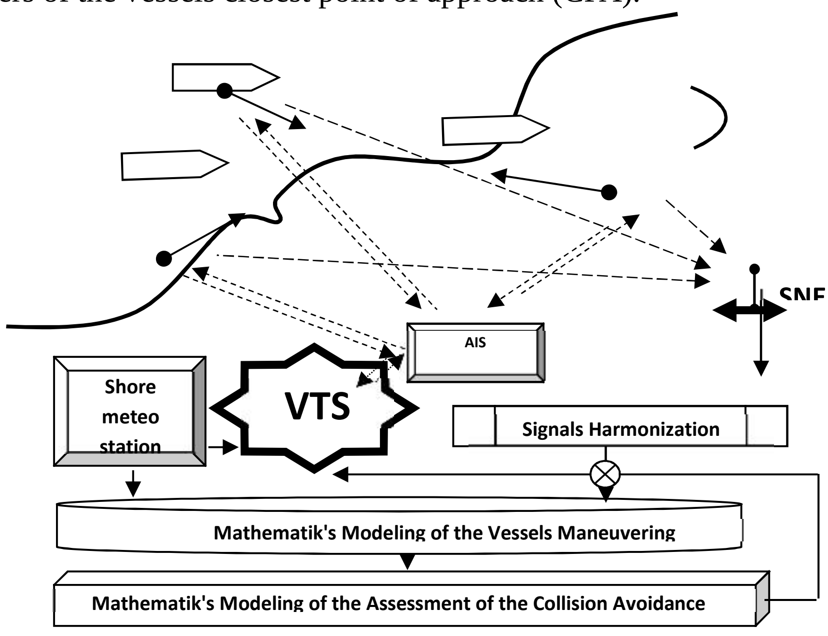


Figure 2 The functional scheme of the safety collision avoidance of the vessels

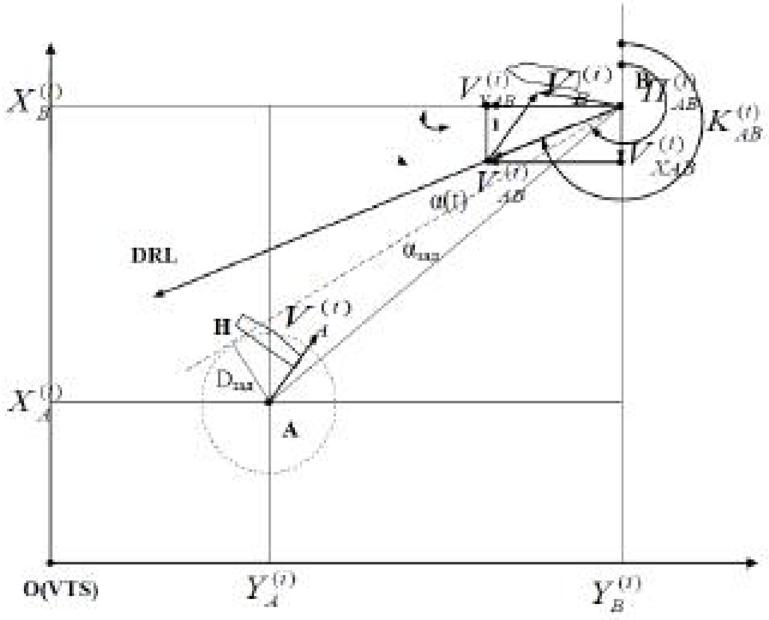


Figure 3 Vessels approaching situation – VTS view

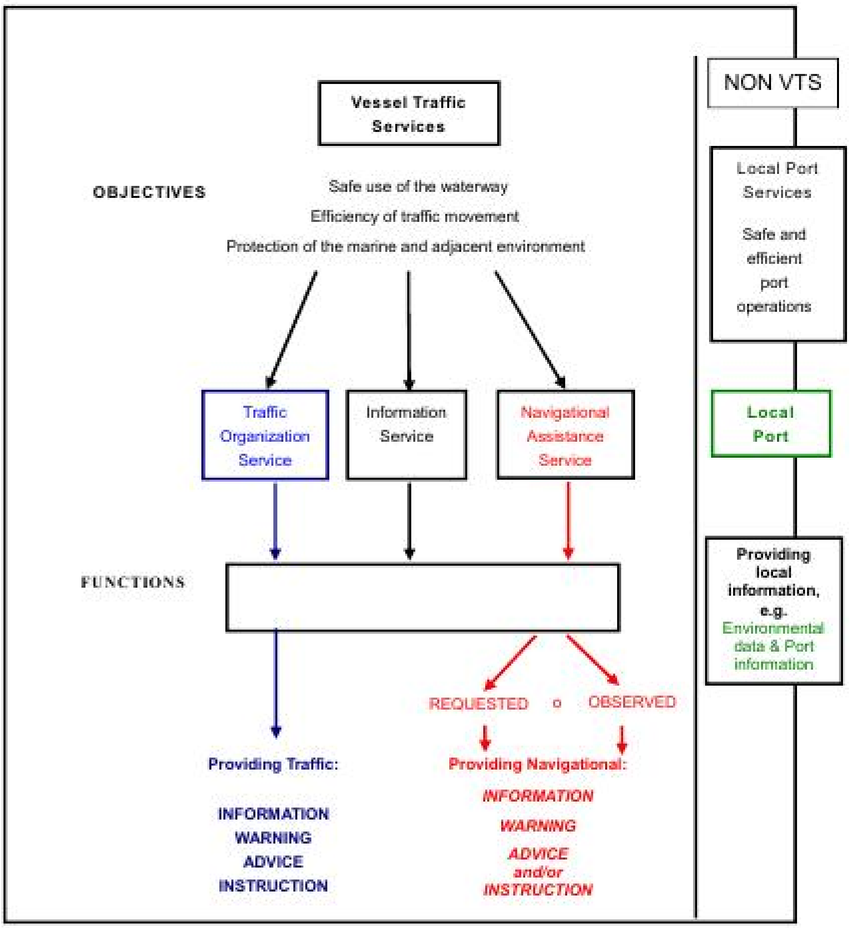
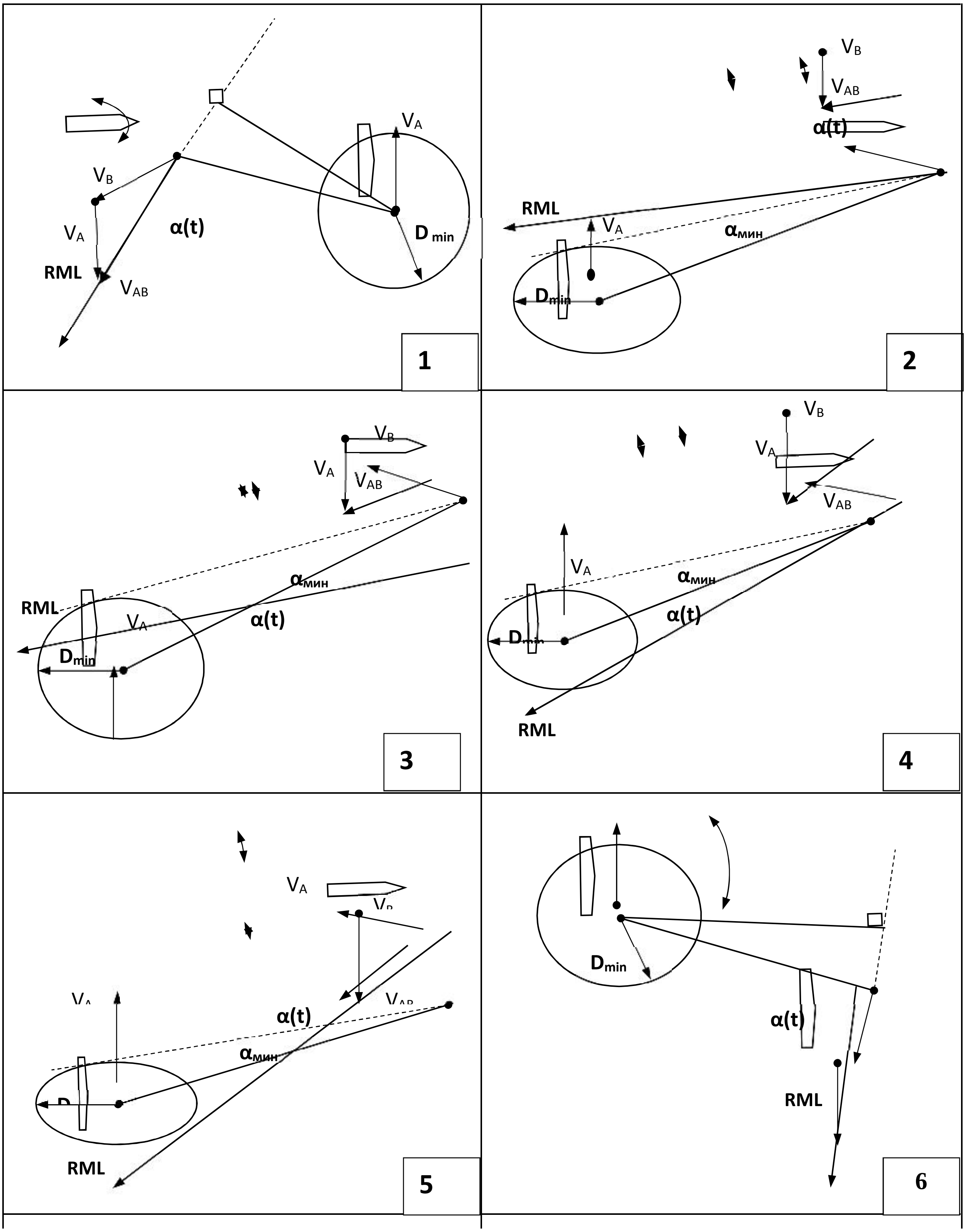


Figure 4 VTS services (source: IALA VTS manual)

2.2 Scientific novelty of the obtained results



1 - $90 \le \alpha(t)$; **2** - $\alpha_{мин} \le \alpha(t) \le 90$; **3** - $0 < \alpha(t) < \alpha_{мин}$;

4 - $-\alpha_{мин} < \alpha(t) \le 0$; **5** - $\alpha(t) \le -\alpha_{мин}$; **6** - $\alpha(t) \le 90$.

Figure 5 The collision situation dependences by α(t)

Minimum value of the α(t): $\sim_{зад}^{(i)} = \arcsin\left(\frac{D_{зад}}{D_{AB}^{(i)}}\right)$ (1)

where $D_{AB}^{(i)}$ - distance between the vessels in time "i":

$$D_{AB}^{(i)} = \sqrt{\left(X_A^{(i)} - X_B^{(i)}\right)^2 + \left(Y_A^{(i)} - Y_B^{(i)}\right)^2} \quad (2)$$

The algorithm of vessel's action for collision avoidance is developed. This algorithm considers three types of maneuvering for each vessel and its dynamic.

The following results with scientific novelty were obtained:

- the method of the collision risk assessment by heading angle to relative movement line (RML) was developed;
- the method of vessels collision avoidance during the movement on curvilinear trajectory was developed;
- the conceptual model for the ensuring safety collision avoidance of the vessels was developed;
- the selection method of the vessel safety action in time of collision avoidance with unlimited number of the vessels was developed;
- algorithms of the assessment the calculation error in the CPA parameters were improved.

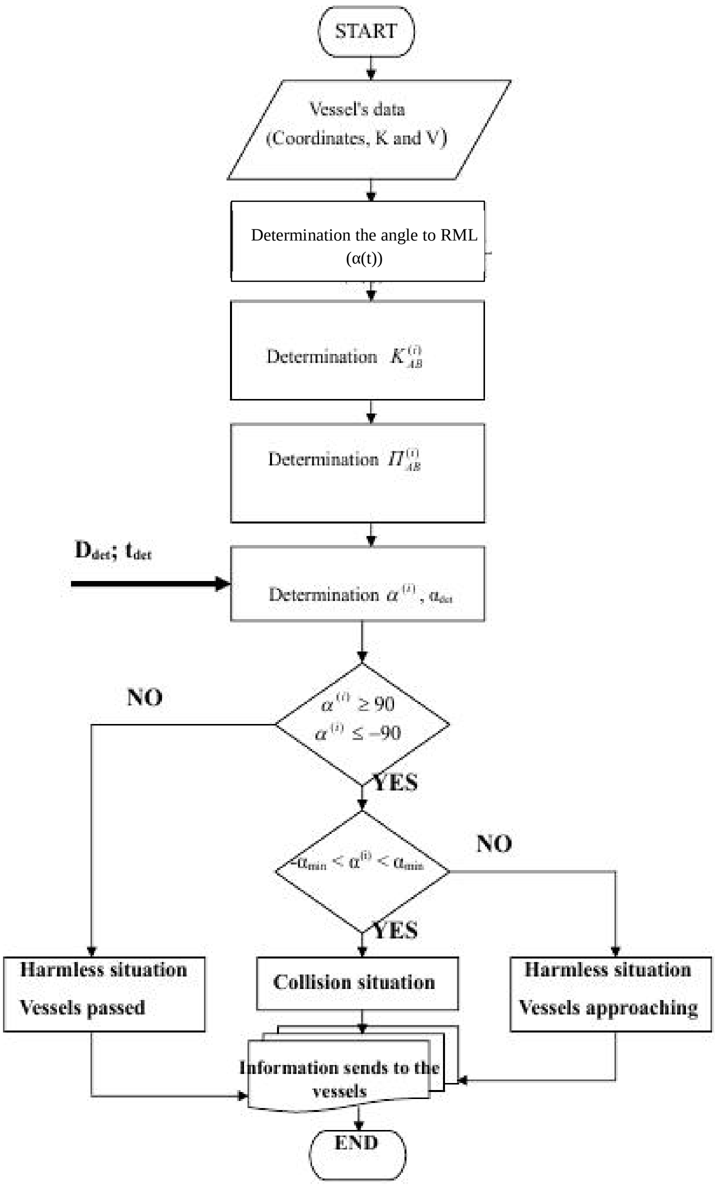


Figure 6 Block diagram of the collision risk assessment by heading angle to relative movement line(RML)

3. Research methods and practical value

For the theoretical part of the research the following methods were used: the method of the operational research, the method of information theory in navigational tasks, mathematical modeling, the theory of random processes with elements of probability theory and mathematics statistics, methods of assessment of the navigational safety level, differential and integral calculus.

Experimental part of the research included the full scale investigation on the merchant vessels and computer simulation. Experiment data was processed by mathematics statistics methods.

Research results can be used in navigation to increase the navigational safety and reduce the accidents number by fuller information support for the vessels collision avoidance. Obtained results form base for improvement of the functionality shore based navigational aids and for fuller information support of the navigation in congested waters. Research results concerning automatic calculation of the range of safety courses and selection safety action of the vessels can find application in automatic radar plotting aid (ARPA). Obtained results also may be useful for researches and investigation connected with design of ports, canals and vessels traffic schemes.

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Evaluating the safety of floating structure under the design sea condition

Msc. Nguyen Tien Cong [1], **Dr. Le Thanh Binh[2]**

1. *Shipbuilding Faculty, Vietnam Maritime University, congnt@vimaru.edu.vn*
2. *Shipbuilding Faculty, Vietnam Maritime University, binhlth@vimaru.edu.vn*

Abstract This paper shows results from the calculations and analyses of the longitudinal strength of a multi-purpose floating structure built by Quang Trung Mechanical Enterprise in Vietnam. The structure is concerned under its design sea conditions, using environmental statistical data and spectral theory of ship hydrodynamic in irregular waves. The long-term distribution of wave bending moment is approximated to the Weibull distribution based on the results of short-term analyses. For analyzing the longitudinal strength, the calculation is taken for different wave propagation directions and in different sea states corresponding to the wave statistical data. As a result, the study will give a conclusion about the safety of the structure in terms of longitudinal strength. This paper also introduces a reliability based approach for accessing structure's strength to predict the working safety of floating structures under the real sea conditions.

Keywords: shear forces, bending moments, floating structure, longitudinal strength, spectral theory, reliability based approach.

1. Introduction

During the lifetime of ships and floating structures, besides loads from structure's weight, cargo, etc the structures have to work under loads induced by surrounding environment, for example sea waves, wind and current. Wave induced motions and loads on structures are the common topics that are being highly concerned in recent years. In the assessment process of longitudinal strength, the most important load is vertical wave bending moment amidships that depends on many factors, for example the loading conditions, the weight distribution, the angle of incoming waves, etc. These factors are mostly random and must be taken into account in calculations. Because of the randomness, many studies often based on probabilistic theory and spectral theory using wave statistic data of the navigating area. So, the researched structures are then evaluated the safety factor by calculating probability of exceeding extreme values. A.P. Teixeira & C. Guedes Soares [5] presented the reliability based approach to determine the design loads for the remaining lifetime of ships. In their study, the probability distribution of the wave induced loads was obtained by weighting the conditional Rayleigh distribution according to the probability of occurrence of the various sea states in the ship route, such as significant wave high H_s, zero up-crossing frequency T_0, the ship heading θ, ship speed v and loading condition c, etc. The exceedance probability of the vertical bending moment (VBM) was approximated to the Weibull distribution. Using these methods, authors evaluated the longitudinal strength of the studied ship in the period of 20 years, predicted the remaining time of the ship. This calculation method was also applied by C. Guedes Soares in the report for "Probabilistic Models for Load Effects in Ship Structures" [6].

In addition, to ensure the safety during working time, the strength of ships are often evaluated through either ships ultimate strength performance or fatigue and fracture analyses. For example, J.K. Paik et al [9], in 2009, used ALPS/ULSAP code for ultimate strength calculations of stiffened plate structures and ALPS/HULL code for progressive hull collapse analysis. The structure in their study is a Suezmax tanker. Z. Shu & T. Moan [10] also presented a study for the "assessment of the hull girder ultimate strength of a bulk carrier using nonlinear finite element analysis".

Regarding the fatigue and fracture analyses, ship structures are often studied in more details, at specific positions which are predicted to occur the fatigue or fracture damages, such as window and door corners of ship structure studied by Mika Bäckström & Seppo Kivimaa [11], fillet welds at doubler plates and lap joints studied by O. Feltz & W. Fricke [12], hatch corners studied by Hubertus von Selle et al [13] and hatch cover bearing pad by Kukkanen T. and Mikkola T. P. J. [15].

This paper presents an analysis of the longitudinal strength of the multi-purpose floating structure built by Quang Trung Mechanical Enterprise. The structure has the main task as a transhipment terminal of containers for container ships in Vietnam, and as a floating dock for building new ship and ship repairing. Because the structure is newly designed with the dimensions exceeding the current upper limit values of Vietnam Register (VR), all the analyses of the structure safety are strictly considered, especially long-term analysis of longitudinal strength. The structure is designed to work along the North coast of Vietnam, between Hon Dau and Hon Ngu islands with the sea data are shown in the section 3 later. The Response Amplitude Operator (RAO) of shear forces and bending moments (SF/BM) of the structure will be calculated, combined with wave spectra data to get the output spectra of SF/BM. From these calculations, the life time of the researched structure will be predicted.

2. Theory background

2.1 Wave load on ships and offshore structures

During the working time, there are a number of forces impacting on the structures. Generally, these forces include static loads, low-frequency dynamic loads and high-frequency dynamic loads.

Static loads are influenced by weights of ship and her contents, static buoyancy of the ship at rest or moving, thermal loads resulting from nonlinear temperature gradients within the hull, etc.

Low – frequency dynamic loads include following components: wave-induced hull pressure variations, hull pressure variations caused by oscillatory ship motions, inertial reactions resulting from the acceleration of the mass of the ship and its contents.

High-Frequency dynamic loads are generally generated by propulsive devices on the hull or appendages, reciprocating or unbalanced rotating machinery, interaction of appendages with the flow past the ship, short waves induced loads and termed springing.

In fact, gathering all aforementioned loads in one study requires much effort and time. Kukkanen T et al [16] gave a summary report of “Nonlinear wave loads of ships”, in which the these wave loads were detailed by using their own numerical calculations and model test results.

Generally, depending on the purpose of particular research, one or several loads are often neglected and the calculations will be easier and faster. Similarly, this paper will focus on the first type of the aforementioned loads: static loads and low – frequency dynamic loads. The low-frequency dynamic loads, loads on ship when neglect dynamic stress amplification are called wave-induced loads.

The calculation of these loads requires a previous determination of ship motions induced by waves. This is based on the assumptions of linear theory which both waves and ship motion amplitudes are small. In addition, the viscous forces are considered as a relatively unimportant forces in vertical loads calculations. Thus, the external hydrodynamic force and moment with respect to the neutral axis of a ship are [1]:

$$\overrightarrow{F_w}(w,x_0) = \iint_{S_x} (-p\vec{n})d$$
$$\vec{M}_w(w,x_0) = \iint_{S_x} \left[\left(\vec{X}-\overrightarrow{X_0}\right)x(-p\vec{n})\right]d \qquad (1)$$

where w is the wave frequency, S_x is the wetted surface partition from stern to the cross-section, p is the summation of the hydrostatic and total hydrodynamic pressures, vector n is the normal vector of the wetted surface pointing towards the fluid field and x_0 is the location of considered intersection point X_0 on the neutral axis.

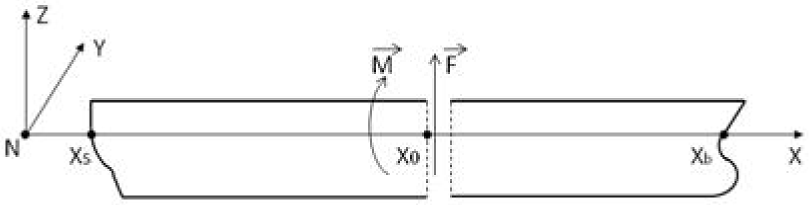


Figure 1 Bending Moment, Shear Force and Neutral axis

The gravitational force and moment with respect to the intersection point X_0 are [1]:

$$\overrightarrow{F_g}(w,x) = \sum_{X=x_s}^{x_0} \{(0,0,-m_j g) - \vec{\theta}x(0,0,-m_j g)\}$$
$$\overrightarrow{M_g}(w,x) = \sum_{X=x_s}^{x_0} \{(\overrightarrow{X_j} - \overrightarrow{X_0})x\lfloor(0,0,-m_j g) - \vec{\theta}x(0,0,-m_j g)\rfloor\} \quad (2)$$

The inertial force and moment with respect to the intersection point X_0 are [1]:

$$\overrightarrow{F_m}(w,x) = w^2 \sum_{X=x_s}^{x_0} m_j\,(u_j, v_j, w_j)$$
$$\overrightarrow{M_m}(w,x) = w^2 \sum_{X=x_s}^{x_0} \{m_j(\overrightarrow{X_j} - \overrightarrow{X_0})x(u_j, v_j, w_j) + (\theta_1, \theta_2, \theta_3)[I_x \quad]\} \quad (3)$$

where (u_j, v_j, w_j) is the motion response at the centre of mass of the j-th section, $[I_x \quad]$ is the moment of inertia of the j-th section. The summations of all load components in equation (1) and (2) are the total shear force and bending moment on ships. The maximum value of shear force and bending moment RAO among all of the calculated wave frequency points at a particular section is called as SF/BM RAO at that section.

2.2 Short-term analysis for longitudinal structure's strength

The short term analysis is based on the spectral analysis approach developed by Rice (1944) and Wiener-Khintchine theorem that allows us to switch from the time domain to frequency and probability domains. Because of stochastic representation, ocean waves are considered to be a Gaussian random process (Rudnick, 1951) so that the wave ordinate follows the normal Gaussian distribution and the wave amplitude follows Rayleigh distribution. Using seakeeping program, we can obtain the Response Amplitude Operators (RAO) of the structure motion parameters and forces. Thus, the spectra of output response is evaluated by [2]:

$$S_R(\omega) = [R \quad (w)]^2 . S_\xi(\omega) \quad (4)$$

where $S_R(\omega)$ is the structure's response spectra, $S_\xi(\omega)$ is wave spectra, and *RAO (ω)* is the response amplitude operators corresponding to the output data that we need for analysis. Subsequently, the spectra of the shear forces and bending moments (SF/BM) on structures will be calculated from wave spectra following equation:

$$S_R(\omega)_{S \quad /BM} = \lfloor R \quad (w)_{S \quad /B} \quad \rfloor^2 . S_\xi(\omega) \quad (5)$$

where $S_R(\omega)_{S \quad /B}$ is the spectrum of the shear forces or bending moments, $R \quad (w)_{S \quad /B}$ is the RAO of shear forces, bending moments, respectively.

Generally, to study the motions and loads on floating structures or ships, the wave frequency is often considered in the range from 0.2 rad/s to 2.5 rad/s.

Regarding the sea spectra, we can describe the sea state as a stationary random process. This means that we can observe the sea at a particular position within a limited time period, from 0.5 to 3 hours. This is the short-term description of the sea. Two commonly recommended wave spectra are JONSWAP and Pierson-Moskowitz. The JONSWAP spectrum is recommended by 17th ITTC for limited fetch [3]:

$$S(\omega) = 155\frac{H_{\frac{1}{3}}^2}{T_1^4\omega^5}\exp\left(\frac{-9}{T_1^4\omega^4}\right)(3.3)^Y\ (m^2s)$$

where

$$Y = \exp\left[-\left(\frac{0.1\quad .\omega.T_1-1}{\sqrt{2}.\sigma}\right)^2\right] \tag{6}$$

and

$$\sigma = 0.07\,f \qquad \omega \le \frac{5.2}{T_1}$$
$$= 0.09\,f \qquad \omega > \frac{5.2}{T_1}$$

T_1 is the mean wave period defined as:

$$T_1 = 2\pi m_0/m_1$$

where (7)

$$m_k = \int_0^{\infty} \omega^k S(\omega) d$$

$H_{1/3}$ is defined as:

$$H_{1/3} = 4\sqrt{m_0} \tag{8}$$

The Pierson-Moskowitz spectrum is a special case for fully developed long crested sea. The spectral ordinate at a frequency (in rad/s) is [3]:

$$\frac{S(\omega)}{H_{\frac{1}{3}}^2 T_2} = \frac{0.11}{2\pi}\left(\frac{\omega T_1}{2\pi}\right)^{-5} e \quad \left[-0.44\left(\frac{\omega T_1}{2\pi}\right)^{-4}\right] \tag{9}$$

where

$$T_2 = 2\pi\left(\frac{m_0}{m_2}\right)^{1/2}$$
$$T_1 = 1.086.T_2 \tag{10}$$
$$T_0 = 1.408.T_2$$

Equation (6) satisfied equation (8) is only true for a narrow-banded spectrum and when the instantaneous value of the wave elevation is Gaussian distributed.

Following IACS Recommendation No.34, [4] with the assumption that the process is narrow banded, amplitudes of the vertical wave bending moment (M_W) in short-term sea state follows Rayleigh distribution. Thus, the probability function for the maxima (peak values) M_W can be obtained following equation:

$$P_{sh}\left(M_W\middle|H_{\frac{1}{3}},T_2\right) = e^{\left[-\frac{M_W^2}{2\sigma_R^2}\right]} \quad (11)$$

Where process variance is calculated as area below response spectrum:

$$\sigma_R^2 = \int_0^{\infty} S_R\left(\omega_e|H_{\frac{1}{3}},T_2\right)d\omega_e \quad (12)$$

Where P_{sh} is the probability that wave induced bending moment on ship exceeding the given peak value of the bending moment M_W; S_R is the spectral of response.

2.3 Long-term analysis for longitudinal structure's strength

Long-term probabilities of the vertical wave induced bending moment exceeding given values are calculated by combining the short-term probabilities with the probabilities of sea state and other factors such as ship headings, ships speeds and loading conditions. Long-term distribution is given in [5]:

$$F_L(M_W) = \sum_{i=1}^{n_\beta}\frac{\Delta\beta}{2\pi}\left[\sum_{j,k}^{n_H,n_T} F_{sh,i,j,k}\left(M_W\middle|H_{\frac{1}{3}},T_{2,k},\beta_i\right).r\left(T_{2,k},\beta_i\right).p(H_{\frac{1}{3}},T_{2,k})\right] \quad (13)$$

where $r\left(T_{2,k},\beta_i\right)$ is the relative number of response cycles in each short-term sea state, $p(H_{1/3},T_2)$ is the probability of occurrence of sea state.

In long-term analysis, the probability distribution of VBM exceeding the given value M_W follows the Weibull distribution $F_{VBM}(M_W)$ [6]:

$$F(M_W) = 1 - e^{\left[-\left(\frac{M_W}{w}\right)^k\right]} \quad (14)$$

Subsequently, probability of the VBM exceeding the given value M_w is calculated as following function:

$$P(M_W) = e^{\left[-\left(\frac{M_W}{w}\right)^k\right]} \quad (15)$$

Where k and w are parameters calculated from the fitting of $P(M_W)$ to $1 - F_L(M_W)$.

3. Long-term safety evaluation of the multi-purpose floating structure

3.1 Parameters of the structure

To evaluate long-term safety of the investigated floating structure, the details of the structure parameters as well as structure's working environment must be provided. Table 1 shows the summarization of the structure's parameters. Because the structure is newly designed, then all load conditions data during the life time of the structure are still unknown. So, in this study, the load conditions of the structure are supposed to include three main cases: Full load, Ballast load and Partial load, with the corresponding time consuming proportions are 0.4, 0.4 and 0.2 (of the structure's working time), respectively.

Table 1 Main parameters of the structure

Main parameters			
Lpp [m]	171.000	*D* [m]	12.000
B [m]	25.000	C_B [m]	0.951
T [m]	4.500	Elastic section modulus amidships [m3]	4.476
Neutral axis [m]	4.600		
Parameters in particular load conditions			
	Full load	Partial load	Ballast load
Draft amidships [m]	4.500	3.830	2.830
x_G [m]	-0.804	-0.404	1.261
y_G [m]	0.000	0.000	0.000
z_G [m]	5.621	4.565	3.949
Displacement [kg]	19173605	16102481	11711206

3.2 Working area data

The structure is designed to work along the North coast of Vietnam, between Hon Dau and Hon Ngu islands shown on Figure 2.

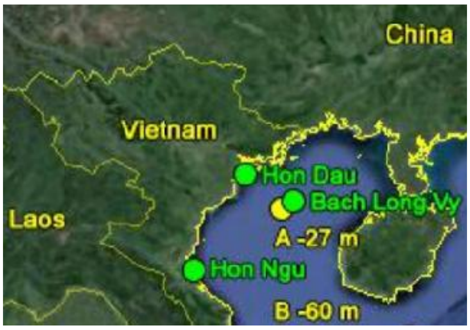


Figure 2 The design working area of the structure

In 2014, Supott Thammasittirong (AIT), Sutat Weesakul (AIT), Ali Dastgheib (UNESCO-IHE) and Roshanka Ranasinghe (UNESCO-IHE) [14] presented a report of their study on "Climate Change Driven Variations in the Wave Climate along the Coast of Vietnam". This report included statistical wave data of sea area along the North coast of Vietnam, between Hon Dau and Hon Ngu islands. The report also shown that during the period of time from 1981 to 2000, the mean wave height at the above sea area ranged from 0.4 m to 1.0 m; the mean wave period ranged from 4.0 s to 6.5 s and the main wave direction was South-East. These data are well fitted with the data from the National Centre for Hydro - Meteorological Forecasting [7] which are given on the Table 2 below.

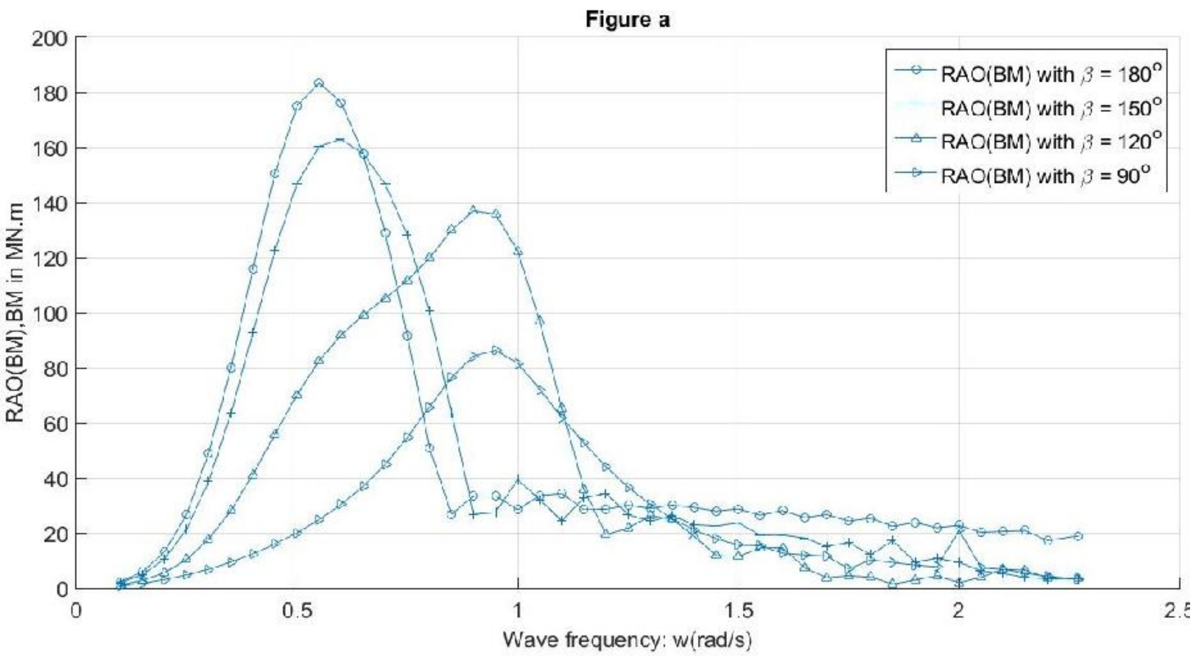
Table 2 gives basic data for the short-term calculations for the structure strength. With the results gained from the short-term calculations, strength of structure will be evaluated in given periods of time, such as 1 years, 5 years, 10 years, and 20 years.

Table 2 Annual statistical data of the design sea area

	SUM	559	315	101	20	4	1	0	0	1000
Significant Wave Height [m]: Hi	>9.5	--	--	--	--	--	--	--	--	0
	8.5	--	--	--	--	--	--	--	--	0
	7.5	--	--	--	--	--	--	--	--	0
	6.5	--	--	--	--	--	--	--	--	0
	5.5	--	--	--	--	--	--	--	--	0
	4.5	--	--	--	--	--	--	--	--	0
	3.5	--	1	1	--	--	--	--	--	2
	2.5	6	11	5	2	1	--	--	--	25
	1.5	73	85	38	9	2	--	--	--	207
	0.5	480	218	57	9	1	1	--	--	766
T_0 [s]		3.5	4.5	5.5	6.5	7.5	8.5	9.5	>10.5	SUM
T_0- mean [s]		4.10								

3.3 Results and discussion

The structure is supposed to work in its design sea wave environment with different wave frequencies and propagation directions. These frequencies range from 0.2 rad/s to 2.5 rad/s. The wave propagation angles range from -180^o to +180^o (a = 30^o) with the corresponding probability of each is 1/12, [3]. We also suppose that the weight distribution in each load condition is fixed, the liquid's sloshing in tanks are neglected, and the structure will generally have 1 month docking for small renovation each year, 3 ÷6 months docking for big renovation every 5 years of working. Figure 3 shows examples of the calculated bending moment RAO at mid-section of the structure in different wave propagation directions.



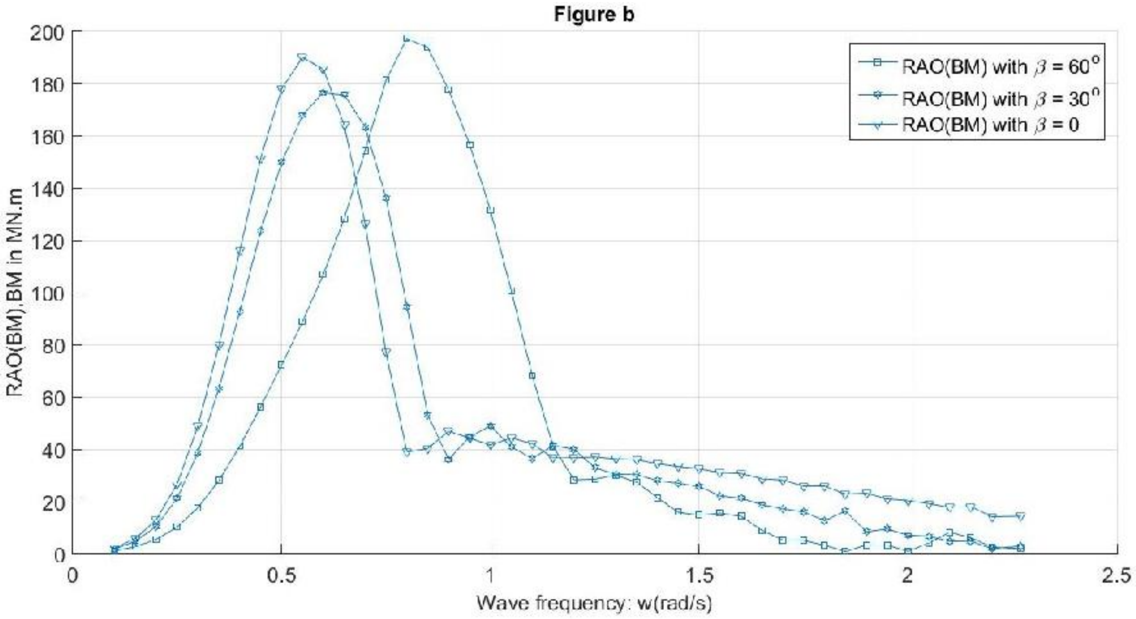


Figure 3 RAO of BM in the full load condition at different wave propagation directions

The results of bending moment RAO calculations can be combined with wave spectra data to obtain the spectra of bending moment following equation (5). The values of σ_R^2 are calculated following equation (12), and the short-term probability (P_{sh}) of bending moment on the structure exceeding the given values are calculated following equation (11), depending on sea state probability, wave propagation directions, wave frequencies. For example, Table 3 shows a result of the full load condition calculation. It shows the probabilities of which the VBM exceed the permissible bending moment of the structure amidships (M_0) in the full load condition. Here, the value of the moment M_0 is determined by the formula following IACS Recommendation 1989/Rev.6 [8]

$$\frac{M}{W_y} \leq [\sigma] \text{ [MN/m}^2\text{]} \tag{16}$$

where $[\sigma]$ is the permissible stress of the structure steel, and $[\sigma]$ = 175 [MN/m^2] for ordinary hull structure steel. W_y is the structure's elastic section modulus, and W_y= 4.476 [m^3] as shown in the Table 1.

From the condition shown in the formula (16), we can obtained the limited value of bending moment of the structure as follows

$$M_0 = W_y.[\sigma] = 787.494 \text{ [MN.m]} \tag{17}$$

Table 3 Corresponding Probability of BM exceeding the limited value M_0 in full load condition

	SUM	8.5E-175	8.45E-21	3.63E-14	5.16E-22	1.2E-23	0			3.63E-14
Significant Wave Height [m]: Hi	>9.5	--	--	--	--	--	--	--	--	0
	8.5	--	--	--	--	--	--	--	--	0
	7.5	--	--	--	--	--	--	--	--	0
	6.5	--	--	--	--	--	--	--	--	0
	5.5	--	--	--	--	--	--	--	--	0
	4.5	--	--	--	--	--	--	--	--	0
	3.5	--	8.45E-21	3.63E-14	--	--	--	--	--	3.63E-14
	2.5	8.5E-175	2.45E-35	1.12E-22	5.16E-22	1.2E-23	--	--	--	6.4E-22
	1.5	0	5.4E-91	3.15E-55	6.64E-53	1.41E-57	--	--	--	6.68E-53
	0.5	0	0	0	0	0	0	--	--	0
T_0 [s]		3.5	4.5	5.5	6.5	7.5	8.5	9.5	>10.5	

It is clearly seen that, in the full load case, the total probability of which the VBM amidships exceed the permissible bending moment of the structure M_0 is 3.63E-14.

By assuming a range of exceeded VBM M_W, we can calculate the corresponding probabilities shown in the Table 4 for all load conditions.

Table 4 Short-term Probabilities of the bending moments exceeding the given values M_W

M_W	Probability of exceeding Mw			M_W	Probability of exceeding Mw		
	Full Load	Partial	Ballast		Full Load	Partial	Ballast
(kN.m)	P_{sh}	P_{sh}	P_{sh}	(kN.m)	P_{sh}	P_{sh}	P_{sh}
10	4.07E-01	3.44E-01	3.39E-01	145	1.43E-03	1.15E-03	1.11E-03
25	1.38E-01	1.16E-01	1.12E-01	160	8.81E-04	7.15E-04	6.86E-04
40	6.77E-02	5.46E-02	5.25E-02	175	5.48E-04	4.48E-04	4.26E-04
55	3.79E-02	2.96E-02	2.90E-02	190	3.43E-04	2.83E-04	2.66E-04
70	2.14E-02	1.66E-02	1.64E-02	300	1.07E-05	9.90E-06	8.63E-06
85	1.20E-02	9.36E-03	9.27E-03	400	5.13E-07	4.79E-07	4.28E-07
100	6.79E-03	5.37E-03	5.29E-03	500	1.95E-08	1.59E-08	1.46E-08
115	3.94E-03	3.15E-03	3.08E-03	600	3.85E-10	2.80E-10	2.54E-10
130	2.34E-03	1.89E-03	1.83E-03	787.494	3.63E-14	2.08E-14	1.78E-14

where $P_{sh} = P_{sh}\left(M_W \middle| H_{\frac{1}{3}}, T_0\right)$ is the short-term probability of VBM exceeding the given value M_W in each load condition. For example, when M_W = 115 [kN.m], the total probability of VBM exceeding this M_W in the Full load, Partial load and Ballast load conditions are 3.94E-03, 3.15E-03 and 3.08E-03, respectively. By fitting the values of P_{sh} in each load condition with the values of $P(M_W)$ given in equation (15), we can find the Weibull parameters k and w shown on Table 5.

Table 5 Long-term safety assessment results of the structure

Load condition		Full load	Partial load	Ballast load
Weibull parameters	k	0.7924	0.7244	0.724
	w	11.24	9.05	8.876
Goodness of fit		*SSE*: 0.0003943 *R-sq*: 0.9975 *Adjusted R-sq*: 0.9973 *RMSE*: 0.005507	*SSE:* 0.000131 *R-square:* 0.9988 *Adjusted R-sq:* 0.9988 *RMSE:* 0.003175	*SSE:* 0.0001535 *R-square:* 0.9986 *Adjusted R-sq:* 0.9985 *RMSE:* 0.003436
T (years)	P_T	P_F	P_P	P_B
1 year	1.417E-06	3.543E-07	3.543E-07	7.087E-07
5 years	2.998E-07	7.496E-08	7.496E-08	1.499E-07
10 years	1.499E-07	3.748E-08	3.748E-08	7.496E-08
20 years	7.496E-08	1.874E-08	1.874E-08	3.748E-08
$P(Mw>M_0)$		2.55027E-13	9.1948E-12	6.71896E-12
$P_T(Mw>M_0)$		1.617E-11		

Here, P_T is the total probability in all load conditions (full load, partial load and ballast load conditions) at which the structure has one time within T years the BM exceeds its limit value. Similarly, P_F, P_P, P_B are the probabilities at which the structure has one time the wave bending moment exceeds its limit value in the time period of survey in the full load, partial load and ballast load conditions, respectively.

$P_T(Mw>M_0)$ is the totally long-term probability occurring one time BM on the structure exceeding the limited value M_0. This probability is 1.617E-11, much lower than 20 years probability shown in the Table 5, which is 7.496E-08. It means that in terms of wave bending moment, the structure have a more than 20 years life time working well under this load. This result should be combined with other calculations such as longitudinal strength analysis of the structure working in hogging and sagging conditions, ultimate strength analysis and other analyses to give a final conclusion of the structure's longitudinal strength.

4. Conclusion

The paper presents a method for long-term analysis of the structure strength under wave induced BM, based on spectra analysis and probability theory. The study also analysed partly the longitudinal strength of the structure in both short-term and long-term periods and predicted the age of the structure under the working sea environment. This is the key study that helps to solve the problems and current arguments of the very large structure built by Quang Trung Mechanical Enterprise. However, there are several issues in the study that need to take into account more carefully, such as the assumptions.

Regarding the input data, the sea environment data should be updated to the latest figures. The distribution of weight components along the structure is supposed to be fixed at each load condition, but in practice, this weight distribution will vary significantly, depending on different working states. Moreover, the load conditions in the study are only three main types (full load, partial load and ballast load conditions), which the corresponding time consuming proportions are supposed to follow the traditional rate of ship as 0.4, 0.4 and 0.2. The reason is the structure is newly built, leading to a lack of statistical data of structure working information.

Besides, the effect of mooring system should be considered, because it has significant influence on the RAO of wave bending moment. Similarly, the probabilities of wave propagation directions need to be obtained from real sea statistics, which may not be equal between different directions as the assumption in this study.

Acknowledgements

This study is a part of the safety assessment process for the floating structure built by Quang Trung Mechanical Enterprise which have been received essential data from the company.

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Integration of Maritime Spatial Planning into the Waterways Safety Management studies

Madli Kopti[1;2], PhD Student; Roomet Leiger[1], MSc; Dr. Inga Zaitseva-Pärnaste[1], PhD; Captain Jarmo Kõster[1]

1. Estonian Maritime Academy of Tallinn University of Technology, emera@ttu.ee, 101 Kopli Str, 11712 Tallinn, Estonia
2. University of Tartu, Estonian Marine Institute, 14 Maealuse Str, 12618 Tallinn, Estonia

Abstract Maritime spatial planning (MSP) arose in the beginning of the millennium as a response to a historic failure to protect the marine environment, because of an increased competition for marine space and the opportunities for economic growth [1]. The EU Directive established a framework for maritime spatial planning [2] and defined objectives of maritime spatial planning (MSP) as follows "When establishing and implementing maritime spatial planning, Member States shall consider economic, social and environmental aspects to support sustainable development and growth in the maritime sector, applying an ecosystem-based approach, and to promote the coexistence of relevant activities and uses. Through their maritime spatial plans, Member States shall aim to contribute to the sustainable development of energy sectors at sea, of maritime transport, and of the fisheries and aquaculture sectors, and to the preservation, protection and improvement of the environment, including resilience to climate change impacts. In addition, Member States may pursue other objectives such as the promotion of sustainable tourism and the sustainable extraction of raw materials." Since historic times, the Baltic Sea has been an important route for maritime trade. During the last decades, the number of ships sailing in the Baltic Sea and their sizes have continued to increase and, therefore, there is growing need for efficient integration of maritime safety into process of MSP.

Estonian Maritime Academy of Tallinn University of Technology (EMARA TUT) is the only educational institution in Estonia that offers higher education in the maritime field. One of the main aims of EMARA TUT is to provide the maritime labour market with highly qualified specialists in different maritime fields. Waterway Safety Management (WSM) is one of the study programmes in EMARA TUT focusing on the development of comprehensive and broad-based knowledge in all aspects of the theory and practice of waterway engineering and maritime safety. WSM studies are regulated by International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) and International Hydrographic Organization (IHO). Studies of WSM are associated with planning and optimization of fairways, charting and surveying navigable waters etc. Graduates work in organizations responsible for ensuring safe navigation of maritime transport in Estonian and international waters. Though, these organizations are not responsible for carrying out the official MSP, they are the key stakeholders, data providers and decision makers in line with safe shipping during the MSP process. Because of the above-described situation and due to the rapid development of MSP in the Baltic Sea region and worldwide there is a need for integrating the MSP efficiently into to the WMS studies.

The contribution attempts to demonstrate the efficient methods on the integration of MSP into the WSM studies. Efficient integration of MSP into the studies of WSM study process will provide students with broad knowledge on the interconnection of WSM and MSP and provide an effective interdisciplinary approach to MSP process.

Keywords: maritime spatial planning, the Baltic Sea, waterways safety management, maritime safety, maritime education.

1. Introduction

Maritime spatial planning (MSP) is having considerable importance all around the world, especially in European Union (EU). According to the United Nations Educational, Scientific and Cultural Organization (UNESCO) initiative [3] "MSP is a public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic, and social objectives that usually have been specified through a political process. Characteristics of MSP include ecosystem-based, area-based, integrated, adaptive, strategic and participatory approach. MSP is not an end in itself, but a practical way to create and establish a more rational use of marine space and the interactions among its uses, to balance demands for development with the need to protect the environment, and to deliver social and economic outcomes in an open and planned way."

Numerous countries have started to establish MSP to achieve sustainable use, to ensure biodiversity conservation in ocean and coastal areas, to encourage investments, to increase cross-border cooperation, to enhance "blue growth", to support synergies and coherent use of marine space among different sectors such as shipping, energy, environment, fisheries, defense etc.

Originally, the concept of MSP was stimulated by international and national interests in developing marine protected areas (MPAs). More recent attention has been placed on planning and managing multiple uses of marine space, particularly in areas where use conflicts and potential synergies and co-use are already well known and specified. In various countries marine regional planning concepts are being used as a first step to make ecosystem-based marine spatial planning a reality. Ecosystem based approach is supported by the EU and the Baltic Marine Environment Protection Commission (HELCOM). For example, Directive 2014/89/EU establishing a framework for maritime spatial planning states [1]: "in order to promote the sustainable growth of maritime economy, the sustainable development of marine areas and the sustainable use of marine resources, maritime spatial planning should apply an ecosystem-based approach." Additionally, the Fifth Ordinary Meeting of the Conference of the Parties to the Convention on Biological Diversity, Nairobi 2000 [4] defined the "ecosystem approach" as "... a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way." HELCOM and the Commission for the Protection of the Marine Environment of the North East Atlantic (OSPAR) jointly adopted their common vision [5] of an "ecosystem approach" as "the comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity."

The need for maritime spatial planning in the region guided the European Union (EU) to develop legal framework for MSP. In July 2014 was adopted Directive of the European Parliament and of the Council establishing a framework for maritime spatial planning (MSP Directive) where Article 15 states that the maritime spatial plans shall be established as soon as possible and at the latest by 31 March 2021. Because of the set requirements in MSP Directive, the development of MSP is especially rapid in the EU. The Directive establishes a framework for MSP [2] and defines objectives of MSP as follows: "When establishing and implementing maritime spatial planning, Member States shall consider economic, social and environmental aspects to support sustainable development and growth in the maritime sector, applying an ecosystem-based approach, and to promote the coexistence of relevant activities and uses. Through their maritime spatial plans, Member States shall aim to contribute to the sustainable development of energy sectors at sea, of maritime transport, and of the fisheries and aquaculture sectors, and to the preservation, protection and improvement of the environment, including resilience to climate change impacts. In addition, Member States may pursue other objectives such as the promotion of sustainable tourism and the sustainable extraction of raw materials."

One of the main purposes of higher professional education is to prepare highly qualified specialists, who are productively able to contribute in different sectors by offering relevant qualifications, high-level knowledge and skills. Due to the rapid developments of MSP, there is a need to integrate appropriate education into corresponding studies that is exemplified in this article by integrating MSP studies into the Waterway Safety Management curriculum.

2. Analysis of Waterway Safety Management subjects in line with Maritime Spatial planning study program

Higher education in Estonia is regulated by Universities Act, Institutions of Professional Higher Education Act, Private Schools Act, and the Standard of Higher Education. There are two types of higher education institutions in Estonia: universities and professional higher education institutions. Estonian Maritime Academy of Tallinn University of Technology (EMARA TUT) provides first level professional higher education, but also offers one master’s level degree programme (Maritime Studies). EMARA TUT is the only higher education institution providing professional higher education and master’s level education in the maritime field in Estonia. EMARA TUT provides the maritime labour market with highly qualified specialists in different maritime fields. Waterway Safety Management (WSM) is one of the study programmes in EMARA TUT, focusing on the development of comprehensive and broad-based knowledge in all aspects of the theory and practice of waterway engineering and maritime safety. The contents of the curriculum of Waterway Safety Management enable students to build specialized knowledge, skills, and gain qualifications, which equip them for employment, primarily in Estonian Maritime Administration or other related organisations, as hydrographic surveyors, marine cartographers, waterway engineers or specialists in diversity of occupations in navigation service and coastal engineering. The curriculum is developed in compliance with the International Hydrographic Organization (IHO) Standards of Competence for Hydrographic Surveyors and Nautical Cartographers. Additionally, graduates can continue their studies in the second-level higher education (master’s level degree programme).

2.1 Waterway Safety Management study program

Going through the curriculum, students acquire comprehensive knowledge of the theory and applications of hydrography and allied disciplines. The curriculum enables to develop competencies necessary for performing various hydrographic surveying tasks and providing assistance to marine navigation, port management and coastal engineering. The curriculum offers a thorough introduction to geodesy, hydrography and cartography as well as into coastal sea processes. Mandatory practices offer opportunities to learn different techniques of hydrography and provide hands-on experience in land surveying, hydrographic surveying, nautical cartography and coastal engineering, with reference to environmental aspects.

According to the IHO S-5 Standards of competence for hydrographic surveyors (publication includes the minimum standards for international recognition of programmes of hydrographic training at two levels) students should study appropriate procedures and limitations for the use of hydrographic surveying equipment in compliance with environmental laws and marine protected area regulations and the role of hydrographic data in Marine Spatial Data Infrastructures [6].

2.2 Integration of Maritime Spatial Planning into the Waterways Safety Management study program

MSP study program provides 2 credit points in line with the European Credit Transfer and Accumulation System (ECTS). According to the European Commission document about ECTS use [7], “ECTS is a learner-centred system for credit accumulation and transfer, based on the principle of transparency of the learning, teaching and assessment processes. Its objective is to facilitate the planning, delivery and evaluation of study programmes and student mobility by recognising learning achievements and qualifications and periods of learning. ECTS credits express the volume of learning based on the defined learning outcomes and their associated workload. 60 ECTS credits are allocated to the learning outcomes and associated workload of a full-time academic year or its equivalent, which normally comprises a number of educational components to which credits (on the basis of the learning outcomes and workload) are allocated. In most cases, workload ranges from 1,500 to 1,800 hours for an academic year, which means that one credit corresponds to 25 to 30 hours of work. It should be recognised that this represents the typical workload and that for individual students the actual time to achieve the learning outcomes will vary."

Aim of MSP subject is to give an overview about the MSP and skills how to compile Maritime Spatial Plan. On the completion of MSP course student should achieve following learning outcomes: 1) knows the meaning and importance of the Maritime Spatial Planning; 2) gives an overview about the political issues considering the Maritime Spatial Planning; 3) knows and exemplifies different phases of the Maritime Spatial Planning process; 4) gives an overview about the different IT programs/software that are used for spatial data presentation and management; 5) knows the situation of the newest Maritime Spatial Plans in Europe, including Estonia. Learning outcomes mean the minimum level of knowledge, skills and attitudes that have to be acquired as a result of passing the subject or the completion of the curriculum [8].

The subject topics have been divided into 8-week sessions and during the studies following topics are covered: introduction, overview of the MSP, phases of the MSP process, political issues of the MSP, IT programs and software used for the MSP, MSP in Europe and in Estonia. First three weeks of studies focus on giving an overview about the MSP and special focus is on the detailed introduction of full cycle of MSP process (Figure 1), by having detailed approach on every phase starting with assessing the MSP context and finalizing with the evaluation of results.

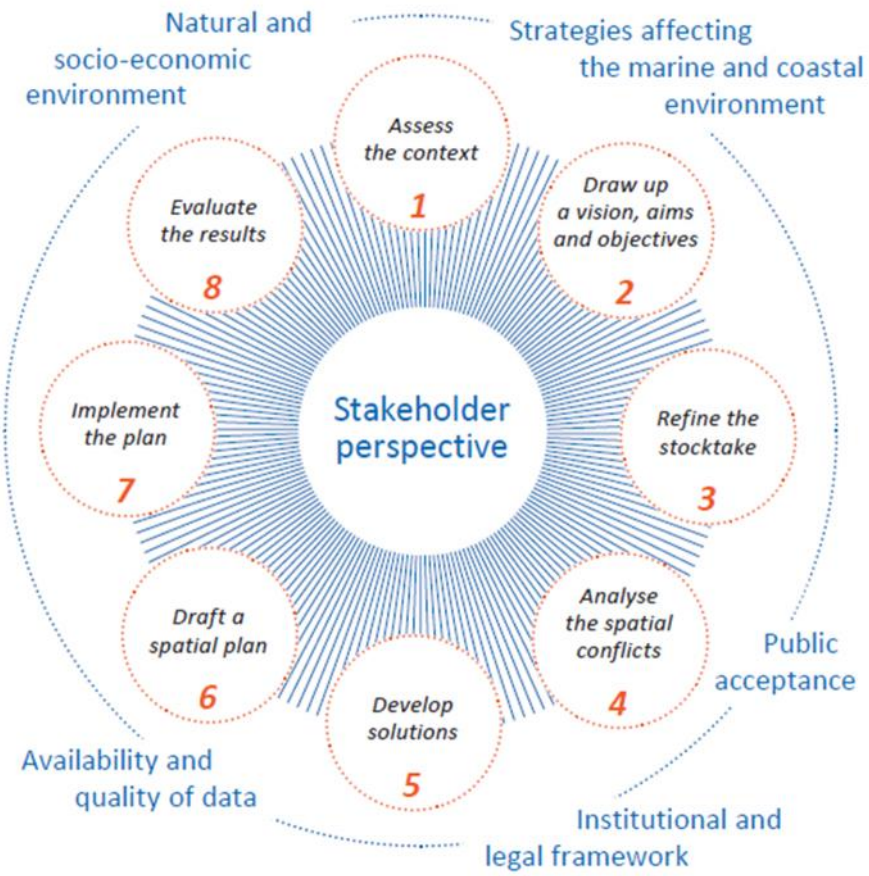

Figure 1 Process of MSP [9]

After receiving a clear overview about MSP process details will be focused on the overall development directions of MSP by giving examples on MSP experiences of different countries and MSP related scientific results. For this, students have to work through different countries corresponding MSPs (group work) and one scientific MSP related paper and present the first results in e-learning environment and second one is presented as oral presentation in the classroom. Additionally, special attention is on the political developments in line with MSP. Last section of the studies focuses on using different geographical information systems (GIS) for gathering MSP related spatial information. The last part exercise is mainly based on using existing public MSP maps and data providers such as HELCOM Baltic Sea data and map service [10] or European Atlas of the Seas [11]. The main focus of the exercise is to acquire knowledge about the possibilities of mapping the MSP relevant information and how to use different GIS tools and features such as metadata, identification of data, downloading the data etc. Additionally, a test is carried out to gain knowledge about EUs spatial information infrastructure developments, different data formats, national MSP data providers and GIS software.

Until year 2015, the course on MSP was mandatory in WSM curriculum. After 2015 the course is optional and included in the Waterway Safety Management and Port and Shipping Management study programmes. Hydrographic specialists need to engage with other users of marine and coastal areas, to ensure that the principles of MSP are taken into consideration while planning waterways and therefore minimising potential conflict between users. Since graduates of the programme work in organizations responsible for ensuring safe navigation for maritime transport in Estonia and international waters, integration of the maritime spatial planning studies into the WSM programme is an important engagement for providing co-ordinated decisions on various use of marine areas and resources in the future. Additionally, as graduates of the WSM study programme are often involved during governmental MSP processes and in waterway design process, planning of the sustainable use of inland waters and coastal areas, the knowledge about MSP allows students to establish a link between different sectors, such as industry, government, environmental- and science communities, within the process of planning shipping traffic lanes, management of the coastal areas and harbours. The result of an integration of MSP studies to the WSM programme provides students with a better understanding of the use of water areas by different users, thus allows to develop appropriate management strategies and plans.

As stated previously, MSP is much wider approach than only providing maritime safety and therefore it is important to provide WSM programme students with knowledge about maritime spatial planning. Sufficiently planned waterways minimize potential risks of shipping accidents and spills by providing solid ground of achieving aims of EU Strategy for the Baltic Sea Region (EUSBSR), Water Framework Directive (WFD) and Marine Strategy Framework Directive (MSFD). The EUSBSR [12] intends to increase levels on environmental sustainability, prosperity, accessibility and attractiveness, safety and security meanwhile the WFD [13] intends to achieve and preserve good quality of marine water (up to one nautical mile from shore) and MSFD [14] aims to achieve Good Environmental Status (GES) of the EU's marine waters by 2020.

2.3 Necessary improvement of MSP study course in line with integration to other subjects in the WSM curriculum

The present course of MSP is focused on general description of the maritime spatial planning and does not give enough specific issue, typical for waterway management tasks, such as design of fairways, waterways risk assessment, hydrographic operations etc. In addition, the course is optional and some students do not choose it. As was mentioned above, the curriculum is developed in compliance with IHO S-5 Standard. According to the learning outcomes listed in the standard, student should know the principles of hydrographic data exchange and limitations in use of hydrographic equipment in accordance with environmental regulations. Some of the mandatory topics are included in compulsory courses' content, but still there is no pronounced relation with MSP. For example, there are some of mandatory courses in WSM study program, e.g. *Environmental Impact Assessment and Audit*, *Environmental Engineering*, *International Law of the Sea* content topics which should be conducted by taking into account the means of MSP principles and vice versa.

In addition, students' feedback suggests integrating hydrography and waterway management component to the MSP course to establish the link between compulsory courses of the study programme, e.g. course *Design of waterways* and *Hydrographic surveying*. First of which is mostly focusing on IALA regulations and guidelines, such as IALA Guideline No. 1058 on the use of simulation as a tool for waterway design and aids to navigation planning and IALA Guideline No. 1078 on the use of aids to navigation in the design of fairways. The aim of the course *Hydrographic surveying* is to give basic knowledge about the main concepts involved in hydrography, planning and execution of hydrographic surveys and includes a study about methods of hydrographic survey, positioning, sea floor classification and object detection, depth determination, specification of hydrographic surveying and IHO standards regulating hydrographic works. This issue suggests changing the overall approach of teaching MSP as a general subject and incite to develop more specific approach to provide interdisciplinarity.

3. Conclusions

During the past 10 years, MSP has gained considerable importance all around the world, especially in European Union, where the MSP Directive has been adopted aiming to create a common framework for maritime spatial planning in Europe. According to the established MSP Directive, the whole EUs' sea area should be planned by 2021. Due to the rapid developments of MSP, there is a need for highly qualified specialists who are sufficiently able to contribute during the MSP process. As the graduates of WSM are working for different organizations that are important stakeholders and decision makers during MSP process this research revealed key factors for integration MSP studies to WSM curriculum.

Efficient integration of specific courses' topics of WSM programme into the MSP studies provide students with broad knowledge on the interconnection of different activities associated with hydrography and waterway management with MSP process. Therefore, the course of MSP should be established as mandatory course for WSM students. Additionally, the hydrography and waterway management component should be integrated into the MSP course to establish the link between compulsory courses of the study programme, e.g. course *Design of waterways* and *Hydrographic surveying*. Finally, reciprocal integration between MSP and other mandatory courses, e.g. *Environmental Impact Assessment and Audit, Environmental Engineering, International Law of the Sea* should be implemented.

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Session 2C

MARITIME ENVIRONMENTAL ISSUES & ENERGY EFFICIENCY

(No. 2)

Effect of Injection Timing and Mixing Rate of Water in Jatropha Emulsion on Combustion and Performance of DI Diesel Engine

Nguyen Kim Bao[1]

1. Vietnam Maritime University; E-mail: nguyenkimbao@vimaru.edu.vn
Address: 484 Lach tray street, Hai phong City, Vietnam

Abstract The current paper studies the effect of the injection timing and Jatropha water emulsion (JWE) with different mixing ratios on the combustion and performance characteristics of a direct injection diesel engine. The experimental study was carried out using a four-stroke, high speed, small capacity, direct-injection diesel engine. The engine ran on the Light oil (LO) and neat Jatropha oil (JO) for baseline data. In this study, Jatropha emulsion was made by mixing mass ratios of 10% and 20% of water so called JWE10%, and JWE20%, respectively. While changing fuels from LO to JO, JWE10%, and JWE20%, we tested the engine with various injection timings of 17, 20, and 23 degree crank angle before top dead center (^{o} BTDC). The acquired data was analyzed for various combustion parameters such as in-cylinder pressure, heat release rate (HRR), ignition delay (ID); for performance parameters such as exhaust gas temperature and brake thermal efficiency (BTE). At the original injection timing, the peak of in-cylinder pressure, and the HRR reduced, and they marginally increased when advancing the injection timing in comparison with those of the Jatropha oil at original injection timing. Ignition delay increased with an increase of the injection timing for both emulsion fuels. When advancing the injection timing to 23^o BTDC, the emulsion fuels reduced exhaust gas temperature. BTE increased when using emulsion fuels, particularly the JWE10%. Overall, the optimum water mixing rate was 10%, while the optimum injection timing was 20^o BTDC.

Keywords: Jatropha water emulsion, mixing rate, injection timing, combustion, performance.

1. Introduction

Diesel engines have been faced with problems like the fossil fuel crisis, and the more stringent criteria regulated by governments the world over attempting to protect the air quality. The main harmful pollutants, namely NOx and particulates, which are trade-offs in using diesel engines, have been closely watched. Additionally, the production of global warming gas (CO_2) is unavoidable whatever the fuel when using diesel engines. To allay these concerns, vegetable oils have recently gained attention as a promising alternative fuel for a greener future. Short-term tests have revealed that most vegetable oils are capable of being used directly in existing diesel engines with little or no modification. However, long-term test has reported some operational problem such as piston ring sticking, injector and engine deposits, gum formation and oil thickening [1]. Physical properties of the vegetable oils such as high viscosity, poor volatility, and bulky molecules result in an increase in CO, HC and PM, but lower NOx emissions compared to those of diesel oil alone [2-4]. Among vegetable oils, Jatropha has been of interest because it is not a food source [3]. Jatropha oil was identified as a leading candidate for an alternative fuel among various non-edible vegetable oils [5] since the plant does not suffer excessively from droughts, or need concentrated irrigation. Higher smoke, HC, CO have been observed [3, 7, 8], while NOx emissions have also been reported lower when engines run on Jatropha oil [3, 8]. In the performance aspect, the brake thermal efficiencies of engines fueled with Jatropha have been generally lower in comparison with those using diesel oil [3, 6-9]. This is attributed to the physical-chemical-properties of Jatropha oil such as high viscosity, poor volatility, bulky molecular structure, and low cetane number. The drawbacks of Jatropha oil may be overcome by preheating [7, 8], and/or blending with diesel [10, 11].

The usage of water emulsion fuel is a well-known way to significantly reduce NOx emissions due to the cooling effect of the vaporization of water in the emulsion fuel [12-16]; while the reduction of soot is seen as a consequence of the micro-explosion [13, 15], or the presence of OH radicals releasing during the combustion process [13, 15], or more air entrainment [16].

From this one might surmise that a combination of a change in injection timing with Jatropha water emulsion may reduce both NOx emissions and soot in diesel engine. Moreover, it may improve performance of the engine as a result the effect of micro-explosion. However, as yet this combination has not been tried to the best of our knowledge.

Our current experimental research was conducted to remedy this situation. We investigated the effect of injection timing and Jatropha water emulsion on the combustion, performance, and emissions characteristics of a diesel engine. During the experiments, the engine were varied with different injection timings of 17^o (default value), 20^o, and 23^o BTDC, while we changed the test fuel from LO and JO to the JWE with water mass mixing ratios of 10% and 20%.

2. Experimental setup and procedures

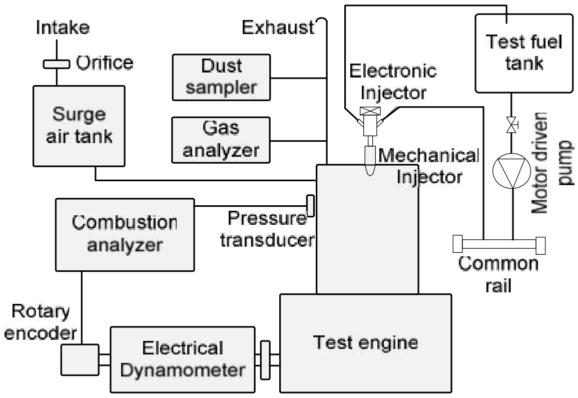

Figure 1 Diagram of experimental setup

Table 1 Specifications of test engine

Model	YANMAR NFD 13-ME
Engine type	Horizontal, 1-cylinder, 4-stroke
Combustion type	Direct injection
Bore × Stroke	92 × 96 mm
Displacement	0.638 liter
Compression ratio	17.7
Rated output	8.1 kW @ 2400 rpm
Injection nozzle	4-hole nozzle
Nozzle opening pressure	19MPa

Experiments were conducted on a single cylinder, four-stroke, high speed, direct injection diesel engine (Yanmar Co., Ltd., Japan). The scheme of experimental setup is shown in Fig. 1 and the main specifications of the test engine are given in Table 1. The fuel injection system of the engine was modified to a common rail injection system. Main components of the common rail system include a motor-driven-pump (radial piston pump), a common rail (high pressure tube), an electronic injector, and an electronic control unit (ECU). The ECU was connected to a computer via a combustion analyzer (Yokogawa) to record the data. The in-cylinder pressures were measured using a piezoelectric pressure transducer (Kistler) fitted into the cylinder of the engine and connected to a charge amplifier. Load of the engine was set through an electrical-dynamometer (Toyo Electric Co., Ltd.) coupled to the shaft of the engine. A set of gas analyzers VIA-510, CLA-510SS (Horiba) was used to measure the emissions of CO_2, NOx, respectively, and along with MEXA-324J (Horiba) for measurement of CO, HC. Dust matters were trapped on the ADVANTEC PG-60 paper filters (glass fiber Fluorine coated filter, Toyo

Roshi Kaisha, Ltd.) in 10 liters of exhaust gas at each step of the experiments with the help of a D-25UP gas sampler (OCT science, Ltd.). In each experiment step, we collected the dust on 4 paper filter sheets. Afterward, soluble organic fraction in the dust trapped filters was dissolved by dichloromethane and was calculated by balancing the mass of the filters before and after extraction (average value). In-soluble organic fraction was calculated by subtraction of the paper filter mass after SOF dissolving and the original filter. Measurements were carried out using LO, JO, JWE10%, and JWE 20%. To make the emulsion fuel, a mixing system with a tank for JO; a tank for water; a circulating pump; and a static mixer was used. The engine was fed with LO, and JO at the injection timings of 17, 20, and 23^{o} BTDC for baseline data. These timings were also set to investigate the effect of the Jatropha emulsion with different water mass mixing rates. Water with 10% and 20% in mass was added to the Jatropha creating emulsion fuels prior to the experiments. The experimental conditions (injection timing and test fuels) of the experiments are provided in Table 2. All experimental steps were conducted at room temperature and the results were recorded at steady operational conditions of the engine. During the experiments, the engine load was set at different values of 3.0 kW, 4.5 kW, and 6.0 kW with a speed of 2000 rpm, while the rail pressure was kept at 100 MPa. The gas emissions including CO, CO_2, HC, smoke, and NOx were read during each step of the experiments. While, the concentration of dust, in-soluble organic fraction (ISF), and SOF were determined in experiments, as well.

Table 2 Experimental conditions

Engine Speed [rpm]	Injection timing [^{o} BTDC]	Test fuels			
		Light oil	Jatroha oil	Jatropha emulsion	
				10%	20%
2000	17	LO-17	JO-17	JWE10%-17	JWE20%-17
2000	20	-	-	JWE10%-20	JWE20%-20
2000	23	-	-	JWE10%-23	JWE20%-23

3. Results and discussions

3.1 Combustion characteristics

In this section, the combustion characteristics are demonstrated by a number of factors, namely combustion pressure, heat release rate, and ignition delay. In-cylinder pressure of the engine is indicated in Fig. 2. It is clear that the peak pressures of the engine depend on the injection pattern as well as the fuel. Perhaps, for emulsion fuels, the development of the pressure in the cylinder depends on some factor, such as the cooling effect; the combustion of cumulated fuel; and the help of second-atomization. When compared with JO-17, the JWE10% reduced the peak pressures of 5%, 5.8%, and 4.5%, while the JWE20% had a minor reduction of 0.1%, 0.9% and 0.2% at 3.0, 4.5 and 6.0 kW, respectively. At this timing, it can be seen that for the emulsion fuels the developments of pressure were retarded when compared with JO or LO. The reduction and retardation of peak pressures can be resulted from the cooling effect and higher viscosity of the emulsion fuels. When advancing injection timing, most emulsion fuel increased peak pressures in the cylinder, particularly for the 23^{o} BTDC. At lower powers, the JWE10% had a relative increment of peak pressure of 7.0% and 8.8%, while the JWE20% had peak pressure of 7.0% and 5.5% higher in comparison with those of the JO-17. At 6.0 kW, the JWE20% had an increment of 5.9%, while the JWE10% had 7.1% higher in comparison with peak pressure of the JO-17. The increment of the peak pressure may result from either the combustion of the fuel cumulated in the combustion chamber or the help of micro-explosion contributing to the better mixing of fuel and air in the combustion chamber. At the 20^{o} BTDC, for the JWE10%, the minor reductions are seen at lower powers, while it had a marginal increase of 6.2% when compared with JO-17. These may result from the cooling effect could over the other factors at lower loads, while at higher power the cumulated fuel and second-atomization could enhanced the development of the in-cylinder pressure. At this timing, and at lower power, the JWE20% had slight increment of 4.3% and 5.8%, while the pressure was comparable with those of the JO-17 at 6.0 kW. This can be explained as the high enough water content in the JWE20% resulting in the dominant second- atomization at lower powers, and it would be enough for cooling effect at high load, respectively.

Heat release rate (HRR) in the cylinder of the engine is presented in Fig. 3. The peak of HRR reduced from 65.9, 66.2, and 64 J/deg. of the LO-17 to 62.5, 59, and 57 J/deg. of the JO-17 at 3.0, 4.5, and 6.0 kW, respectively. This is resulted from properties of the JO such as higher viscosity, lower volatility, and lower cetane number. At the 17° BTDC, the HRR of the emulsion fuels had a relative reduction of 13.1%, 12.9%, and 11% for the JWE10%, and 3.1%, 8.1%, and -1.5% for the JWE20% in comparison with those of the JO-17 at 3.0, 4.5, and 6.0 kW, respectively. The reduction of the HRR may attribute to the cooling effect of the water in the emulsion fuels. However, less reduction of the HRR for the JWE20% may result from the aid of dominant micro-explosion over the cooling effect. When advancing the injection of the emulsion fuels the HRR start increasing in comparison with those of the JO-17, particularly for the injection timing of 23° BTDC. At the 20° BTDC, the JWE10% reduced the HRR 6% at 3.0 kW, while it increased the HRR 10.6% and 19.7% at 4.5 and 6.0 kW. At this timing, the JWE20% increased HRR 12.1% and 16.5% at 3.0 and 4.5 kW, and it had a reduction of 6.5% at 6.0 kW. At the 23° BTDC, for the JWE10%, the HRR of had an increment of 9.6%, 33.2% and 31.4%, while for the JWE20%, the reduction was 14%, 13.6%, and 9.7% in comparison with those of the JO-17 at 3.0, 4.5, and 6.0 kW. This may result from the dominant cooling effect of the JWE20% over the JWE10%, especially for higher engine powers.

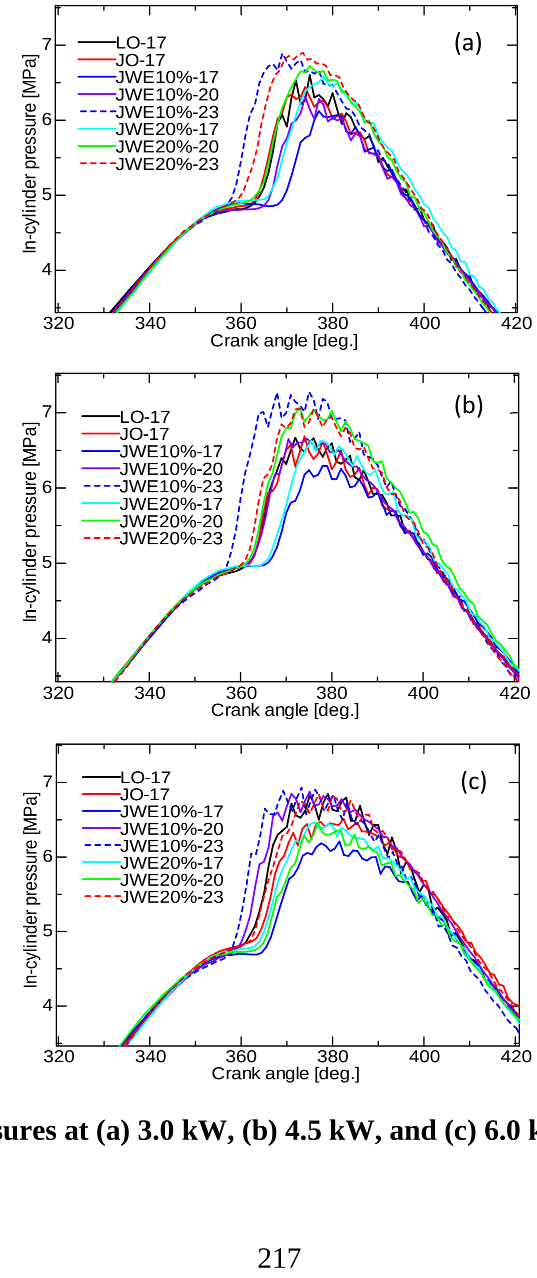

Figure 2 In-cylinder pressures at (a) 3.0 kW, (b) 4.5 kW, and (c) 6.0 kW at a speed of 2000 rpm

Ignition delay is shown in Fig. 4. The ignition delay is the duration from the start of injection to the start of combustion. The start of combustion is determined by the timing at which the HRR changes from a negative to a positive value. The ignition delay was shorter for LO and JO, while the emulsion fuel increased the ID and also increased with an increase of injection timing. At default timing, the JWE10% increased the ID from 6.4% to 8.3%, while at the 23º BTDC the ID had an increment of 22.9% to 29.9% when compared with those of the JO-17. For the JWE20%, at the 17º BTDC, the ID increased 4.0% to 6.4%, and it increased up to around 30% when timing advanced to the 23º BTDC in comparison to those of the JO-17. The increment of the ID for the emulsion fuels and when advancing the injection timing can be attributed to the cooling effect of water in the emulsion fuels and the worse combustion conditions at advanced injection timing, respectively.

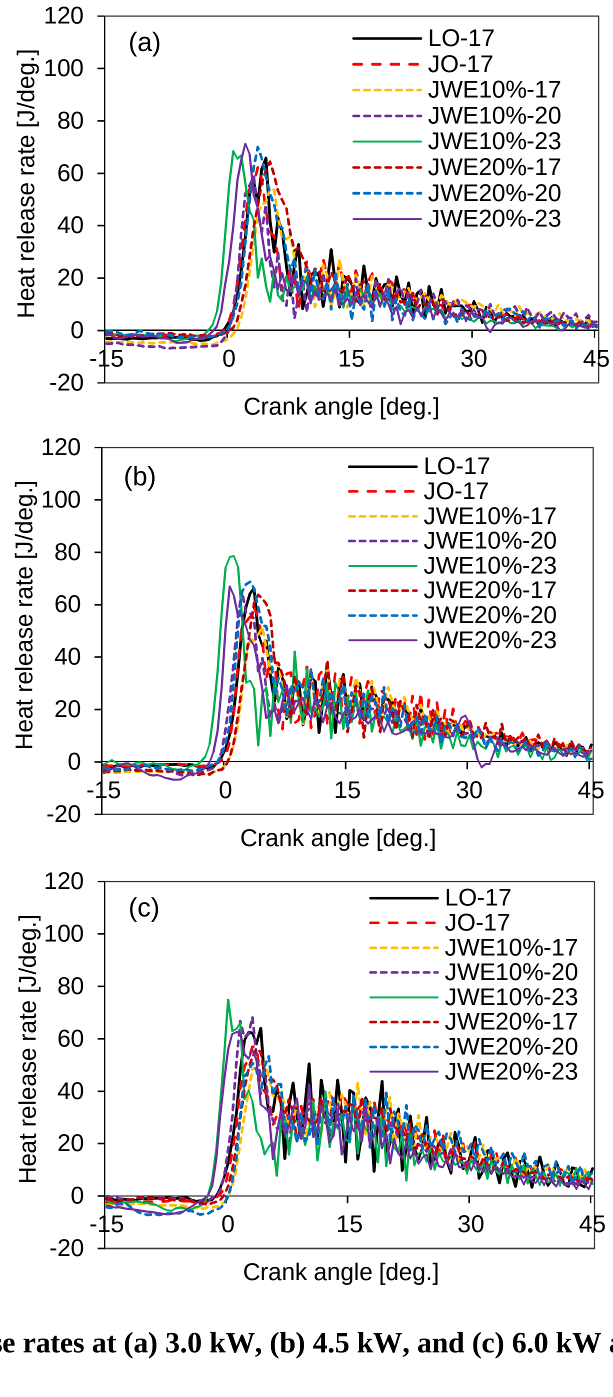

Figure 3 Heat r elease rates at (a) 3.0 kW, (b) 4.5 kW, and (c) 6.0 kW at a speed of 2000 rpm

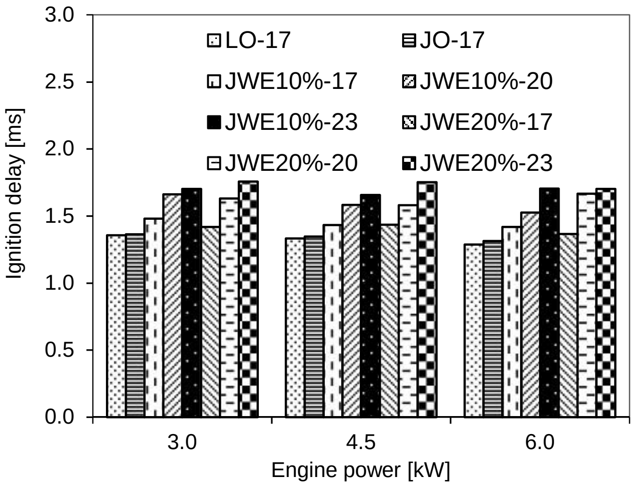

Figure 4 Ignition delay at different powers and at a speed of 2000 rpm

3.2 Performance characteristics

The performance parameters of the engine, such as in-cylinder and exhaust gas temperatures, and brake thermal efficiency will be introduced in this section.

Exhaust gas temperature is shown in Fig. 5. Exhaust gas temperatures increased with an increase in the engine power. This is due to more fuel injected and combustion which generates more engine power. At most injection timing, for JWE10%, the exhaust gas temperature reduced when compared with those of the JO-17. At the 17^o and 20^o BTDC, the exhaust gas temperatures reduced from 2.1% to 3.1% when compared with those of the JO-17. At the 23^o BTDC, they had more relative reduction of 5.2%, 5.9%, and 2.0% at 3.0, 4.5, and 6.0 kW, respectively in comparison with those of the JO-17. This may result from the cooling effect of the water in the emulsion fuel, also when advancing the injection timing, the heat released more early resulting in early combustion in the combustion chamber. For the JWE20%, at the original timing, the exhaust gas temperature had a relative reduction of 2.6% to 3.4%, while at the 23^o BTDC the reduction was 3.9%, 2.8%, and 0.6% at 3.0, 4.5, and 6.0 kW, respectively. At the 20^o BTDC, the exhaust gas temperature was comparable with those of the JO-17.

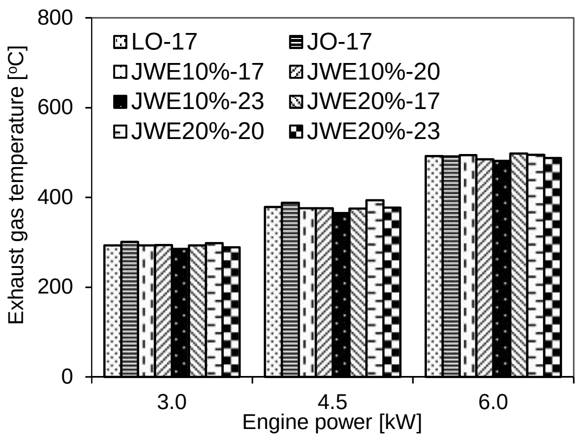

Figure 5 Exhaust gas temperatures at different powers and at a speed of 2000 rpm

Brake thermal efficiency of the engine is indicated in Fig. 6. The emulsion fuel significantly increased the BTE, especially for the advancing timing, when compared with those of the neat Jatropha oil at the original timing. At the default timing, at higher engine powers, the JWE10% had a relative increment of 3% to 6%, while the JWE20% had a relative increment of 8% to 10.7% in comparison with those of the JO-17.

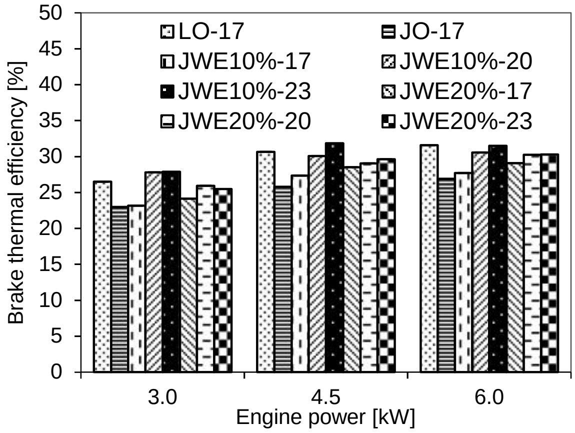

Figure 6 Brake thermal efficiencies at different powers and at a speed of 2000 rpm

At 20° BTDC, the JWE10% increased from 13.6% to 21%, while the JWE20% increased around 12.5% when compared with those of the JO-17. The relative increment was 17% to 23.5% of the JWE10% and 10.9% to 14.9% of the JWE20% at 23° BTDC. At medium power, and at the 23° BTDC, the JWE10% had optimum BTE up to 31.8% that overs the BTE of the LO-17 of 30.7%. The increment of the BTE of the emulsion fuels may attribute to the effect of micro-explosion resulting to the better mixing of fuel and air in the combustion chamber.

3.3 Emissions characteristics

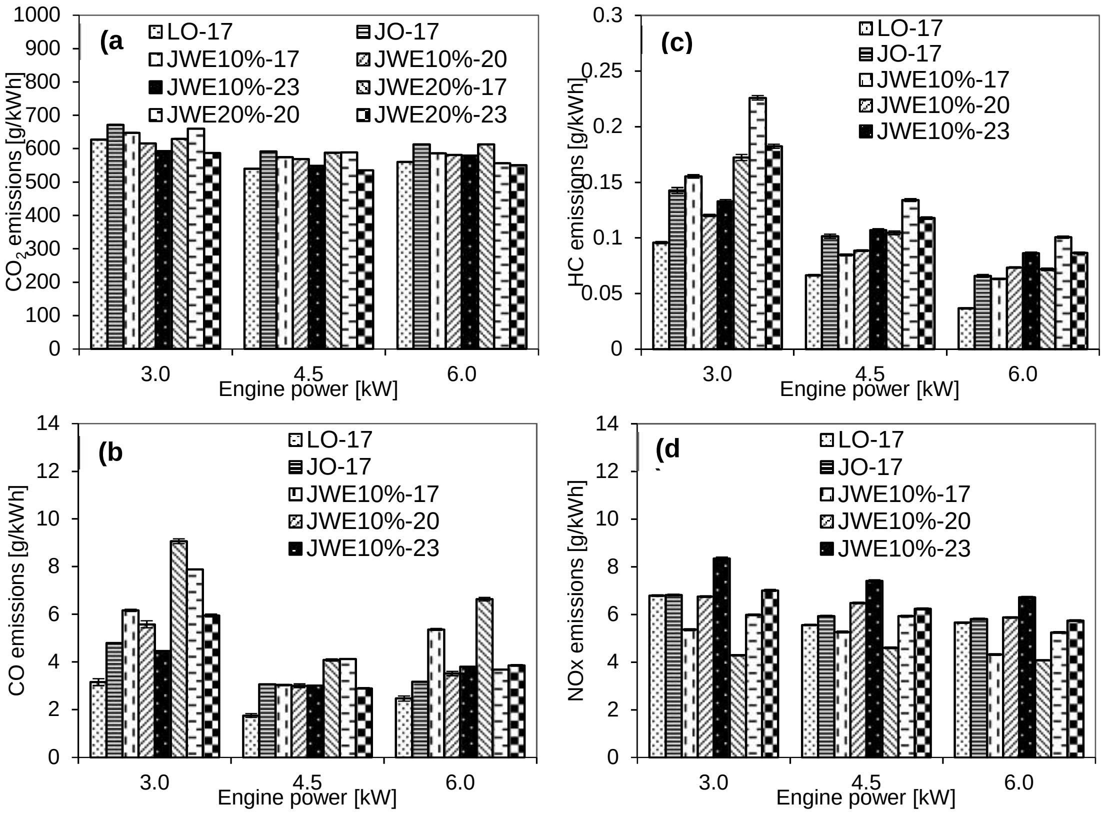

Figure 7 Exhaust gas emissions at different powers and at a speed of 2000 rpm

The gas emissions of the engine such as CO_2, CO, HC, and NOx are indicated in Fig. 7a-d. Emission of CO_2 is presented in Fig. 7a. It is clear that the emissions of CO_2 were higher for JO when compared with LO at the original timing. When using emulsion fuels, the emissions of CO_2 reduced when compared with JO-17. When advancing the injection timing, the emulsion fuels reduced CO_2. At the original injection timing, the JWE10% reduced 3.6%, 2.9%, and 4.5%, while the JWE20% reduced 6.3%, 0.6%, and 0.1% when compared with those of the JO-17 at 3.0, 4.5, and 6.0 kW, respectively. At the 23^o BTDC, the JWE10% had a reduction of 11.8%, 7.2%, and 5.5%, while the JWE20% had a reduction of 12.6%, 9.5%, and 10.2% when compared with those of the JO-17 at 3.0, 4.5, and 6.0 kW, respectively. The reduction of CO_2 may result from the better mixing between fuel and air, especially, when advancing the injection timing. The better BTE also means the less fuel consumption and the less emission of the CO_2.

Emission of CO is shown in Fig. 7b. The emulsion increased emission of CO with an increase of the water in the emulsion fuel. When advancing the injection timing of the emulsion fuel, the emission of CO dramatically reduced. For the JWE10%, at 3.0 kW, increaments of the CO were 28.6%, 16.4% at 17 and 20^o BTDC, respectively, while for the 23^o BTDC, the reduction of the CO was 6.8% when compared with the JO-17. At 4.5 kW, the emissions of CO were comparable with the JO-17. At 6.0 kW, a much increment of 70% was at the original injection timing, and when injection was advanced to 20 and 23^o BTDC, the emission of CO increased 11% and 20%, respectively. For the JWE20%, at the original timing, CO emission increased 89%, 33%, and up to 110% at 3.0, 4.5, and 6.0 kW, respectively. When timing was advanced to 20^o BTDC, the increment of emission of CO was 64%, 35%, 16%, while at 23^o BTDC, it was 24%, -5.3%, and 22% at 3.0, 4.5, and 6.0 kW. The higher emission of CO for the emulsion fuel can be attributed to the cooling effect of water, and the higher viscosity of the emulsion fuels. The reduction of the CO when advancing injection timing may result from more available time for oxidation of CO to CO_2, the less fuel consumption, the higher BTE as seen previously.

HC emission is indicated in Fig. 7c. The emission of HC depends on the power of the engine, the injection timing, and the fuel. The emissions of HC decreased with an increase in the engine power. This is due to the higher combustion temperatures at higher engine powers. At lower power, for the JWE10%, HC decreased 16.6% for the 20^o BTDC and 4% for the 23^o BTDC when compared with those of the JO-17. This can be explained by the more available time for fuel oxidation. While, for the JWE20%, HC increased 20.8% up to 58% when compared with the JO-17. This could result from more water in the emulsion fuels, thus the higher viscosity and density, therefore more fuel droplets got into the crevice clearance. In the other hand, the combustion conditions were inferior in lower power, thus increased the HC. At medium power, due to the better combustion conditions, thus the JWE10% at moderate advancing injection timing marginally reduced HC with 12.7% in reduction compared with the JO-17. At higher power, the JWE10% slightly increased HC. While, for the JWE20% at medium or higher powers, the HC emissions were higher than those of the JO-17. These could attribute to the higher viscosity and density of the emulsion fuels when compared with those of neat Jatropha oil.

Fig. 7d displays NOx emissions of the engine. The emissions of NOx had a strong correlation to the fuel and injection timing. It is clear that combustion of the emulsion fuels released less NOx than the JO and LO at the original injection timing. When compared to those of the JO-17, for the JWE10%, the reductions were 21.3%, 11.2%, and 25.8%, while for the JWE20%, the reductions were 37.1%, 22.4%, and 29.9% at 3.0, 4.5, and 6.0 kW. This is due to the cooling effect and the dilution of the water in the emulsion fuel. NOx emissions increased with an increase of the injection timing. This is due to more fuel cumulated in the combustion chamber when advancing the timing. However, at the 20^o BTDC, for the emulsion fuel, particularly the JWE20%, NOx were 10% to 12% less than or comparable to those of the JO-17.

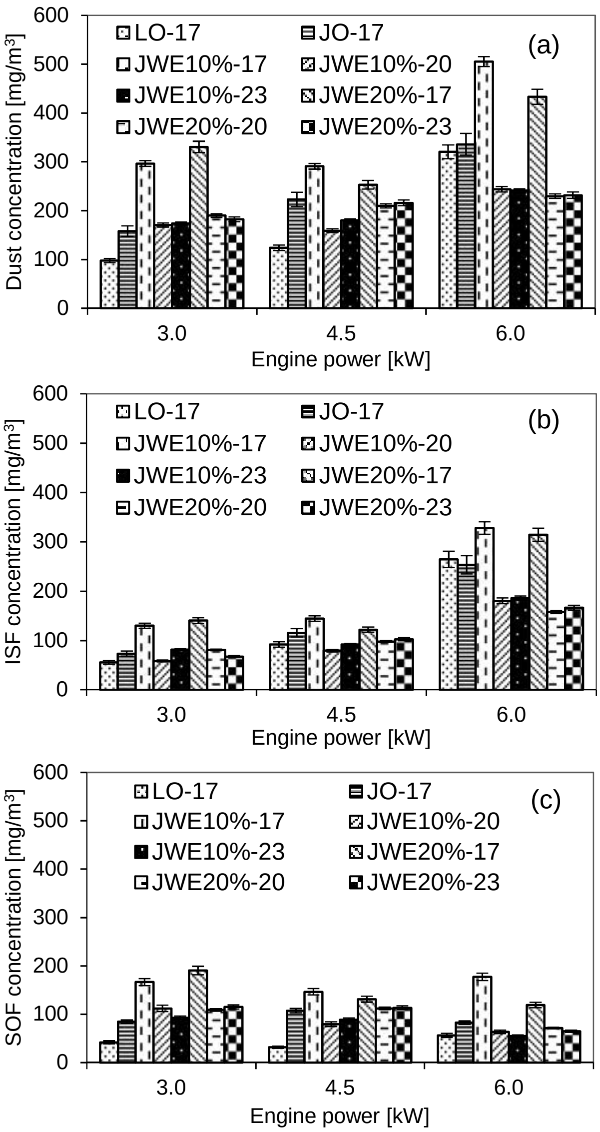

Figure 8 Concentrations of (a) dust, (b) ISF, and (c) SOF at different powers and at a speed of 2000 rpm

Concentration of dust, in-soluble organic fraction (ISF), and soluble organic fraction (SOF) are displayed in Fig. 8a-c. This shows that the dust emissions were higher for emulsion fuels when compared with those of the LO and JO at the original injection timing. In comparison with JO-17, dust increased 87.7%, 30.5%, and 50.4% for the JWE10%, while it increased 109%, 13.5%, and 29% for the JWE20% at 3.0, 4.5, and 6.0 kW, respectively. When advancing the timing to the 20° BTDC, at higher powers, the dust reduced around 28% for the JWE10%, and decreased 5.8% to 31.6% for the JWE20%. For the 23° BTDC, the reductions of dust were 19.1% and 28.3% for the JWE10% and were 3.1% and 31.1% for the JWE20%. The reductions of dust when advancing injection timing can be attributed to the dilution of the fuel by the water, the aid of micro-explosion, and the longer time for more complete combustion. Fig. 8b shows the reduction of the ISF when advancing the injection timing. When compared with JO-17, the highest reduction of the ISF was 31.3% at 20° BTDC for the JWE10%, while it was 37.7% for the JWE20% at the same timing. At low power, due to the combustion conditions were inferior, thus the SOF were higher for the emulsion fuels. At medium power, and at the advanced injection timing, the SOF reduced 25.9% and 17.7% for the JWE10% at the 20° and 23° BTDC, while for the JWE20%, SOF slightly increased when compared with the JO-17. At 6.0 kW, the reductions of the SOF were 23%, and 33.7% for the JWE10%, while for the JWE20%, the reductions were 13.1%, and 21.2%. At higher power, the combustion temperature is higher resulting in better micro-explosion; and the longer available time for combustion thus reducing the SOF.

4. Conclusions

A direct injection diesel engine was used to investigate the effects of injection timing and Jatropha water emulsion fuels with a mixing rate of 10% and 20% on the combustion, performance, and emissions of the engine. In summary, the main features are as follows.

1- The peak of in-cylinder pressure reduced when the emulsion fuels were used at the original injection timing. When advancing the injection timing, it marginally increased when compared with those of neat Jatropha oil at the original timing. The increment was from 7% to 8.8% for the JWE10%, and from 5.5% to 13.1% for the JWE20% at 23^o BTDC in comparison with those of the JO-17. The HRR slightly reduced at the original injection timing when using the JWE10%, while for the JWE20%, the marginal increment has seen at lower power, and the reduction has observed at high power. When advancing injection timing, heat released more early and higher than those of the JO-17. The ignition delay increased with an increase of injection timing, and up to 30% when compared with those of the JO-17 for both emulsion fuels.

2- Emulsion fuel reduced the exhaust gas temperature at lower engine powers. When advancing injection timing to 23^o BTDC, both emulsion fuels reduced exhaust gas temperature. BTE of the engine using emulsion fuels was higher than that of the neat Jatropha oil fueled engine. When advancing injection timing, emulsion fuels increased the BTE, particularly for the JWE10% with a maximum relative increment of 23.5% when compared with that of the JO-17 fueled engine.

3- When advancing the injection timing to a reasonable timing, the emulsion fuel reduced or kept the comparable emission of CO_2, CO, HC, and NOx. For emulsion fuels, the dust, ISF, and SOF concentration dramatically reduced when injection timing advanced to 20^o or 23^o BTDC, especially for the JWE10%.

4- Overall, the optimum mixing rate of water for Jatropha emulsion fuel was 10%, while the optimum injection timing was at 20^o BTDC for combustion, performance, and emissions of the engine.

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Sediment management practices for ports and shipyards – applicable approach

Vlado Frančić, Assistant professor, Lovro Maglić, Assistant professor, Marija Šimić Hlača, Ph.D. student

Faculty of Maritime Studies Rijeka, Croatia, vfrancic@pfri.hr, Studentska 2, Rijeka, Croatia
Faculty of Maritime Studies, Rijeka, Croatia, maglic@pfri.hr
Faculty of Maritime Studies, Rijeka, Croatia, marija@pfri.hr

Abstract The management of ballast water sediment has not so far been extensively researched. Although it was not analysed as often as ballast water itself, the ballast water sediment has been also recognized as a significant vector for transfer of alien invasive species (AIS), harmful organisms and pathogens (HAOP). Additionally, ballast water sediment is identified as a matter that may also contain toxic chemical compounds or heavy metals.

So far, the sediment management procedures are not yet harmonized among stakeholders, in particular those involved in maritime transport such as port and shipyard managements and maritime administrations. Therefore, development and implementation of such harmonized procedures shall decrease risks associated with transfer of HAOPs, toxic elements and compounds. At the procedural level, ballast water sediment management should include at least sampling procedures, collecting and disposal procedures as well as information dissemination. The responsibility to implement measures is primarily on ships' crews and secondary, on national maritime administrations responsible for the implementation of the Ballast Water Management Convention.

Generally, sediment management comprises of on-board and on-shore sediment removal and disposal procedures. Although very similar, the responsibilities for those procedures are very different: in case of removal and disposal of ballast water sediment in shipyards, only national legislation is applied, while on-board removal procedures are strictly regulated by the BWM Convention and related guidelines. In any case, the operation should not cause delays or unduly costs to ships, port operators or any other person or entity operating within port areas and shipyards, unless such delay or cost is reasonable and can clearly prevent or minimise transfer of alien invasive species or HAOP.

This paper analyses best practices of sediment management for ports and shipyards, including relevant legal issues and applicable training requirements for personnel. The disposal options by using innovative technologies are analysed and presented considering their technical aspects, application requirements, safety aspects, training needs and the need to keep operational costs within acceptable ranges. Furthermore, detailed analysis for the existing sediment management procedures in the Adriatic Sea is presented.

Finally, knowledge, understanding and proficiencies that may or should be considered as a part of the STCW Convention (once the BWM Convention enters into force) are discussed.

Key words: ballast water sediment, ports, shipyards, best management practices, BWM Convention.

1. Introduction

Ballast water transfer by ships as a vector for the movement of HAOP through different ecosystems can be considered as a significant threat to the world's seas, human health, property and resources 0. Ballast water transfer was regulated by the International Convention for the Control and Management of Ship's

Ballast Water and Sediments, 2004 (BWM Convention) which defines the global standards on ballast water and sediment management requirements.[2]

Sediments in ballast water tanks and their management, although mentioned in numerous different documents, have not been extensively researched [2].[3] Before adopting BWM Convention, the accent was on evaluating possibilities and the extent of transfer of HAOPs via ballast water. Internationally available sources do not deal much with sediment management. The majority of the documents and scientific papers on ballast water sediments deal with presence of organisms and their identification proving that sediment is a significant vector for the transfer of organisms [2].

Another group of papers deals with ship design, management and new treatment techniques for reducing the build-up of sediments and sediment sampling methods from the ballast water tanks [10-12].

The research on the physical and chemical properties including the presence of heavy metals in ballast tank sediments is presented in the study created by Macdonald and Davidson in 1997 [13] and Maglic in 2016 [14]. The first study was based on an extensive number of samples taken from ships visiting Scottish ports. The results showed that the levels of heavy metal in ballast tank sediment build-up are frequently higher than those detected in the natural environment. In the second paper, the analysis of samples from three ships visiting the port of Rijeka (Croatia) revealed no significant abundance of heavy or toxic metals. However, high concentrations of detected metals may endanger humans or environment.

The Contracting States are responsible for deciding on best sediment management and disposal practices for ports and shipyards taking into account technical aspects, application requirements, safety aspects, and the related costs. Sediment management should take into account three main issues: whether a sediment accumulation which is about to be unloaded from a ship may endanger human health and/or the environment, how to treat the unloaded sediments, and where it may be disposed.

Policies and regulations that will be proposed should be in accordance with principles and requirements outlined in guidelines adopted by the International Maritime Organization, notably in line with Resolution MEPC.152(55) Guidelines for Sediment Reception Facilities (G1) [15] and Resolution MEPC.150(55) Guidelines on Design and Construction to Facilitate Sediment Control on Ships (G12) [16]. New regulations should cause no delays or unduly costs to the ships or port operators or any other person or entity operating within port areas and shipyards, unless such delay or cost is reasonable and clearly prevents or minimises the transfer of alien invasive species or influence of the toxic or heavy metals to humans and environment.

2. Ballast water tanks sediments

Ballast water sediment builds up in ballast tanks from water containing different solid particles either sucked or being produced by different processes in tanks and associated pipelines. Soil sediment drawn consists mostly of clay, silt and sand and sometimes includes even larger granular particles.

Clay is a natural earthy material consisting mainly of fine particles of hydrated silicates of aluminium and other minerals. In most cases, clay soil shows plastic behaviour due to water content. However,

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[2] BWM Convention is still not in force. Presently 50 countries have ratified the Convention. However these 50 countries represent 34,8% of the GT of the world’s merchant fleet, less than the 35% that is required.

[3] A “search by title” in Web of Science revealed 1.850 publications with the term ‘ballast water’ as opposed to only 338 with ‘ballast sediment’ (May 2016). However, a significant increase of interest in the topic is noted because the number of results increased approximately 3 times for ‘ballast water’ and 10 times for ‘ballast sediment’ term within one year.

after being dried, clay usually becomes hard and brittle. Depending on additional substances, it may appear in various colours, including white, grey, brown or red. The size of clay particles is usually considered to be 2 μm or less. As such, it is easily sucked and deposited in ballast tanks. If homogenous structure is formed in tank, clay removal may be quite a demanding task.

Silt may occur as soil (low water content) or as sediment mixed with water. On board ships it is almost always found as a suspended load in a body of water. It may be found also as soil deposited at the bottom. Silt, when dry, usually has a floury feel, and may give a slippery feel when wet. Silt particles are much larger then clay but smaller than sand particles, usually in range between 2 μm and 63 μm. It can be found across the world.

Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. It is finer than gravel and coarser than silt. Sand particles range in diameter from 63 μm to 2 mm. The composition of sand varies, depending on the local sources and conditions, but the most common constituent is silicon dioxide, usually in the form of quartz, or calcium carbonate. Colour can be different, depending on other constituents, and vary from white to yellow, orange and even red.

Larger particles may occasionally be found in ballast tanks. They may be found in tanks if suction point is quite close to the sea bottom and/or external forces upheld larger particles in the water column (for example, in river estuaries where tidal currents meet fresh water flow).

Beside sediment in the ballast tanks, there also may be found particles produced by different processes in tanks or in associated pipelines. These particles include the corrosion products, parts of protective coatings, and organic material.

Finally, there is sea water. Pumping out the complete volume of ballast water is rarely possible. The quantity that persistently remains in a tank mostly depends on design of the suction line(s) and efficiency of the ballast pumps. Usually, in the area around suction bell it remains up to 5 centimetres of water, assuming that sediment build-up does not block the free water flow. The quantity of water depends on sediment content; sediment actually prevents free water flaw, thus decreasing the capability of the ballast pumps to suck out maximum quantity of water. The water may contain up to 70% of content of the tank that cannot be pumped out.

Deposited sediments are not removed by themselves from the ballast tanks, even though the tanks are repeatedly filled and emptied. In fact, the quantity of deposited sediments may increase gradually as ballast water is loaded and discharged because pumps cannot extract sediments that have already settled down.

Sometimes, particularly when mud-based sediments prevail, deposits on the bottoms of the ballast tanks gradually harden and become denser under pressure. This hardening is caused by repelling of water. Such hardened, mud-based dense sediments from the ballast tanks are usually difficult to remove, requiring lot of manual work.

A layer of sediment in a ballast tank may reach up to 10-15 centimetres. It may occur in tanks that are not easily accessible (low water dynamics and/or restricted movement of water between different compartments made of athwart ship floors and bottom longitudinals).

For example, a Panamax-type bulk carrier, with a length over all of 220 m and a breadth of 32.20 m, typically contains ballast tanks that encompass a joint area of about 150 m length and about 30 m width, rendering an area of approximately 4,500 m^2. A layer of 0.10 m of sediment over such bottom would result in a mean volume of 450 m^3. With an estimated average sediment density of 1.5 kg/ dm^3, the sediment may reach 675 tons. However, such build-up is relatively rare. Usually, the height of the deposited sediment reaches up to few centimetres, rarely more. Density of sediment may vary between

1.2 up to 2.0 kg/dm³, mostly depending on the water content. For the most mid-sized ocean-going ships the weight of accumulated sediments typically varies between 10 to 15 tons.

3. Sediment disposal options

While ballast water can be easily pumped out, the removal of sediment accumulated in the tanks requires additional efforts. Since the sediment structure is solidified and firm, the removal requires manual collection and safe disposal.

The main goal of the sediment disposal management is to ensure that sediment is not disposed into sea, neither in wet nor in dry condition. Accordingly, sediment disposal management must include: on-board sediment removal and disposal, and on-shore sediment reception facilities.

On-board sediment removal implies collection of sediments while vessel is underway or in port. It is initiated when sediment build-up on tank bottoms and other tank surfaces is such that in some way impacts ship's operations.

After being collected, the sediment is either disposed overboard, or delivered to the shore reception facilities.

If decided to dispose sediment overboard, the BWM Convention provisions should be followed, in particular procedure outlined in the vessel's Ballast Water Management Plan (discharge of sediments has to be carried out when vessel is in areas sufficiently distant from the shore and with minimum depth as it is required for ballast water exchange standards).

If decided to deliver sediment to shore reception facilities, it has to be properly packed and secured. In this case, the main obstacle is possible water content (wet sediment). If handed over as ordinary ship's waste, the additional fee will be charged for excessive mass to be handled. Therefore, delivery of sediment as ship's waste in ports is rarely carried out. It is much easier to dispose it overboard.

In case of sediment removal in shipyards, two distinctive phases can be recognized:
- collection of the sediment and its temporary storage within shipyard area, and
- transfer of sediments to permanent storage facility.

The main reasons for favouring removal during vessels' dry-docking are:
- need to survey hull,
- need to repair ballast tanks,
- need to refurbish damage of the ship hull or any damage to ship's structural elements.

Tank repair is usually the outcome of the ballast tank survey process. If the tank condition requires repair and maintenance, it has to be clean and free of water and any kind of sediments or material. Generally, on-shore removal methods include:
- mechanical collection of sediments,
- sediments' unloading by using industrial vacuum cleaner equipment.

Mechanical collection of sediments is very similar to the process carried out by shipboard crew. The only difference is that it is usually carried out while ship is alongside in shipyard or in dry-dock and is carried out by the shore based manpower. After being removed from tanks, sediments have to be disposed in appropriate impermeable containers (Figure 1) and then transported to dedicated landfills within the shipyard or port.

Landfills (Figure 2) are used as temporary storage facility. There sediment has to be drained before being moved to permanent reception facility, usually land waste disposal area outside port or shipyard area.

Figure 1 Containers for sediment collection

Figure 2 Landfill for temporary sediment disposal

If there are expected big quantities of sediment, vacuum cleaning equipment is normally used. The sediments are sucked up in provided containers.

As far as it is learned in the ports and shipyards in the Adriatic Sea region, aforementioned sediment disposal options are regularly used in repairing shipyards during vessels' dry-docking. The other option i.e. to collect by crew members and dispose in ports occurs quite rarely.

It has to be emphasized that some national regulations clearly prohibit sediment disposal overboard.[4]

4. Sediment disposal management

4.1 Legal framework

Existing legal framework dealing with ballast sediment disposal management and implementation of the associated plan for sediment disposal management follows the BWM Convention regulations and relevant guidelines adopted by the Organization. In addition, several national and local regulations outline procedures related to sediment management.

The BWM Convention clearly gives specific details on sediment management in two articles and in one regulation [2]. In Article 1 sediment is defined as matter settled out of ballast water within ships. Article 5 sets up rules on sediment reception facilities which are complemented with the guidelines developed by the Organization. Finally, Regulation B-5 of the BWM Convention provides requirements for sediment management on ships.

According to the aforementioned provisions of the BWM Convention, the following should be taken into consideration:

- In ports and terminals where cleaning and repairing of ballast tanks occur, adequate sediment reception facilities should be provided.
- Reception facilities should operate in a way not causing unnecessary delays to ships, providing environmentally safe sediment disposal.
- Each state shall report to the Organization on availability and location of any reception facilities for the environmentally safe disposal of sediments, and any inadequacy of the reception facility.

In addition, the Convention gives detailed requirements for sediment management for ships (Regulation B-5). The ships shall remove and dispose sediments from spaces designated to carry ballast water in accordance with the ships' BWM Plan. Accordingly, ships shall be designed and constructed in a way

[4] For example, Croatian "Ordinance on ballast water management and control" in Article 20 clearly prohibits disposal of sediments into sea: "It is prohibited to discharge sediments into sea…".

that minimizes the uptake and undesirable entrapment of sediments, facilitates removal of sediments, and provides safe access that allow sediment removal and sampling.
Coastal states are obliged to report any requirements and procedures relating to the Ballast Water Management, including laws, regulations, and guidelines implementing the BWM Convention. Accordingly, any provisions related to the implementation plan for sediment disposal management should be adequately reported.

The guidelines (G1) contain provisions that refer to:

- Provision of sediment reception facilities,
- Treatment, handling and disposal of received sediment,
- Capabilities of a reception facility, and
- Training of personnel engaged in sediment management disposal.

According to the guidelines, any sediment disposal measure shall avoid unwanted side effects to environment, human health or damage to property or resources. Adequate information on available facility should be made available to ships wishing to use facility. Employed personnel should receive adequate instructions and training on sediment disposal management.

Based on the BWM Convention rules and regulations, several countries have already adopted their national requirements in addition to the internationally recognized legal framework.

For example, the United States Code of Federal Regulation (CFR) provides comprehensive requirements on Ballast Water Management where specific regulations are set up for particular navigable areas. Title 33 of the CFR "Navigation and navigable area" in part 151 – "Vessels carrying oil, noxious liquid substances, garbage, municipal or commercial waste, and ballast water" separately prescribes ballast water management for Control of Nonindigenous Species in waters of the United States (Subpart D) and in the Great Lakes and Hudson River (Subpart D). The rule gives detailed explanation on ballast management control options, including requirements for ballast water management, ballast water discharge standards (BWDS), instructions for ballast water management methods and reporting as well as recording requirements for sediment management.

Transport Canada provides "A Guide to Canada's Ballast Water Control and Management Regulations" – Transport Publication TP 13617 E. Part A of the guide – "Guidelines for Ballast Water Management" under paragraph 1.3 gives details on Sediment Management. According to the guidelines, removal of sediment from ballast tanks should preferably be undertaken under controlled conditions in port, at a repair facility or in dry-dock. Any removed sediment should preferably be disposed in a sediment reception facility if it is available, reasonable and practicable. The sediment could also be disposed from the vessel at sea, but that should take place at least 200 M from the nearest coast and in water depths of over 200 m.

4.2 Proposal for sediment disposal management procedures

Procedures on sediment disposal management should comprise the following sections:

- General provisions
- Sediment disposal options
- Treatment, handling and disposal of sediments
- Sediment reception facilities
- Reporting
- Training

General provisions should provide definitions, requirements dealing with prohibitions (if any) and common overview of the sediment disposal management.

Sediment disposal options should define locations and methods that are to be used in collection process. Additionally, handling and treatment measures and options used shall be provided to effectively reduce the risk of nonindigenous species to be discharged into sea or in any other way impair or damage the environment, human health, property or resources of the disposal area.

Treatment, handling and disposal of sediments should include provisions for health and safety measures to be applied by workers.

Sediment reception facilities should describe facility-related procedures and actions such as quantities, restrictions, minimal requirements, etc. Information about facilities shall be available to ships and could include:

- methods of ship-to-shore sediment transfer,
- information required, in particular on:
  - approximate quantity of sediment,
  - moisture content if possible,
  - plan of the ballast tanks,
  - other information that may be required from the ship.

Reporting shall include mandatory information exchange procedures and records on all activities on sediments disposal including quantities removed from ships and quantities disposed.

5. Training

As it is already noticed, the provisions of BWM Convention as well as the provisions of STCW Convention do not explicitly require training for non-crew personnel. However, the IMO MEPC in several Guidelines (G1 - G14) requires training for the following personnel:

- ships' masters and crews (G4 and G6),
- personnel in charge of and those employed in the provision of a ballast water and sediment reception facility including the treatment and disposal of ballast water and sediment (G1 and G5),

Training for ships' masters and crews should cover the requirements of BWM Convention, the ballast water and sediment management procedures and the Ballast Water Record Book as well as topics on the safety issues associated with the BWE procedures. Training should follow information from the relevant guideline.

Training for personnel of the reception facility should be organized internally and delivered by competent and skilled professionals.

In order to satisfy aforementioned, the following training requirements can be proposed:

- personnel in charge for sediment reception facility shall receive training including information on international and national provisions on BWM including principles of the BWM Convention, risk to the environment and human health associated to sediment disposal process, equipment and process used for sediment collection and disposal, the ship/port communication interface and understanding of local disposal requirements.
- personnel employed on sediment disposal shall receive adequate familiarization on safety procedures, tank entry procedures, human health risks and use of personal protective clothes and equipment.
- managing authority of the shipyard should ensure adequate training and familiarization for personnel involved in sediment disposal.

Training may be divided in separate modules, thus offering combination of different modules to be delivered depending on target audience.

In the following tables applicable competences and topics in the "BWM options for ports" module are proposed.

Table 1 Standard of competence and knowledge related to training on sediment management options

Competence	Knowledge, understanding and proficiency
Shore-based Ballast Water Management options	Principal knowledge of the available Ballast Water treatment technologies
Use of shore based reception facilities	Knowledge and ability to use shore-based reception facilities Knowledge and ability to explain use of barge-based reception facilities Understanding of ballast water sediment and use of shore sediment reception facility

Table 2 Main topics on sediment management options

Subject Area and topics
1. Introduction Possible BWM and sediment options Regulatory perspective of BW sediment options in ports and shipyards
2. Ballast Water port options Use of different ballast water technologies Preconditions for use of the shore based BWM options Land based reception facility system Barge-based reception facility system Mobile land-based reception facility system Sustainability and environmental acceptance of different options (advantages and disadvantages) Guidelines for ballast water reception facilities (G5)
3. Implementation standards Environmental constraints Feasibility of shore based sediment management options
4. Ballast sediment management Sediment removal methods Best practices of sediment management in ports Sediment disposal management options Guidelines for sediment reception facilities (G1)
5. Impact to environment Ballast Water quantities – influence to the environment Sediment composition Possible negative impact to environment Environmental friendly treatment methods and disposal options

Proposed training topics could be considered as a recommendation. It is assumed that more precise programme with detailed requirements for training on sediment management has to be developed.

6. Conclusion

Sediments from ballast tanks are clearly recognized as a potential vector helping to globally spread non-indigenous species. Generally, sediments are removed from ballast tanks in cases when build-up is such manner that impacts commercial effectiveness or when thorough inspection of ballast tanks is required. The sediment removal is mostly carried out in repairing shipyards and only occasionally by ships' crews underway or in ports. One of the main issues that should be addressed when sediment is removed from the tanks is to ensure that neither water content nor dry sediment finds its way into sea. Generally, removed sediment has to be dried at temporary storage facilities which is sufficiently distant from nearest shoreline, and properly protected to prevent leakages into sea. Afterwards, dry sediment should be permanently stored at waste disposal facilities or area where similar materials are stored. Alternatively, wet sediment may be transported directly to permanent storage facility by using only vacuum storage containers.

All contracting States should introduce regulations on removal, transport, temporary and permanent disposal of sediment. In that respect, particular attention should be paid to sediment management in repairing shipyards.

Workforce involved in any sediment handling process should be properly equipped, trained and shall receive adequate familiarization on potential hazards, importance of sediment management and all operational procedures.

For efficient implementation of the BWM Convention, the training should be developed for shipboard personnel (for essential on-board competences) and for shore-based personnel (advanced competences). Training for shipboard personnel should also include the shore-based ballast water management options and the use of reception facilities.

Currently, trainings on BWM are usually developed and offered by the classification societies and various MET institutions solely for shore-based personnel involved in the implementation of the BWM Convention. As a consequence of entering BWM Convention into force, appropriate training on sediment management options should be introduced, primarily for shore-based personnel but also for shipboard personnel.

Effectiveness of the BWM Convention implementation, once it enters into force, inevitably will depend on the development of appropriate training and education. MET institutions, particularly higher MET institutions, should be prepared for development of appropriate and harmonized training programme on BWM.

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Particle emissions from ships at berth using heavy fuel oil

Thuy Van Chu[1, 2, 3, a], Thomas Rainey[1, 2, b], Zoran Ristovski[1, 2, c], Ali Mohammad Pourkhesalian[1, 2, d], Vikram Garaniya[4, e], Rouzbeh Abbassi[4, f], Liping Yang[1, 2, 5, g], Richard J. Brown[1, 2, h]

[1]*Biofuel Engine Research Facility, Queensland University of Technology (QUT), QLD, Australia*
[2]*ILAQH, Queensland University of Technology (QUT), QLD, Australia*
[3]*Vietnam Maritime University (VMU), Haiphong, Vietnam*
[4]*Australian Maritime College (AMC), TAS, Australia*
[5]*Institute of Power and Energy Engineering, Harbin Engineering University, Harbin, China*

[a]*thuy.chuvan@hdr.qut.edu.au*
[b]*t.rainey@qut.edu.au*
[c]*z.ristovski@qut.edu.au*
[d]*alimohammad.pourkhesalian@qut.edu.au*
[e]*v.garaniya@utas.edu.au*
[f]*rouzbeh.abbassi@utas.edu.au*
[g]*yangliping302@hrbeu.edu.cn*
[h]*richard.brown@qut.edu.au*

Abstract In this study, the composition of exhaust from a marine diesel auxiliary engine running on Heavy Fuel Oil (HFO) on-board a large cargo vessel was investigated. Measurements of particle number and size distributions in the range 5-1000 nm and gaseous emissions of O_2, CO, CO_2, SO_2 and NO_x were undertaken. The measurements were performed on two large cargo ships at berth and during travel. Measurements were also carried out on auxiliary engines of two ships when they were at berth. Data on engine power, engine revolution, fuel oil consumption, intercooled air temperature, scavenging air pressure, cooling fresh water and exhaust gas temperature were measured using instrumentation of the ship. Results showed that emission factors (g/kWh) are higher than that of previous studies for SO_2. This may be due to the high sulphur content of fuel. Particle number size distribution was observed to be the highest around 35 – 45 nm in diameter, and the particle number remarkably decreased during higher engine load conditions.

Key words: On-board ship emission measurement, heavy fuel oil, fuel sulphur content, particle number emission factor, particulate matter emission factor, HFO composition.

1. Introduction

Exhaust emissions from ships have negative effects on both the environment and public health [1-6]. Based on sufficient evidence in 2012, the International Agency for Research on Cancer (IARC), which is part of the World Health Organization (WHO), classified diesel engine exhaust as carcinogenic to human health (Group 1, same as asbestos). According to Viana et al. [7], shipping-related emissions are one of the major contributors to global air pollution, especially in coastal areas. This is obvious because over 70% of ship emissions may spread up to 400 km inland and significantly contribute to air pollution in the vicinity of harbors [8]. They may cause an increase in the levels and composition of both particulate and gaseous pollutants and the formation of new particles in densely-populated regions [7, 9]. Corbett et al. [6] estimated that shipping-related $PM_{2.5}$ emissions are the causes of approximately 60,000 deaths globally associated with cardiopulmonary and lung problems yearly. Continued implementation of the amendments to the Maritime Pollution Convention (MARPOL) Annex VI regulations is a good way to reduce ship emissions, however, further regulation should be implemented because a fuel shift to low sulphur alone seems to be not enough to reduce fine and nano-particle emissions [10]. Quantitative and qualitative estimation of pollutant emissions from ships and their dispersion thus are becoming more important [4]. However, a very limited number of on-board measurement studies are found in the literature [4, 11].

Heavy Fuel Oil (HFO), which contains many impurities including sulphur, ash, vanadium, and nickel, is the main fuel for up to 95% of 2-stroke low-speed main engines and around 70% of 4-stroke medium-speed auxiliary engines [12] owing to its economic benefit [2]. Different compounds like sulphate, organic carbon (OC), black carbon (BC), ash and heavy metals in emitted particles are associated with

HFO combustion [13, 14]. In practice, while gaseous emissions have been extensively studied over several decades, diesel engine fine and nano-particles have recently emerged as a major health concern and received more attention from researchers and port managers.

The aim of this study is to investigate the particle emissions with respect to number concentration and size distribution, from an auxiliary marine engine using HFO (3.13 wt% S) when the ship is at berth. The auxiliary engine operates at a constant speed, with different engine load conditions.

2. Ship Emission On-board Measurement Campaign

The measurements were performed in October and November 2015 on two large cargo ships of CSL shipping company at Ports of Brisbane, Gladstone, and Sydney. The work was a collaboration of the Australian Maritime College (AMC), Queensland University of Technology (QUT), and Maine Maritime Academy (MMA). The first on-board measurement was performed on Vessel I from 26th to 31st of October, 2015 when she was running from Port of Brisbane to Port of Gladstone. The second measurement was conducted on Vessel II from 03th to 06th of November, 2015 in her voyage from Gladstone to Newcastle. All measurements have been carried out on both main and auxiliary engines of two ships for different operating ship conditions, such as at berth, manoeuvring, and at sea.

The on-board measurement presented in this paper was performed on the auxiliary engine of Vessel II. Instruments were arranged on a deck high up in the machinery room and the exhaust gas was sampled, and measured continuously from a hole cut in the exhaust pipe after turbocharger of auxiliary engine No.1. The details of the measured engine can be seen in Table 1. At the sample point, one hole was created for the present measurements using a Testo 350XL and a DMS 500. The Testo 350XL was calibrated on 10th, August 2015 by the Techrentals Company and was used to measure gaseous emissions. Particle number size distributions in the size range 5 nm – 1.0 µm in the hot exhaust gas were analysed with a time resolution of 10 Hz (0.1 s) using a DMS 500 MKII – Fast Particulate Spectrometer with heated sample line, and build in dilution system (Cambustion). The schematic diagram of exhaust gas sampling setup is presented in Figure 1.

Table 1 Technical parameters of Main Generator (Auxiliary Engine)

MAIN DIESEL GENERATOR			
AUXILIARY DIESEL ENGINE		**GENERATOR**	
Type	Four-stroke, trunk piston type marine diesel engine with exhaust gas turbo charger and air cooler	Type	Protected drip proof type (FE 41A-8)
Output	425 kW	Output	531.25 kVA x 450V x 60 Hz x 3Φ
Revolution	900 RPM	Revolution	900 RPM
Max Combustion Press	165 bar		
Mean Effective Press	16.7 bar		
No. Cylinder	4		
Cylinder Bore x Stroke	200 x 280 mm		
Maker	Wartsila Diesel Mfg Co., Ltd	Maker	Taiyo Electric Co., Ltd

Data on engine power, engine revolution, fuel oil consumption, and exhaust gas temperature were measured by the ship's instrumentation. The measurement procedure is in line with the ISO 8178 standard [15, 16]. The specifications of the fuel used are presented in Table 2. All auxiliary engines used on board cargo ships work at load characteristic, which means that a marine diesel engine is working at a constant speed while the torque load is varied. Engine load depends on demand of electric equipment of the ship. In this study, investigation was carried out at different engine loads, including 0, 24, 35, 55, 70, 83, and 95% of the maximum continuous rating (MCR) by means of alternating the load between two auxiliary engines. It is shown in Figure 2c.

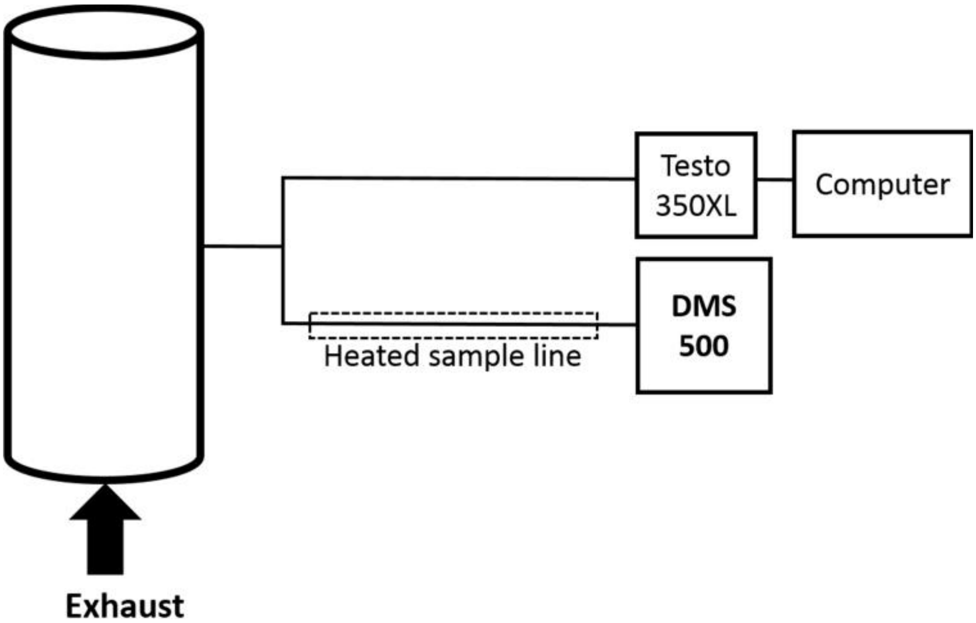

Figure 1 Schematic diagram of exhaust gas sampling setup

Table 2 Fuel characteristics of HFO (from Bunker Delivery Receipt 28th, September 2015)

Parameter	Units	Method	Result	Parameter	Units	Method	Result
Density at 15^0 C	kg/m^3	ISO 3675	986.2	Silicon	mg/kg	IP 501	9
Viscosity at 50^0 C	mm^2/s	ISO 3140	377	Aluminium	mg/kg	IP 501	6
Flash point	^{0}C	ISO 2719	118.5	Vanadium	mg/kg	IP 501	141
Water	% Vol	ISO 3733	0.2	Sodium	mg/kg	IP 501	41
Sulphur	% mass	ISO 2719	3.13	Iron	mg/kg	IP 501	14
Ash	% mass	ISO 6245	0.064	Lead	mg/kg	IP 501	0
Carbon residue	% mass	ISO 10370	14.65	Nickel	mg/kg	IP 501	34
Total sediment	% mass	ISO 10307	0.03	Calcium	mg/kg	IP 501	10
Calorific value	MJ/kg	IP 501	40.22	Zinc	mg/kg	IP 501	1
Asphaltenes	% mass	IP 143	7.42	Potassium	mg/kg	ASTM D5185	0.8

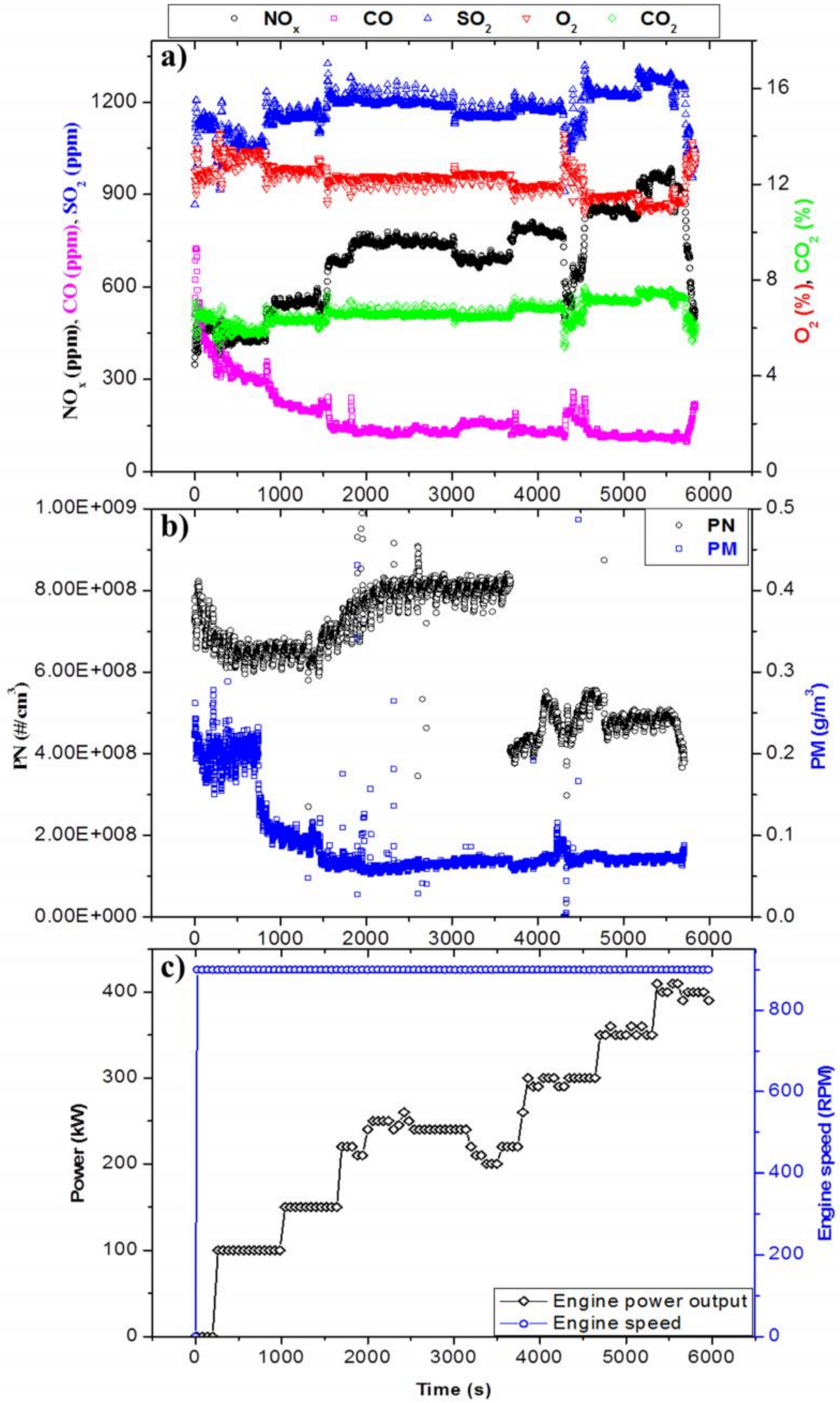

Figure 2 Auxiliary engine at berth: (a) Gas concentrations measured NO_x, CO, SO_2, O_2 and CO_2; (b) Particle number and mass concentrations; (c) The relationship between engine speed, engine power with period of measurement time.

Emission factors for emitted gas-phase species and number/mass of particles were calculated following ISO 8178 [15, 16], using specific fuel consumption and formed CO_2 to obtain the exhasut gas flow rate (equation (1)). These calculations assume that all carbon in the fuel is converted completely into CO_2.

$$E\ ha\ \ g\ \ f = \frac{F\ \ c\ \ \left(\frac{k}{hr}\right) \times F\ \ o\ \ c\ \ \ c\ \ (\%) \times \left(4\ /_1\ \right)}{D\ \ o\ \ C\ _2\left(\frac{k}{m^3}\right) \times \left(C_{C\ 2,e\ h} - C_{C\ 2,a}\ \right)}\ \left[\frac{m^3}{h}\right] \tag{1}$$

$$E\ _P = \frac{E\ ha\ \ g\ \ f\ \ \times P}{E\ \ \ p\ we}\ \left[\frac{g}{k\ \ h}\right] \tag{2}$$

$$E\ _P = \frac{E\ ha\ \ g\ \ f\ \ \times P}{E\ \ \ p}\ \left[\frac{\#}{k\ \ h}\right] \tag{3}$$

where $C_{CO2,\ exh}$ and $C_{CO2,\ air}$ are the CO_2 concentration in v/v % in the exhaust gas and in the air, respectively. Data on fuel consumption and engine power were obtained from the ship's instrument. The emission factors of both gases and particulate matter are presented as mass or number per kWh of engine work (g/kWh, #/kWh), and normalised to standard conditions regarding temperature of 273.15 K and pressure of 101.325 kPa.

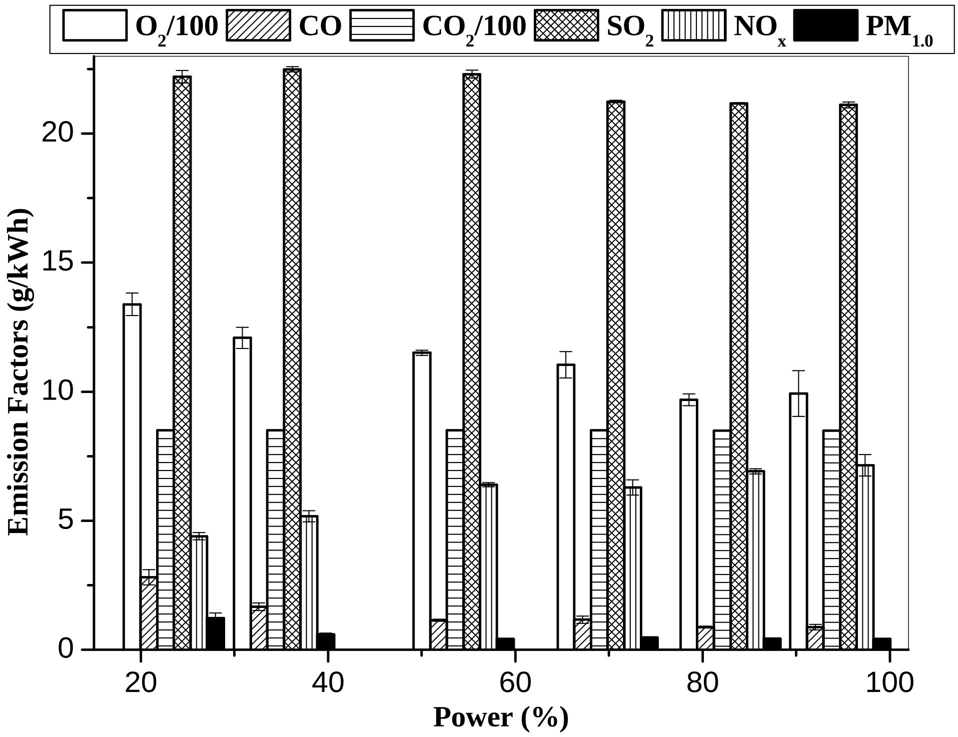

Figure 3 Specific emissions against engine load. (A 95% CI for each mean value is shown as the mean ± X)

3. Results and Discussion

The major gaseous emissions of interest in the engine exhaust were NO_x, CO, SO_2, O_2, and CO_2. The real-time on-board measurement of these gases can be seen in Figure 2a. Figure 2 demonstates the relationship between the changes of emisions with time and engine power output while engine speed is kept at a constant value. The results of gas-phase emision factors for O_2, CO, CO_2, SO_2, and NO_x in terms of g/kWh are presented in Figure 3. There was an initial peak in CO concentration at start-up in cold start period - this can be seen in Figure 2a and 3. This is due to the cold start of the engine and the low engine load condition, which leads to incomplete combustion and aids carbon monoxide to gain the highest level. The CO concentration then significantly decreased and remained at a stable value at high engine load condition.

Table 3 Comparison of gaseous emissions between this study and previous studies.

Study	Engine Type	Fuel (% S)	Engine Load (%)	O_2 (g/kWh)	CO (g/kWh)	CO_2 (g/kWh)	SO_2 (g/kWh)	NO_x (g/kWh)
Moldanová et al. [17]	4-stroke, medium speed, main engine, 4440 kW	HFO (1.0)	30 80	1127 1054	1.82 1.17	617 678	3.24 3.65	9.6 9.6
Khan et al. [18]	2-stroke, low speed, main engine, 36740 kW	HFO (3.14)	29 52 73 81	- - - -	0.57 0.41 0.36 0.35	577 555 561 576	11.4 10.9 11.0 11.3	19.5 18.5 19.5 19.1
Winnes and Fridell [10]	4-stroke, medium speed, main engine, 4500 kW	HFO (1.6)	50 70 90	- - -	1.05 0.74 0.3	620 603 607	4.62 4.62 4.57	7.49 8.49 10.71
Agrawal et al. [19]	2-stroke, low speed, main engine, 15750 kW	HFO (2.85)	13 25 50 75 85	- - - - -	2.5 1.5 1.0 0.8 0.5	~1200 640 620 670 680	13 12 10.5 10 10	22 17 18 21 20.5
Cooper [20]	4-stroke, medium speed, auxiliary engine, 1270 kW	HFO (0.53)	47-58	-	1.06 - 1.71	763-803	2.5-2.7	13.3 - 17.5
	4-stroke, medium speed, auxiliary engine, 2675 kW	HFO (2.2)	41	-	0.90	691	9.5	15.2
	4-stroke, medium speed, auxiliary engine, 2005 kW	HFO (2.2)	39	-	0.77	697	9.6	12.9
This study	4-stroke, medium speed, auxiliary engine, 425 kW	HFO (3.13)	24 35 55 70 83 95	1338 1208 1150 1104 969 992	2.81 1.66 1.14 1.16 0.88 0.87	850 850 849 849 849 849	22.20 22.49 22.30 21.24 21.17 21.11	4.40 5.17 6.40 6.30 6.91 7.14

A significantly decreasing trend of O_2 emissions with power was observed as shown in Figure 2a and 3. This may be due to the engine revolution being constant, which makes the amount of air stable while the engine load is increased. Thus, more fuel is required and a rich fuel-air mixture combustion condition is reached. The fuel-dependent specific emissions of SO_2 and CO_2 is given in Figure 2a are generally proportional to the fuel carbon and sulphur content, and therefore these emission factors of SO_2 and CO_2 seem to be constant as was expected. Of most interest in this study is that the emission factor of SO_2 was much higher than that of compared studies (Table 3), which is the result of higher sulphur content fuel used in this research. The theoretical value of SO_2 emission factor calculated in this study was around 16.6 g/kWh, which was significantly less than measured cases. The emission of NO_x depends on the engine temperature, and thus the emission of NO_x presented in Figure 2a and 3 shows a dependence on engine load in which high engine load produces the highest emission. Shown in Table 3, the value of NO_x emission in the present research was much lower than that of previous studies, this may be due to difference engine types and working conditions.

For particle emissions presented in Figure 2b, a general pattern in the emitted nanoparticles is that there was an initial peak both in mass and number concentration at engine start-up in cold start period before reaching the constant value or significantly decreasing to low level at higher engine load working condition. This can be seen clearly in PN case, a significant difference in particle number concentrations observed between low and medium engine load of 0, 24, 35 and 55% with 70, 83 and 95% of engine load working conditions, which illustrated in Figure 2b and 4. This may be due to low temperature inside engine combustion chamber at low loads, which caused more particles can be created [3]. Figure 4 indicated that the number size distributions were dominant by nano-particles and only one modal with the peak at around 35 – 45 nm for all engine load working conditions. Particle mass emission factor (PM) was calculated from the number concentrations measured with the DMS 500 (5.0 – 1000 nm) assuming spherical particles with unit densities for nucleation and accommodation mode. A 95% confidence interval (CI) to each mean value in Table 4 was calculated.

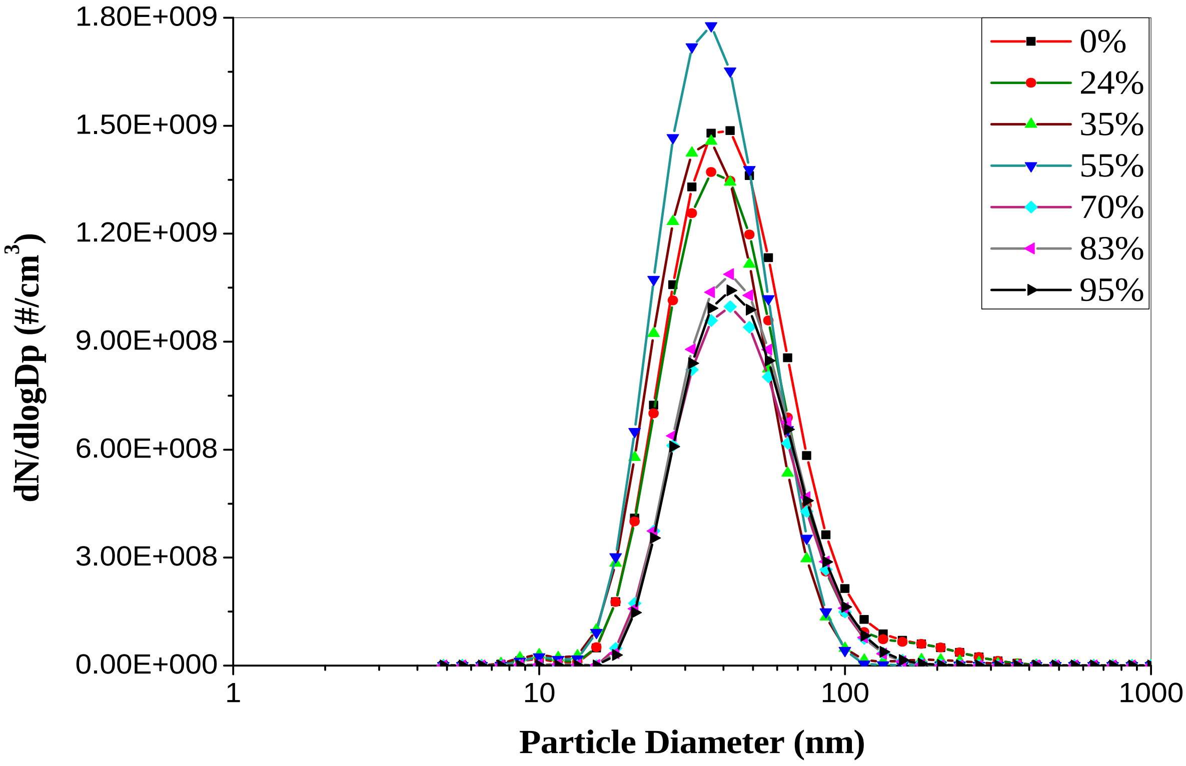

Figure 4 Number size distributions of measured particles (5-1000 nm) for idle, 24%, 35%, 55%, 70%, 83%, and 95% load.

In comparison with the literature that can be seen in Table 4, there is a large variation of particle number emission factor, which may be due to limited available data on PN and a difference in fuel used, engine models, working conditions, and instruments used for PN measurement [21]. A decreasing trend of both PN and PM emission factors was observed clearly as engine output power increased in this study. This trend was also observed in the study of Anderson et al. [3], but particle number emissions at 10 and 25% load in this study (HFO, 0.12 wt% S) were much higher than that of present study (HFO, 3.13 wt% S). This shows that a fuel shift to low sulphur content fuel may only have limited effect on small size particle number concentrations. It can be supported by studies of Winnes and Kasper [10, 22]. Magnitude of PM emission factor in this study was rather similar to that of previous studies.

Table 4 Comparison of PM and PN between this study and previous studies. (A 95% CI for each mean value is shown as the mean ± X)

Study	Engine Type	Fuel (% S)	Engine Load (%)	PN (10^{16} #/kWh)	PM (g/kWh)		
					PM_{10}	$PM_{2.5}$	$PM_{1.0}$
Moldanová et al. [17]	4-stroke, medium speed, main engine, 4440 kW	HFO (1.0)	30 80	-	0.35 0.41	-	0.27 0.41
Khan et al. [18]	2-stroke, low speed, main engine, 36740 kW	HFO (3.14)	29 52 73 81	-	-	1.19 1.44 2.14 2.19	-
Hallquist et al. [21]	4-stroke, medium speed, SCR-equipped main engine, 12600 kW	HFO (0.49)	75	2.05 ± 0.27	-	-	0.13 ± 0.02
Anderson et al. [3]	Test-bed engine, 4-stroke, 5-cylinder, high speed, 81 kW	HFO (0.12)	10 25 35	12 ± 0.04 17 ± 0.059 0.17 ± 0.003	-	-	0.45±0.025 0.71±0.11 0.65±0.03
This study	4-stroke, medium speed, auxiliary engine, 425 kW	HFO (3.13)	24 35 55 70 83 95	0.468 ± 0.013 0.450 ± 0.009 0.501 ± 0.025 0.310 ± 0.013 0.290 ± 0.011 0.281 ± 0.012	-	-	1.221 ± 0.198 0.585 ± 0.064 0.423 ± 0.009 0.473 ± 0.020 0.424 ± 0.013 0.421 ± 0.011

4. Conclusion

Although in-port auxiliary engine emissions account for a relatively small proportion of the total emissions from shipping compared to main engine emissions, they have some of the most significant health effects on the surrounding population [20]. To improve the limited knowledge regarding marine engine emissions [21], especially on particle number size distribution, a measurement campaign on two commercial ships plying the east coast of Australia was conducted as described in this study. Engine performance and emissions of an auxiliary engine while in berth, were measured on-board the ship during actual harbour stopovers. The focus was directed toward characteristics of particle emissions. Gaseous and particle emission factors were presented in g/kWh or #/kWh, and investigated at different engine loads while engine speed is kept at constant value. The particle number size distribution was peaked at around 35 – 45 nm and dominant by nano-particles, which have negative impact on human health and climate.

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Guessing to Prediction – A Conceptual Framework to Predict LNG Bunker Demand Profile in Australia

Rumesh H Merien-Paul[1], Hossein Enshaei[2], Shantha Gamini Jayasinghe[3]

1. Australian Maritime College, University of Tasmania, rhmerien@utas.edu.au
2. Australian Maritime College, University of Tasmania, hossein.enshaei@utas.edu.au
3. Australian Maritime College, University of Tasmania, shanthaj@utas.edu.au

Abstract Liquefied Natural Gas (LNG) is considered as one of the most appropriate alternative fuel to replace conventional marine fuels in near future. Major motivations for adopting LNG as a marine fuel are the recent international and regional regulations on ship emissions, increased awareness on improving air quality in strategic sea routes, demarcation of Emission Controlled Areas (ECAs) and the need for preserving marine environment including Particularly Sensitive Sea Areas (PSSAs) such as Great Barrier Reef, Coral Sea and Torres Strait in Australia. In recent years, European Union and few other individual countries such as Norway have been in the forefront in adopting LNG as a marine fuel and have invested heavily on research and development as well as in infrastructure development for LNG bunkering. The U.S. and Asian countries such as Singapore, South Korea and Japan have also followed the suit with similar interests in LNG adoption. Nevertheless, the lack of adequate LNG bunkering infrastructure along major sea routes and the early stages of the current developments found to be the main deterrent among several barriers for the adoption of LNG as a marine fuel.

Australia is well placed to become the leading LNG producer in the world by 2018 [1]. It is expected that Australia, as the world's leading LNG supplier, could gain enormous economic benefits and preserve its invaluable ecosystems by actively adopting LNG as a marine fuel. Nevertheless, compared to the aforementioned leading countries, Australia has not taken strong initiatives so far to promote LNG as a marine fuel, build up necessary bunkering infrastructure and conduct relevant research and development work. Besides, a comprehensive scientific research to predict the future LNG demand in Australia has not been conducted so far. This leads to guessing rather than accurate prediction in taking important decisions related to the LNG future in Australia. In order to fill this knowledge gap, authors are developing an LNG bunker demand prediction method for Australia. This paper presents the conceptual framework of the prediction method. The projection could be used as a strategic decision support tool for Australian Government/authorities for development of LNG bunkering infrastructure in Australia, especially to identify the most important regions for bunkering.

Keywords: Emission Control Areas, Emission Regulations, LNG Bunkering, Liquefied Natural Gas, Marine Environment and Prediction tool.

1. Ship Emissions and Control Measures

Human civilisation has been intricately bound to its dependency on carbonaceous fuels for many millennia. The carefree and widespread use of such fuels has taken its toll causing far-reaching damages to the interdependent ecosystems we share. For the marine sector, Heavy Fuel Oil (HFO) and Marine Diesel/Marine Gas Oil (MDO/MGO) have been fuels of the choice for many ship operators due to obvious economic reasons. Key emission components from these fuels are Carbon Dioxide (CO_2), Nitrogen Oxides (NO_X), Sulphur Oxides (SO_X), Volatile Organic Compounds (VOC), Black Carbon or soot (BC) and/or particulate organic matter POM/PM. It has been reported that even the emissions occur at sea, they affect coastal areas and reach further inland polluting atmosphere, land and water [2; 3; 4; 5]. Out of these emissions NO_X and SO_X cause acidification of ecosystems. In additions, excessive Nitrogen input causes eutrophication in freshwater habitats, which threatens biodiversity [6] and contributes to increase of ground level ozone and thereby many respiratory issues. Having assessed the effects of emission factors on human health, the World Health Organisation (WHO) classified diesel exhaust as a human carcinogen [7]. Therefore, not only the economic and environmental factors but also human health related issues force to look for alternative fuels.

1.1 International treaties, regional and national regulations

Intergovernmental agreements such as Kyoto/Paris agreements aim to control Green House Gas (GHG) emissions and address the issues of global warming in the context of climate change phenomena. The international maritime organisation (IMO), through its MArine POLlution prevention treaties (MARPOL) regulates the pollutions and emissions by ships. MARPOL Annex VI (Prevention of Air Pollution from Ships) establishes control measures against SO_X and NO_X emissions as well as global fuel quality requirements. Following IMO regulations, U.S. and European Union (EU) have incorporated the emission control regulation in their national legislature and declared regional ECAs. To limit the CO_2, IMO has introduced Energy Efficiency Design Index (EEDI) and Ships Energy Efficiency Management Plan (SEEMP) through advancements in engine efficiency. However, studies have shown that CO_2 reduction achieved by EEDI/SEEMP is on the borderline and is not absolute [8]. In view of Paris Convention 2016 and global consensus against GHG emissions and climate change, mounting pressure is envisaged on IMO from various environmental lobbies demanding more stringent approach in near future to limit CO_2 and PM output from ships by 2030 [9]. However, it remains to be seen if the industry sets out long-term solutions to reduce these substances or they would just be fleeting counter measures.

Figure 1 illustrates the progression of emission regulations from the declaration of sulphur controlled areas (SECA) in Europe, NO_X restrictions through tiered limiting approach and towards subsequent 0.5% global sulphur caps expected in 2020. It is anticipated that the scheduled review in 2018 would defer this deadline to 2025. Climate change phenomena linked to current unprecedented levels of CO_2 in the atmosphere and increasing pressure from public and green Non-Governmental Organisations are potential driving forces for future regulations curbing CO_2 and GHG emissions.

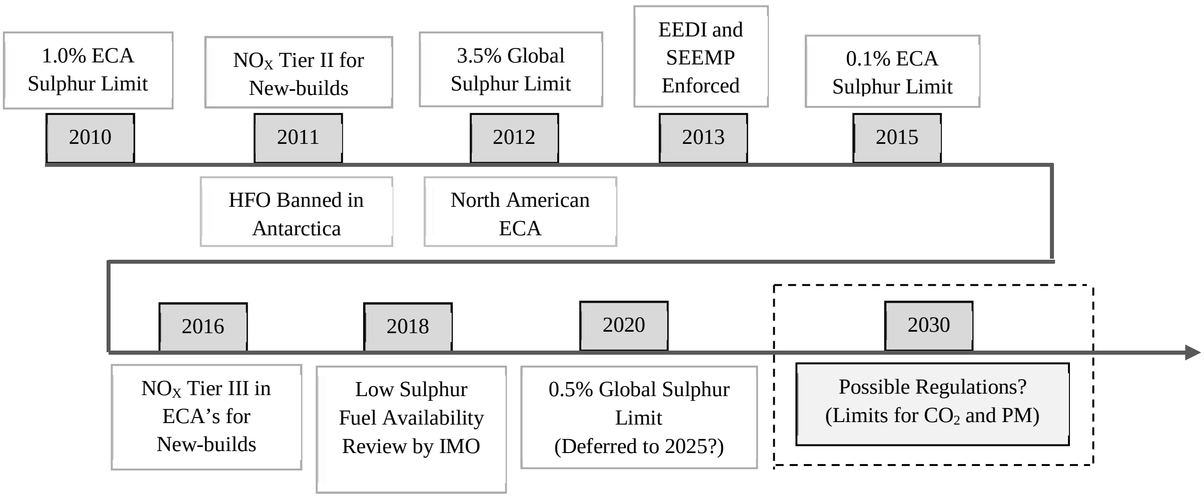

Figure 1 Progression of emission regulations [19; 24]

2. Compliance options

It is perceived that initial compliance is likely to be achieved by MGO and Ultra low sulphur HFO until viable and economical alternatives are available and/or fuel switching systems are accessible. One of the existing technologies for emission reduction is scrubbers. Although wet scrubbers eliminate sulphur from the exhaust gasses, they will eventually increase acidity of sensitive sea areas. Dry Scrubbers are considered a better solution for this issue, but the technology is still under development.

It is possible that NO_X emission could be limited with Selective Catalytic Reactors (SCR). However, it was found that this technology is less effective at partial loads and absolutely ineffective before the system reaches operational temperature hence limits the application [10; 11; 12]. Even for the full compliance, this necessitates the use of low sulphur fuel during start-ups. In addition, a network for supply of Urea-catalyst and disposal of residue from SCR and scrubbers are needed at a global scale.

Methanol is an alternative to be considered in fuel switching, which is easily transportable. However, due to its higher GHG potential, additional safety precautions in the fuel system and higher Free On Board (FOB) price thwart its adoption. Nevertheless, there are cleaner options [13] such as: biofuels, hydrogen, wind power and nuclear energy, which could be strong contenders as future ship fuels. In a very conservative and capital intensive industry such as shipping, new technologies are adopted cautiously, often after assessing their merits in other industries. Therefore, new alternatives are unlikely to be adopted in the immediate future due to various technical, economical, and safety challenges. In this context, LNG is considered as the most promising alternative marine fuel capable of meeting present emission regulations along with its availability/abundance and low cost compared to HFO/MGO.

3. LNG and its advantages

LNG produces 100% less SO_X, about 25-30% less CO_2 and 95-100% less PM while reduction of NO_X is 40-90% depending on the combustion cycle [14; 15; 16; 17; 18; 19; 8]. According to Ashworth 2016 [9], proven vast resources of gas are estimated to be sufficient for next 200 years' worth of demand. The net calorific value of LNG is 18-20% higher than HFO/MGO [20] and is cost competitive, [21] with HFO/MGO through 2035. With vast known reserves and higher energy output, LNG commands respect as an economical and viable alternative compared to conventional fuel oils for many years to come.

3.1 Challenges for LNG adoption

Deal 2013[22] claimed that cost of LNG conversions for new-builds is going to be high by additional 15-20% of capital requirement. In addition, experiences from Norwegian LNG ferries and related studies [11; 23; 16] confirm that, the volume required to store LNG can be up to three times higher than HFO/MGO. Reduction in cargo volume and/or passenger carrying capacity and increased capital expenditure are main deterrents of LNG adoption.

IMO 2016 [24] calls for a reliable network of LNG bunker distribution essential for LNG adoption. Many relate this issue to chicken-egg paradox. While ship owners complain the lack of bunkering infrastructure for LNG adoption, bunker suppliers blame the lack of demand for LNG bunkers as a deterrent against investing on infrastructure. Many ship-owners and bunker suppliers are therefore likely to follow wait-and-see approach in LNG adoption.

Lack of unified regulation and standards [18; 25] are identified as an obvious issue for the widespread use of LNG as a ship fuel and therefore, IMO adopted International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code) in June 2015 to address this concern. Reviewing the safety records of gas carriers, it is expected that a similar safety culture could be developed upon careful training and enforcement of safety regimes. However, critics [26] argue that IGF Code applies only to receiving vessel and not the LNG supplier. This regulatory gap is expected to be fulfilled through International Standard Organisations' (ISO) LNG bunkering guidelines including standardisation of bunkering equipment.

LNG as a bunker fuel is still a novel concept for the world and there are many LNG-specific hazards [14] which may result in casualties and damage to property during delivery and storage. Emphasise are given on safety and security [27; 28] of transporting LNG through populated areas and development of filling stations in strategic areas. That highlights the importance of risk analysis in development of LNG bunkering infrastructure, which requires thorough risk assessments, control measures and mitigation procedures. Any catastrophe involving LNG can create a public outcry against its adoption and discourage potential initiatives from governments and private sector. Even minor seepages could make LNG a worse alternative [11] considering its GHG potential, which is 25 times that of CO_2 if released accidentally.

4. Future of LNG in Australia

Australia is a signatory to both MARPOL and Paris Convention [29] and the commonwealth has pledged to reduce country-wide emissions of 2005 baseline by 26-28 per cent by 2030. The record warming of atmosphere and recent unprecedented bleaching phenomena of the Great Barrier Reef have prompted public support for stricter environmental regulations at state and federal level. According to EPA NSW 2015 [30], government of New South Wales has urged the commonwealth to address shipping emissions when developing The National Clean Air Agreement, which is due for completion in 2016. In addition to strict limits for SO_X and NO_X as in ECAs, CO_2 and PM/BC emissions shall probably be given precedence in these regulations. Enforcement of relative regulations would encourage adoption of cleaner fuels; this is more evident in North European ECA where LNG's prominence as a marine fuel is on the rise. A similar effect is anticipated assuming Australia would declare emission controlled areas in its waters in near future.

Australia is en-route to become the leading LNG producer in the world by 2018 [1] owing to its various LNG projects nearing completion. Meanwhile in the milieu of widespread regulatory push for stricter emission controls, Australia is in a unique position as a nation which attracts significant international/domestic maritime traffic. These opportunities present the strong possibility of using LNG as a transient fuel for a future energy by breaking away from dependency from fuel-oil. Australia should seize this opportunity and learn from leading countries in LNG adoption and thereby, secure enormous environmental and economic benefits for the society and the generations to come.

4.1 Challenges to be met

Ongoing LNG projects in Australia have run into cost overruns and delays due to their remote locations, high labour costs and interference of powerful trade unions [1]. The repercussions of these eventualities would cause higher LNG prices and reluctance of investors to launch new projects, limiting future supplies as well as damage to Australia's reputation as a LNG supplier.

Natural gas in Australia was first utilised for domestic power generation. As a result, some state governments declared gas reservation policies to secure supplies for domestic use in view of LNG projects targeting export market. However, as noted by EnergyQuest 2009[31], reservation policies have not prevented domestic price sensitivity in relation to global gas demands. Therefore, domestic consumers demand subsidies and/or nationwide reservation policies to be in place. If Australia is to supply LNG as bunker fuel, it would add another dimension to the current issues surrounding reservation policies. If security of LNG supply as a bunker fuel to be ensured, it would probably warrant intervention of the commonwealth to declare an across board gas distribution policy addressing all stakeholders.

It is now apparent that existing regulatory framework for LNG fuelled shipping in Australia is inadequate [17]. However, adoption of IMO's gas and low-flash point fuels code (IGF Code) and ISO standards for LNG bunkering could well supplement these gaps. Once the regulations and standards are in place, it is expected that public support can be earned if all stakeholders collaborate [27].

The initial capital requirements for establishing LNG bunkering facilities could be overwhelming for many investors considering the current economic outlook and price dynamics in worldwide energy markets. Therefore, government intervention in the form of subsidies/tax rebate schemes and co-sharing the initial risk by various stakeholders would encourage first movers and expedite early adoption of LNG as a ship fuel.

Given the political landscape in Australia, all these factors would demand concerted efforts of states, the commonwealth, port authorities and individual investors if they are to influence LNG adoption positively.

5. LNG Bunkers in Australian ports; Guessing to Prediction

Investing on new technologies carry great risks and therefore an erroneous decision based on wrong predictions may have irreparable consequences for an organisation [32]. Yet, predictions have to be made to carry out decision making for future direction of institutions, nations and society as a whole. It is expected that an LNG demand prediction tool brings forth consistent and accurate projections based on available data and trends that were consistent within the last 15-20 years. The tool is commanding in terms of its ability to produce projections for each port or cluster of ports as well as demand of fuel by each ship type. By analysing future LNG demand profiles for each ergion, the most important ports or cluster of ports are identified for initial development and coordination of LNG bunkering solutions. This enable the Australian Maritime Industry to make sound judgements and set out for its future endeavours with regard to formulating business strategies and policy decisions in LNG Bunkering Infrastructure.

5.1 Conceptual framework, Assumptions and Limitations

Figure 2 shows the conceptual framework of the LNG demand prediction methodology for Australian ports through 2050. A time line of 30 years, starting from 2020 to 2050 is chosen to provide a reasonable scope for this study. It is anticipated that LNG projects which are under development at present shall be fully operational by 2020 and they would continue to deliver LNG steadily through 2050.

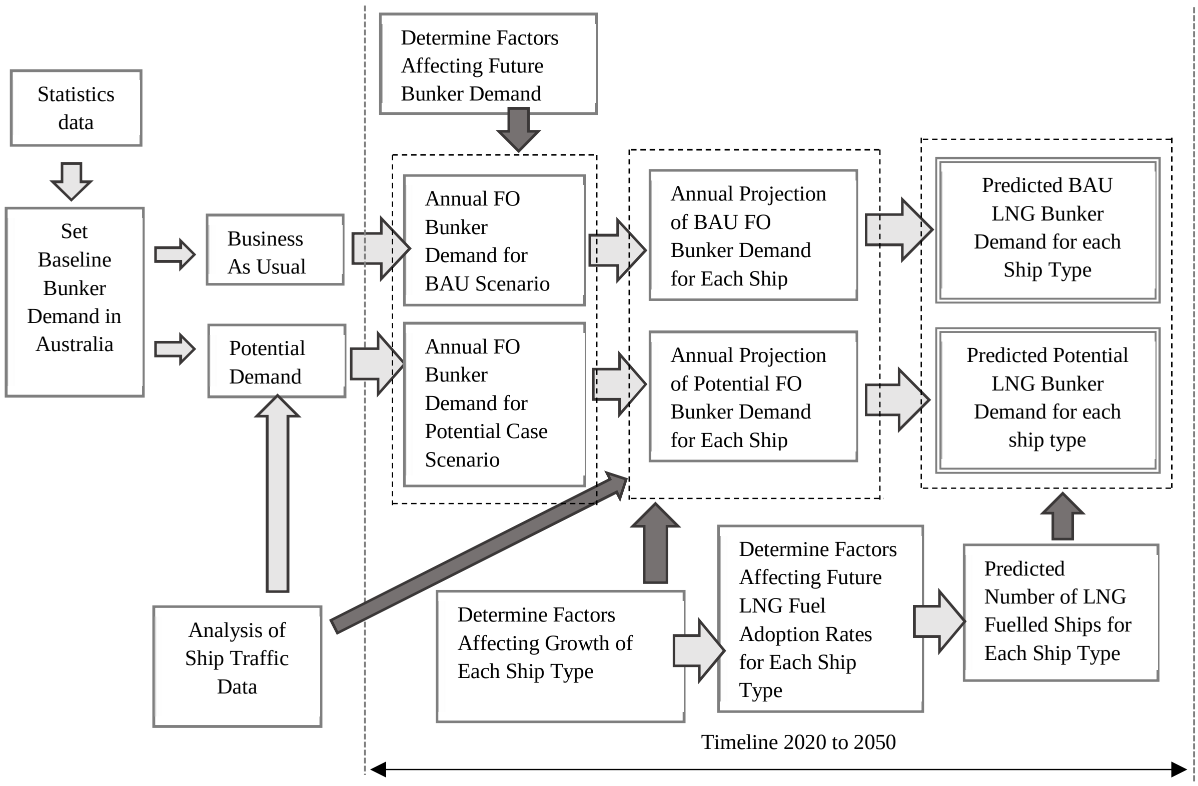

Figure 2 Conceptual framework of the LNG Demand prediction method

5.2.1 Baseline of fuel oil bunker demand

In this conceptual framework, the present Fuel Oil (HFO/MDO/MGO) bunker demand in Australia is considered to be business as usual (BAU). This represents the annual aggregate bunker quantities received by domestic ships and deep-sea-going vessels in Australia.

By anticipating stringent air emission regulations in near future, there is a strong possibility that all vessels shall be obliged to consume ECA compliant fuels in Australian territorial waters. In addition, there is a great potential that fuel burnt in Australian waters will be bunkered in Australia provided that fuel pricing is attractive compared to international markets.

These two baselines of demand profiles set a foundation for future prediction paths of BAU bunker demands as well as potential bunker demands.

Analysis of annual ship traffic data determines the time spent by ships in Australian waters and thereby, the fuel consumption in Australian waters is calculated.

5.2.2 Factors affecting FO bunker demands

Trade volumes and/or GDP have strong correlation to shipping traffic trends [33; 34]. Considering the present global economic downturn and grim state of offshore/mining sectors, there is a high probability of a decline in shipping activity in Australia along with its GDP and trade-volumes. However, a thorough analysis of historical data related to fuel consumptions and trade-volume/GDP can be carried out to establish whether similar correlation exists in Australia. Another fact that affects future of fuel consumption is the trend in engine and hull form efficiency improvements. O'Malley et al. 2015 [16] suggested that the operating efficiency of ships is expected to increase at an average of 1% annually. The regulatory push from EEDI and SEEMP as well as competitive research and development efforts by engine makers are expected to improve this trend further. Therefore, efficiency improvement rates shall be factored in bunker demand projections. Thus, annual fuel oil (FO) bunker demands for both BAU and potential case scenarios are projected through 2050 in relation to mentioned two governing factors.

5.2.3 Annual bunker demands for ship type

It was identified [20] that offshore support vessels, tug segments, new-build cruise and new-build container feeder segments are the potential early adopters of LNG in Wider Caribbean, whilst another study [17] found that tug and offshore segments could trigger early LNG adoption in Australia. As experienced in Norway and EU, it is widely expected that initial bunkering of LNG will cater the small vessels followed by larger ferries and cargo ships. Considering diverse operations in Australian waters, the offshore sector and commodity export market, tugs, offshore support vessels, container feeders, bulk carriers, ferries, and tankers should all be included as ship types for future prediction.

Analysis of ship traffic data is a reliable source to identify present distribution of each ship type in Australia. It is assumed that growth rate of each ship type is generally dependent on future trends in trade-volume/GDP growth projections in Australia. In addition, key trends in demand for different shipping services in Australia shall be identified so that ship-type-specific trends could also be factored for projections in growth trend of ship types through 2050. Annual FO Bunker demand is then projected for dual scenarios by combining annual projected FO demands with growth trend for each ship type through 2050.

5.2.4 Factors affecting future LNG adoption

As per report DNV-GL 2014 [19], 100 LNG fuelled new-builds are on order as of end 2015 and would increase to 1000 by 2020. The global drivers affecting adoption of LNG fuelled ships are regulatory push, attractive pricing, public consensus and push for cleaner fuels and possible economic incentive schemes. Australian-specific elements for LNG adoption are security of gas supply for bunkering, outlook of ongoing and future LNG projects, and future trends in potential regulatory changes at federal level. Whilst these are common factors which affect all ship types, present order books for new-builds reveal that different ship types have different rates of LNG adoption, which is referred to as LNG adoption rate in figure 2. Therefore, in addition to common factors, ship-type-specific factors should be considered and factored in determining future LNG adoption forecasts. The combination of common factors and ship-type-specific sub-factors shall be used to forecast LNG fuelled portion of each ship type through 2050. Consequently, by comparing the projected growth trend (through 2050) of a certain ship type and its projected portion of LNG adoption through 2050, the number of LNG fuelled ships for a particular ship type could be determined.

5.2.5 Predicting LNG bunker demands

The annual bunker demand forecast for ship types in both scenarios are compared against annual predicted number of LNG fuelled vessels to determine the annual LNG demand through 2050. To derive at predicted LNG bunker figures, simply an energy equivalent conversion factor in relation to HFO/MGO is introduced.

5.3 Data Collection and Analysis

Data of past Bunker quantities can be sourced from publications of Australian Petroleum Statistics to project future growth rates for BAU scenarios. As Bunker delivery quantities are categorised for each state, Analysis of ship traffic data is necessary to recognise concentration of ship traffic and various ship types in different ports so that approximate individual bunker delivery could be assigned to each port/port-cluster. Nevertheless, ship traffic data could be obtained from Automatic ship Identification Systems' (AIS) or AMSA's vessel traffic data.

GDP and trade-volume growth rate forecasts required for LNG prediction could be retrieved from publicly available reports of Reserve Bank of Australia and World Monetary Fund. Annual growth rate of Ship efficiency is assumed to be 1%; however, relevant literature shall be continuously scrutinised for further developments in engine and ship design enhancements, which effect fuel consumption profiles.

According to Verbeek 2012 [35], prediction techniques and Econometric conceptualising could be categorised as follows, depending on their objectives and utilization of data:

a) Models that appraise interactions between descriptive and dependent variables over periods of time, which normally lack inclusion of causal economic dynamics;
b) Techniques that represent interactions between the historical and contemporary parameters, and estimate forthcoming events based on historical outcomes with addition of causal economic dynamics;
c) Models that describe relationships between several variables at a point in time for diverse entities; and
d) Methods that study interactions between different variables for different entities over a long period of time involving panel data.

Nature of this framework suggests utilising time-series data such as fuel consumptions, GDP growth, cross sectional data such as ship traffic data and multistep projections over time with many variables or factors, which could potentially evolve over the timeframe. This complexity demands a model that could carry out individual projections for various entities separately over a period of time and show how their final projections interact with each other to present final dual scenario predictions. Considering multiple variables involved and the type of data to be utilised, the third prediction model mentioned above is appropriate for developing the projection tool. Review of literature suggests that combining regression methods and stochastic forecasting is adequate to tackle the complexity of the demand prediction methodology. For projecting LNG adoption rates, different weights are allocated in addition to the common factors affecting LNG adoption for all ship types. Ship-specific weightages would be allotted for each ship type concerning their suitability for early LNG adoption. However, the workable model is to be verified and validated accordingly.

6. Conclusion

There are clear and obvious benefits of adopting LNG as a ship fuel, especially in Australia as stated in section 4. However, there remains a number of challenges which should be overcome by cooperation of various stakeholders in the private and public sectors. The conceptual framework set forth in this paper aims to develop a decision support tool which would assist the decision makers to formulate sound strategies with regard to developing bunkering infrastructure in Australian ports. The demand prediction methodology is based on dual scenario approach; addressing BAU and Potential future bunker demand in Australia. Such methodology widens potential gains as it increases scope of exploring prospective growth paths of LNG bunkering in view of future trends in energy markets and environmental regulations. As various ship types show different growth trends as well as differing LNG adoption rates, both variables are projected separately in order to derive the number of LNG fuelled ships for each ship type and finally, LNG bunker demands through the timeline. Whilst the data collection is deemed simple, the data analysis part, especially that of ship traffic data and FO bunker consumptions, would be a complex task entailing cautious approach to determine distribution of vessel types and their individual bunker intakes. The ultimate product can be customisable so that it could be applied to a specific port or port-cluster based on baseline bunker demand and ship traffic data specific to that region.

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EEDI reduction by investigating the capability of RANSE CFD for propeller, propeller– hull form performance calculation during ship optimization process

Dr. Tran Ngoc Tu (1), Msc. Nguyen Manh Chien (2)

1. Vietnam Maritime university, tutn.dt@vimaru.edu.vn
2. Vietnam Maritime university, chiennm.@vimaru.edu.vn

Abstract. In recent years, the concerning about environment protection has grown significantly, especially about global warming and reduction of CO2 emission. Besides, there are considerable development in marine transportation and activities: from offshore installation supply to the exploitation of marine resources. It leads to the high increasing of fuel consumption for ship operation on the ocean. Moreover, in 2010, International Maritime Organization (IMO) introduced Energy Efficiency Design Index (EEDI) as a technical measure to limit pollution of the environment resulted by marine engines [1]. EEDI is expressed by CO2 gram per ship's capacity. So smaller EEDI means smaller CO2 exhausting to the environment.

With that reason, many efforts have been made to optimize ship's fuel consumption, to save the operation cost, on the one hand and to reduce the CO2 emission, or reduce EEDI on the other hand. From the EEDI equations [2], according to Bazari & Longva, 2011 and IMO MEPC 63 (2011) [2], there are 15 methods of EEDI reduction. Within these 15 methods, hull form and propulsion optimization are common approaches for many designers and researchers.

To optimize the hull form and propeller, the designers need to carry many designs then select the best one based on their performance. Estimation of hull form and propeller performance usingmodel tests widely accepted as most reliable means, and could be considered as the closest method to reality. However, due to time and cost for making testing models, it is not suitable for optimization process; it is just only used to validate the result of optimization. Besides, with the rapid improvement of computational resources, Computational Fluid Dynamic (CFD) is getting to become a useful tool in ship design and power prediction. CFD method is able to look into local flow properties and providing a room for designers to improve the design.

In this paper, the authors will investigate the capability of CFD method for propeller and propeller – hull form performance calculation, during ship optimization process. The approach of CFD here is Reynolds-averaged Navier–Stokes equations (RANSE). During the optimization process, many designs have to be analyzed, so the level of accuracy and computational time of the calculation have to be taken into account.

The paper has two major parts. For the propeller calculation in open water, the authors will perform 3 methods to model the rotation of propeller and select the best one in terms of accuracy and time consumption. Later, the self-propulsion simulation is carried out. That is a setup with full rotating propeller behind a ship. The ISIS - CFD code, integrated in the commercial software Numeca Fine Marine is used. The simulation results will be compared with model test results.

Keywords: propeller, hull, CFD, optimization, RANSE, EEDI reduction, ISIS code.

1. Introduction

Propeller calculation using CFD method is not a new topic for researchers. Many authors have predicted the performance of the propeller, both in open water and behind condition. Giulio Dubbioso et al [3] has performed the open water simulation with INSEAN E779A propeller with fine mesh (1.31 million cells) and in-house solver χ navis - a finite volume uRaNSe (unsteady Reynolds-averaged Navier–Stokes equations) solver. To investigate "the effect of turbulence models on RANSE computation of propeller vortex flow", Hongxuan (Heather)Peng,WeiQiu n, ShaoyuNi [4]did the simulation on David Taylor Model Basin (DTMB) 5168 propeller. Three mesh sizes (1.92, 2.4 and 2.74 million cells) and 10 turbulence models (k-ε, k-ω, SST, Omega RSM …) has used during the simulation. In terms of Propeller and hull interaction simulation, G. Dhinesh [5] used RANSE solver Star CCM+ with k-ε turbulence model and sliding interfaces between propeller domain and ship domain. All the authors have presented good simulation result in comparison with experiment result. However, almost the simulations has just concentrated on the accuracy of the simulation, the computational time as well as the practical use of the method has not been studied., although it plays an important role during ship optimization process because many designs have to be considered in short period of time. Thus, this paper also presents the balance between computational time and level of accuracy of propeller calculation. Some methods for open water simulation are studied to choose the best one. The solver using in this paper is commercial RANSE code ISIS Solver, integrated in Numeca Fine Marine software. The turbulence model which mainly uses is k-ω SST. All the simulations are performed on cluster over 16 up to 96 cores.

The first part of this paper deals with open water simulation over 3 different methods: Sliding Grid, Rotating Reference Frame, and the last one is whole calculation domain rotating with propeller (called Rotating Domain in this paper). After selecting the best method to do open water simulation, the authors are going to do the second part: simulation of propeller working behind the hull. At the end, the authors give the assessments and evaluations about the computational resources, level of accuracy and the practical use of simulation

2. Literature Review

2.1 ISIS Flow Solver

The ISIS flow solver is a solver based on incompressible unsteady Reynolds – averaged Navier-Stokes equation (RANSE) and developed by *Laboratoire de Mécanique des Fluides, Ecole Centrale de Nantes, France*. Finite volume method is used in the solver for discretization of fluid domain. The velocity field and pressure field are obtained by solving momentum and mass conservation equation [6].

2.2 Method for open water simulation

As stated above, the study of 3 methods using for open water simulation is carried out: Sliding Grid, Rotating Reference frame and Rotating domain.

Sliding Grid is the common approach to describe the rotational motion of fluids. In this method, there often have two parts which are connected together: stationary part and rotating part. The rotating part rotates each every time steps, and the connection between two parts is also re-calculated each time steps. For the standard cells (non – rotating cells), we have to calculate fluxes in and out the cells. For the cell and face at sliding interface, we search the cell centre (in the other part) that is best match the face. This cell will be used for flux computation as the same as for the standard cells.

Another approximately approach to describe the rotating motion is the Rotating Reference Frame. The mesh of rotational part does not have to change its position each time step. Instead of that, there are 2 coordinates system: the stationary and the moving one. The propeller viewed from the rotating reference frame will be stationary. This method can be considered as "a steady approach" for rotating motion, therefore, compared with Sliding Grid, it takes less computational resources

The last one is the classical approach for open water simulation: the rotating domain method. It means that there is only one domain (the fluid around the propeller) rotates with the same revolution of propeller

The open water simulation is carried out with all 3 methods. The authors are going to compare in terms of level of accuracy and computational time, then select the best one.

3. Open water simulation

3.1 Propeller Test Case

To evaluate the result of open water test, the well – known propeller test case is used. It is Potsdam propeller test case [7]. The Potsdam propeller is 5 blades, right handed propeller (look from the pressure side) with some basic dimension as follows: diameter 0.25m, area ratio: 0.77896; skew angle: 18.837 degree.

3.2 Mesh generation

As stated above, the open water simulation is carried out by 3 different methods: Rotating Reference Frame, Sliding Grid and the classical approach: whole domain rotating with propeller (in this paper, we call Rotating Domain). The same mesh can be used for Rotating reference frame and rotating domain method. The difference between two methods is the simulation setup. For Sliding Grid method, we need to generate different mesh, because there are 2 domains: propeller domain and fluid domain.

3.2.1 Mesh generation for Rotating Domain (RD) and Rotating Reference Frame (RRF) method

The mesh is hexahedral and mesh is generated by using Hexpress. Detail characteristic of calculation Domain is described in *Figure 1*. The Domain is a cylinder with the Diameter equaling 10 times the Propeller Diameter

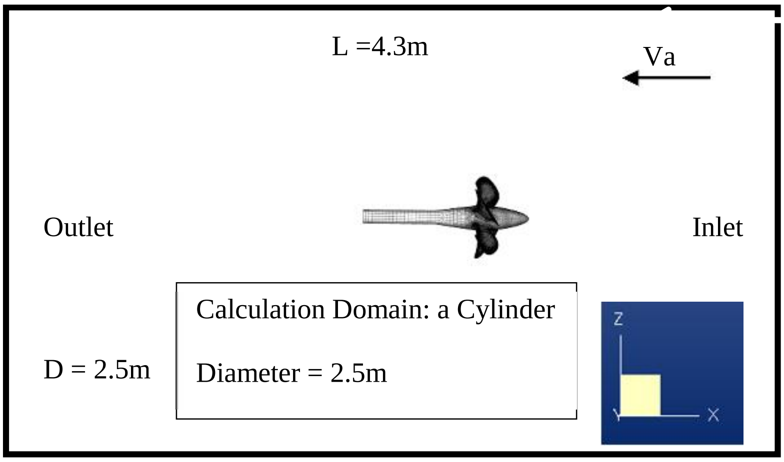

Figure 1: Calculation Domain for RRF and RD method

The Leading Edge, Trailing Edge and Tips of propeller are much more refined compared to other areas due to complex geometry at these areas. The mesh size for RRF and RD method is around 3.9 million cells

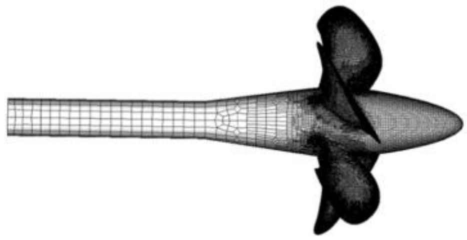

Figure 2: Typical mesh of propeller

3.2.2 Mesh generation for Sliding Grid method

As mentioned above, with sliding grid method, there are two domains: the rotating domain inside the fixed domain (Figure 3). The outer domain has same dimension as RRF method, and the inner one is just small enough to cover whole propeller inside. Between two domains there are common faces - “Non matching connection face”. The grid of common face between two domains is not required point-to-point matching each other. This connection enables the solver to compute flux through two domains. For each time step, the inside domain rotates and changes its position, therefore the solver has to re-calculate this connection each time step.

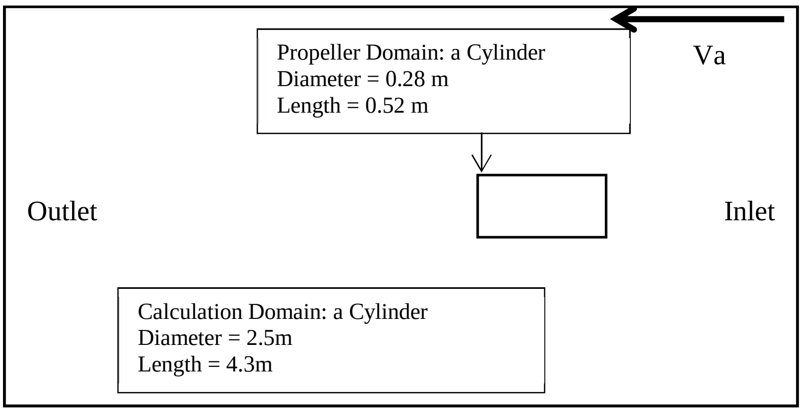

Figure 3 Calculation domain for Sliding Grid method

The mesh size after generation and inserting viscous layer is 3.9 million cells, similar to 2 other methods.

3.3 Computational Setup

The open water simulation is carried out with different advance coefficient J. We keep constant revolution n = 15 rps for the propeller, J is changed by varying advance velocity Va. Particularly, 5 advance coefficients J is simulated:

Advance velocity Va (m/s)	2.25	3.00	3.75	4.50	5.25
Advance coefficient J	0.6	0.8	1.0	1.2	1.4

Turbulent models: k-ω SST. The same boundary condition is applied for all three methods as follows:

- Inlet and External boundary: Far field with advance velocity (Va) imposed;
- Outlet boundary: Prescribed pressure (frozen pressure);
- Solid parts: Wall function approach. When selecting this option, ISIS solver automatically calculates the y+ to apply appropriate model: wall function or low Reynold number approach. (low y+).

The major differences in setup of 3 methods are the time step and the number of iteration per time step. This setup directly influences to time consumption or computer resources during simulation. The Rotating reference frame method can be considered as a steady approach for open – water test, therefore large time step and small numbers of iteration is used. Detail setup of time step is as follows:

Table 1 Time step setup for open water simulation

Method	Number of Iteration per time step	Time step
Rotating Domain	8	0.0003333s (200 time steps per round)
Rotating Reference Frame	4	0.00667s (10 time steps per round)
Sliding Grid	8	0.00013333s (500 time steps per round)

Computation of the simulation is performed parallel on cluster with 16 cores.

3.4 Result and discussion

The result is achieved by measuring the force in X direction (thrust) and the moment through X axis (torque) on propeller blades and hub when convergence is reached. The thrust and torque are expressed in non-dimensional forms by K_T and K_Q. After that, the open water efficiency η_O is also calculated.

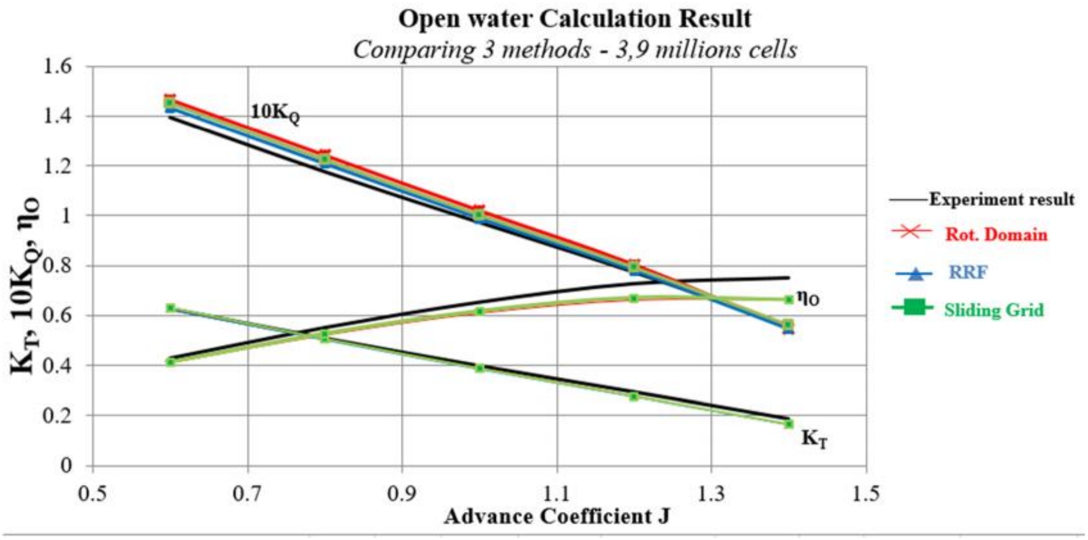

Figure 4 Open water curves obtained from 3 different methods, comparing with experiment result (EFD)

General view, compared to experiment data, the simulation results of three methods are good at J from 0.6 to 1.0 particularly, from 3% to 6% difference for all K_T, K_Q, and η_O . The result of K_Q is also good for all J, less than 5%. The difference just gets higher for K_T, with J from 1.2 to 1.4, up to 7% and 13%, respectively. The reason for that could be because the magnitude of K_T is getting very small with increasing J.

There is not much difference in terms of numerical result among 3 methods. The Rotating Reference Frame method shows very good estimation of K_Q, giving the best result compared to two other methods. For K_T, the Sliding Grid is the closest to experiment. The details of computational result are described in the *Table 2* below:

Table 2 Open water simulation result of different methods

	Experiment	Sliding Grid		Rotating Domain		Rotating Reference Frame	
J	**$10K_Q$**	**$10K_Q$**	**ΔK_Q**	**$10K_Q$**	**ΔK_Q**	**$10K_Q$**	**ΔK_Q**
0.6	1.396	1.451	**3.94%**	1.466	**4.98%**	1.432	**2.53%**
0.8	1.178	1.224	**3.88%**	1.242	**5.41%**	1.208	**2.52%**
1.0	0.975	1.002	**2.78%**	1.019	**4.57%**	0.988	**1.35%**
1.2	0.776	0.791	**1.92%**	0.803	**3.50%**	0.779	**0.33%**
1.4	0.559	0.559	**0.10%**	0.546	**-2.36%**	0.546	**-2.38%**
	Experiment	Sliding Grid		Rotating Domain		Rotating Reference Frame	
J	**K_T**	**K_T**	**ΔK_T**	**K_T**	**ΔK_T**	**K_T**	**ΔK_T**
0.6	0.629	0.630	**0.13%**	0.630	**0.12%**	0.623	**-0.99%**
0.8	0.510	0.506	**-0.74%**	0.508	**-0.33%**	0.501	**-1.74%**
1.0	0.399	0.388	**-2.97%**	0.390	**-2.35%**	0.383	**-4.08%**
1.2	0.295	0.277	**-6.06%**	0.278	**-5.72%**	0.273	**-7.39%**
1.4	0.188	0.166	**-11.37%**	0.162	**-13.69%**	0.162	**-13.71%**
	Experiment	Sliding Grid		Rotating Domain		Rotating Reference Frame	
J	**η_O**	**η_O**	**$\Delta\eta_O$**	**η_O**	**$\Delta\eta_O$**	**η_O**	**$\Delta\eta_O$**
0.6	0.430	0.414	**-3.66%**	0.410	**-4.63%**	0.415	**-3.43%**
0.8	0.551	0.527	**-4.44%**	0.521	**-5.44%**	0.528	**-4.15%**
1.0	0.652	0.616	**-5.59%**	0.609	**-6.62%**	0.617	**-5.34%**
1.2	0.726	0.669	**-7.82%**	0.661	**-8.91%**	0.670	**-7.69%**
1.4	0.749	0.663	**-11.44%**	0.662	**-11.59%**	0.662	**-11.59%**

In terms of computational time, the simulation for all 3 methods is performed in parallel with 16 cores. The mesh sizes are 3.9 million cells.

The average computational time is follows:

Table 3 Computational time of 3 different methods

Method	Sliding Grid	Rotating Reference Frame	Rotating Domain
Computational time (average)	58.3 h	15 h	40h
Percentage (compared to Sliding Grid method)	100%	25.%	68.6%

It is clear that Rotating Reference Frame takes least computational time, by less than one-third compared to two other methods. Therefore, Rotating Reference Frame method has big advantage in practical and daily use.

3.5 Assessment and conclusion of result for open water simulation

Rotating reference frame method proves that it is suitable method for open water simulation, concerning computational time and level of accuracy, as well as convergence of result. However, this method is only suitable for simulation with 1 domain, it cannot be used for simulation of propeller behind the ship. In this case, Sliding Grid approach should be used. The investigation of setup for sliding grid approach in this section is very useful for doing simulation of propeller behind the ship in the next part of this paper.

4. Propeller behind ship simulation

To have consistency with experiment, the simulation is carried at model scale for ship and propeller. The ship is bulk carrier, with a 4-blade propeller [8], from a Chinese shipyard. The experiment result is provided by China ship scientific research center (CSSRC) [8]. The output is wake fraction (w_T), thrust deduction factor (t), relative rotative efficiency (η_R), and hull efficiency (η_H). Besides, the factors that represents performance of propellers also need to be taken into account: thrust coefficient (K_T), torque coefficient (K_Q) (note that these two coefficients are calculated in the case of propeller behind the hull, different from open water case).

In order to get all the output, it is necessary to use open water curve from open water test simulation. Hence, the simulation steps and result of open water for this propeller will be shortly presented.

4.1 Ship and propeller geometry

Basic dimension of ship and propeller are described below:

Table 4 Basic dimension of ship and propeller

Ship (bulk carrier)			Propeller		
Length overall	7.5	m	Diameter	0.2333	m
Length between Perpendicular	7.233	m	Chord length at 0.75R	0.0502	m
Breadth moulded	1.0753	m	Expanded blade ratio	0.3766	
Design draft	0.4067	m	Number of blades	4	
Displacement	2.708	m^3	Direction of turning	Right handed	
Block coefficient C_B	0.855				

4.2 Open water test result

The mesh generation and calculation setup for open water case has been described completely in the previous chapter. Therefore, only brief information about this simulation is presented. The method using is Rotating Reference Frame method, mesh size 2.1 million cells, turbulence model: k-ω SST. The open water curve is presented in Figure 5 below.

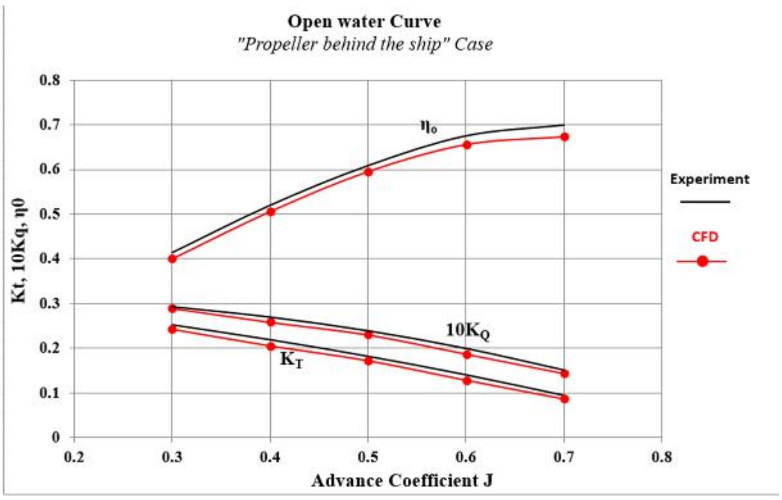

Figure 5 Open water Curve - Self propulsion test

4.3 Mesh setup for simulation of propeller behind the ship

The number of cells for Propeller domain and Ship domain are 2.9 and 2.1 million cells, respectively. The total cells are 5 million cells. It can be considered as reason number for mesh size, because time consumption for Sliding Grid is very high.

The simulation is performed at services speed 14.5 knots, corresponding with Froude number equals to 0.159.

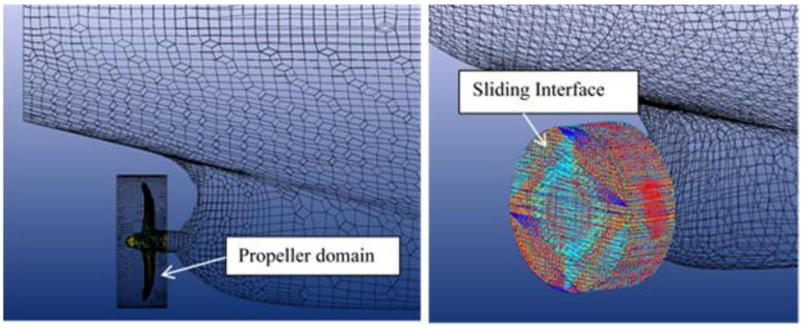

Figure 6 Propeller domain and sliding interface

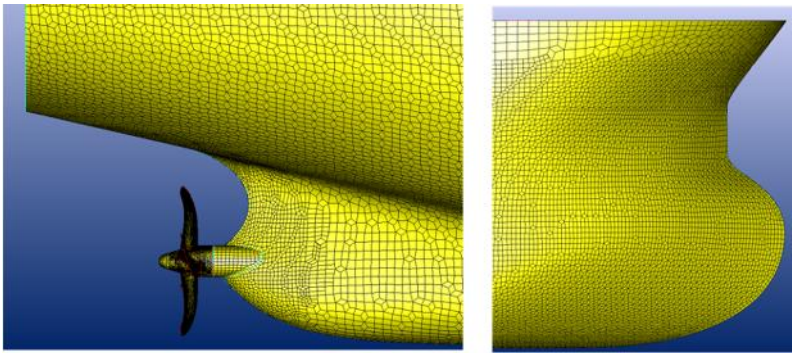

Figure 7 Mesh generation for propeller and ship

4.4 Setup of simulation

The basic setup of simulation is as follows: multi fluid approach (air and fresh water) and free surface. Turbulence model is k-ω SST. For the boundary conditions, wall-function approach is used for solid parts (hull, propeller, shaft, hub and cap), while the external boundary is set to Far field condition except Prescribed pressure for Top boundary. The propeller is connected to the ship by "Pin" connection. At first, large time step is applied to simulation: Δt = 0.026 second (equal to 5 times step per propeller revolution). The number of iteration per time step is 4. After the force acting on the ship becomes quite steady (around 1000 time-step), we switch to second simulation using previous result, but much smaller time step, Δt = 0.000525 (250 time steps per propeller revolution), and 8 iterations per time step, to stabilize propeller thrust. Time steps setup for propulsion test is described in the table 5 below:

Table 5 Time steps setup for propulsion test

Computational case	Propeller revolution (rps)	Time step (s)	
		1st computation	2nd computation
Vs = 14.5knots	7.623	0.026	0.000525
	8.2	0.024	0.000488

4.5 Result and discussion

The propulsion factors acquired from CFD simulation is shown below, in comparison with experiment result:

Table 6 Simulation result of propeller behind the ship

Self - propulsion parameters	CFD result		Experiment result [8]
		Compare to experiment	
Thrust coefficient K_T	0.154	-7.49%	0.166
Torque coefficient K_Q	0.213	-3.14%	0.22
Revolution n	7.812	2.48%	7.623
Thrust deduction coefficient (1 - t)	0.808	3.06%	0.784
Advance coefficient J	0.5408	-0.04%	0.541
Open water coefficient	0.633	-0.92%	0.639
Relative rotative efficient η_R	0.980	-3.48%	1.015
Effective wake coefficient (1 - w)	0.724	2.37%	0.707
Hull efficient η_H	1.116	-1.02%	1.128

Regarding level of accuracy, the result of simulation is quite promising. The difference is around, and less than 5% for the propulsion parameters in behind-condition (thrust deduction, wake fraction, relative rotative efficiency).

In terms of time consumption, the average computational time by using 16 cores on 1 node, the mesh size is 5 million cells is below
First computation (large time step) Time: 1200 min = 20 hours
Second computation (small time step) Time: 10000 min = 167 hours = 7 days

There is extremely time consumption for second computation; it takes 160s to calculate 1 time step.

However, there is a solution for that. The computational time will reduce much if we run parallel on 96 cores over 3 nodes. It only takes around 70 second to calculate one time step. It means the speed increases by 2.5 times. And if the calculation is performed in 128 CPU over 4 nodes, the speed can increase by roughly 4 times, around 50 seconds per time step. Therefore, one simulation (including two steps of computation) can be done within 1.5 days (36 hours).

5. Conclusion and further development

The paper presents the CFD approach using RANSE solver for propeller calculation, in both case: open water and behind condition case, with concentration on the practical use of the method during optimization process. Few methods have been tested for open water simulation. The investigation also points out that Rotating Reference Frame method is the most suitable one for doing open water simulation, considering level of accuracy and computational resources. Rotating Reference Frame method could be applied in practical or daily use, to simulate propeller in open water condition.

The self-propulsion simulation (or simulation of propeller working behind ship) shows quite promising result. The results of the parameters, characterizing “propeller behind ship performance”, such as thrust deduction (t), effective wake coefficient (1 - w) or relative rotative efficiency (η_R) are good in comparison with experiment: less than 5% difference.

However, the most difficulty of this simulation is computational time. Using Sliding Grid with large number of cells (including full ship, propeller and rudder) is very time and resources consumption.

Regarding the use of these approaches for hull form and propulsion optimization, due to quite large computational time, currently, those methods should use to validate propulsion performance of optimized hull form. For example, the hull form can be optimized by doing simulation with Potential Flow theory (non-viscous fluid) for many designs. After that, few good performance hull forms are selected to do the second simulation with viscous flow by applying those methods which are investigated in this paper. However, with the significant development of computational resources, the authors believe that in the short future, we are able to perform simulation of many design with RANSE solver and methods described in this paper, to obtain optimized hull form and propeller.

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Session 3A

MARITIME EDUCATION AND TRAINING

(No. 3)

Characteristic of post-degree courses organized in GMU on example "MODERN SHIP MANAGEMENT" course

Laczynski Bogumil,Prof. Captain [(1)]
Laczynski Tomasz, M. Sc. , PhD student [(2)]

Gdynia Maritime University, POLAND, Email: acamars@gd.pl

Abstract Apart of undergraduate and postgraduate studies offered in GMU new concept of post degree studies was developed on Faculty of Navigation from 30th September 2015. Post degree course follow requirements of Ministry of Higher Education of Poland. According to this requirements post degree course should be continuous minimum 2 semester in total amount of lessons 200 hours and total credits should be minimum 60 ECTS. Curricula's and programs of post degree studies accepted by Dean's Board. The group of 15 person in age 30-55 years old was established and they decide that lessons took place on Wednesday afternoon 14:00 – 18:00. Participants of post – degree course "Modern Ship Management" have few years of experience as officers on board or few years as an office workers in different offices. In Feb 2015 was established The Polish Ship Managers' Association, what is a is a voluntary organization of Polish business entities performing technical and crew management of ships belonging to foreign shipowners and ship operators and marine risk management concerning those ships. Above association fully accepts post degree course.

Intention of organizers is presenting no theoretical knowledge but practical experience, "keys studies". Apart of GMU teachers about 80% of presenters were the top managers of ship management companies from Poland and Europe. 30% of lessons were conduct in English language, 70% in Polish. Apart of the lessons in GMU facilities a special exercise were prepared on board vessel mooring in Port of Gdynia (active participation of students in inspection of PSC). Special lessons were done DNV-GL Inspections Simulator in their office in Gdynia. Part of course are the individual students projects for example: organizing of crew exchange, ship supply, medical care on board vessel etc. The final common project it is legal establishing of brand new private ship management company. Realistic plans contain: budgeting for 1 year, organizing office and staff , preparing ISM code, etc.

Keywords: ship management, crewing, technical management, GMU, post-degree, course syllabus, commercial management

Contain of paper:

Introduction & System of Maritime Education in Poland

Gdynia Maritime University founded in 1920 is the biggest Maritime school with over 6000 students in 4 faculties:

1. Faculty of Navigation (1200 students)
2. Faculty of Marine Engineering
3. Faculty of Electrical Engineering
4. Faculty of Entrepreneurship and Quality Science

Actual system of education in Poland existing since 2007 after compulsory adopting Bologne regulations show picture no.1

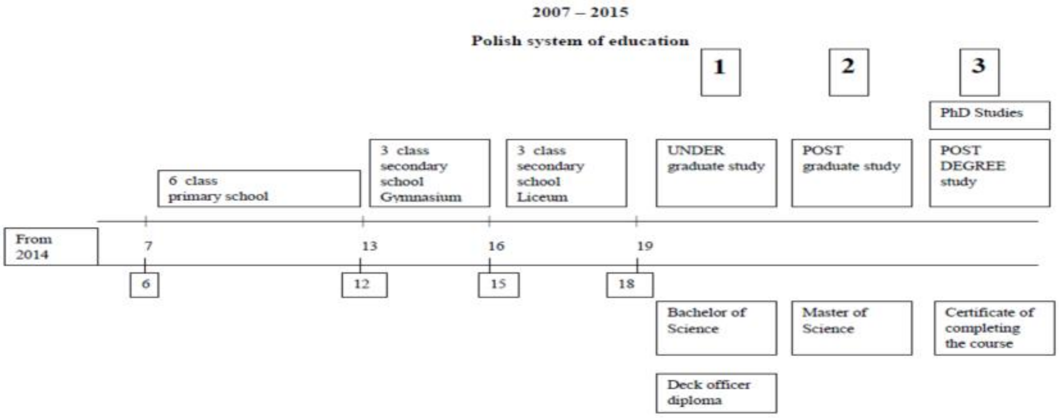


Figure 1 Actual system of maritime education in Poland

Post graduate studies offered in Gdynia Maritime University

1. Maritime transport
2. Management of safety in sea transport
3. Offshore technologies
4. Arctic navigation
5. Ocean yachting

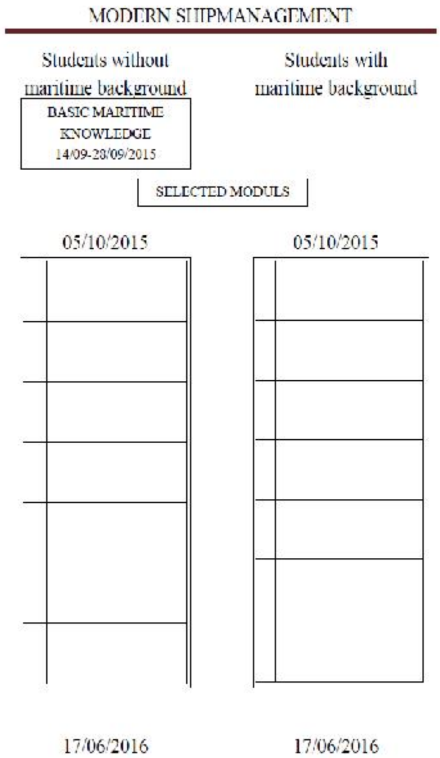
The specific post degree studies

Any University or College has a right to open Post Degree Studies, in a field of profile of study. Plans, curricul as and programms of post degree studies should be accepted by Dean's Board. Duration of post degree studies should be not less than 2 semesters (200 hours) and total quantity of ECTS is minimum 60 points. University or College has a right to collect fee for a period of education. Graduates of post degree studies receive certificate of completing course. The condition of issue of the above certificate are strictly identified in regulations. New certificates should be issued to students which began above study after 30th September 2012. [1]

In the years 2011 and 2012 on request and suggestion of Jeppessen (group Boeing), hydrographic office in Gdynia special post degree study was offered : Geographic information system for navigation application . Each academic year 12 people.

Post degree studies is designed for officials in national marine departments, port and terminal operations, ship owners, ship operators and senior seagoing officers decided to start working shore based shipping field. The studies provide student with excellent knowledge base and helps to move career forward.

New post degree study: Modern Ship management (Pic.2)



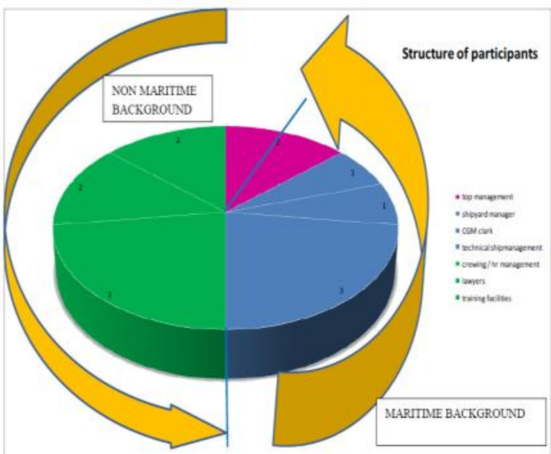
Selected moduls

1. Tools of Modern Shipmanagement understanding of international bussines interface between shore and ship management
2. Quality systems and enviromental issues
3. Technical Shipmanagement
4. Manning and training, personel shipmanagement
5. Operational shipmanagement
6. Budgeting, accounting and bussines plans
7. Insurance, Maritime law, International Conventions, Port State Control
8. Budgeting, accounting and bussines plans
9. Insurance, Maritime law, International Conventions, Port State Control
10. Managing a Shipping Company, Shipmanagement Compnay, etc.
   For individual decission of participant:

11 Selected topics : communication skills

Figure 2 Organizing scheme of Modern Ship Management studies

There is an interesting analyze of participants to whom post-degree studies addressed. People are working for ship manager companies, crewing agencies, technical management, shipyard, ship owner, training institutions. From 14 people only 6 have maritime backgroung (Pic. 3A), they are in different age (average 36) (Pic. 3B). After completing 2 semester studies graduate receive special GMU diploma (Pic. 3C) and official standard diploma issued by Ministry of Education (Pic. 3D).



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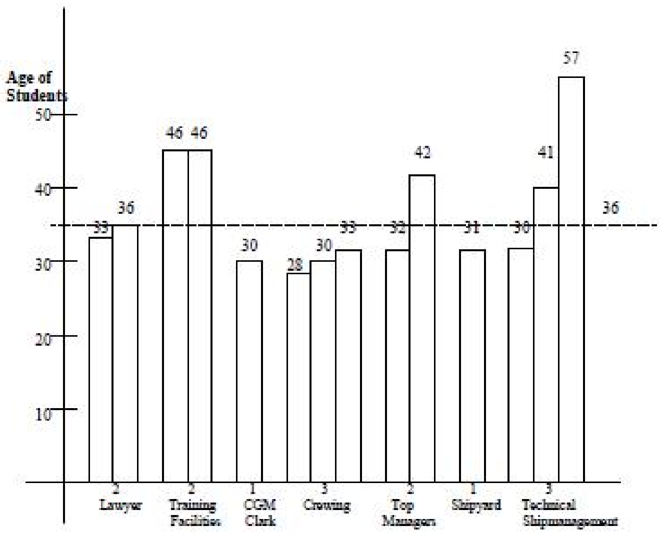


B

CERTIFICATE

MSM N° 14/2016

Zaświadcza się, że / This is to certify that

Mr. Adrian Belczewski

ukończył z powodzeniem 2 semestralne studia podyplomowe

has succesfully completed 2 semesters postgraduate studies

MODERN SHIP MANAGEMENT

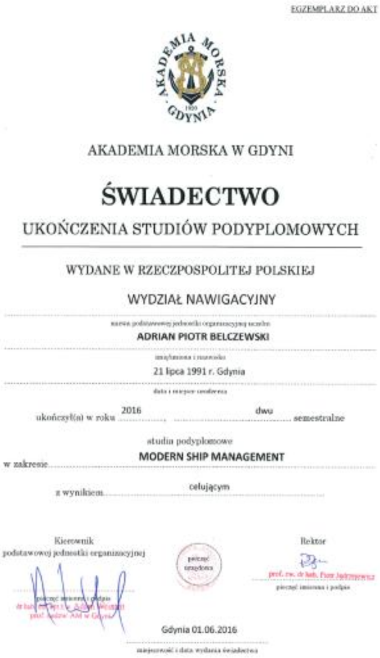
zorganizowane przez Wydział Nawigacyjny Akademii Morskiej w Gdyni

organized by Faculty of Navigation Gdynia Maritime University

Prof. dr hab. Piotr Jędrzejowicz
Rektor Akademii Morskiej w Gdyni

Dr inż. kpt. ż.w. Bogumił Łączyński
Kierownik studiów podyplomowych

Gdynia June 2016



EGZEMPLARZ DO AKT

AKADEMIA MORSKA W GDYNI

ŚWIADECTWO

UKOŃCZENIA STUDIÓW PODYPLOMOWYCH

WYDANE W RZECZPOSPOLITEJ POLSKIEJ

WYDZIAŁ NAWIGACYJNY

ADRIAN PIOTR BELCZEWSKI

21 lipca 1991 r. Gdynia

ukończył(a) w roku 2016 dwu semestralne

studia podyplomowe

w zakresie MODERN SHIP MANAGEMENT

z wynikiem celującym

Kierownik podstawowej jednostki organizacyjnej

Rektor

Gdynia 01.06.2016

C

D

Figure 3

Particulars of course: cost 2750 PLN per semestr (total 5500 PLN), passing all 9 moduls and final project (modul 10), minimum 12 participants , four hours lessons in one day of week (agreed with employers of participants) preferable Tuesday or Wednesday 15:00 – 19:00

Figure 4 Closing ceremony of 1st Edition of Post Degree Studies MODERN SHIP MANAGEMENT

Polish Ship Managers' Association

The name of the association is "Polski Związek Zarządców Statków (hereinafter called "Association"). The Association may also use its English name "Polish Ship Managers' Association" and abbreviated names: "PZZS" in Polish and "PSMA" in English, was established January 15th 2015. The Association is a voluntary organization of Polish business entities performing technical and crew management of ships belonging to foreign ship owners and ship operators and marine risk management concerning those ships. The Association goal is ensuring the necessary professional level of services provided by the members to the contracting parties, in accordance with international standards and quality norms. President of association, Mr. Irek Kuligowski, managing director of Green Management said: „Our Maritime Universities educate people on a very high level quality and all can find a job only abroad. What for graduates should emigrate? Maritime Universities should change a little their behaviour and start to educae specialist for ship management bussines."

Prognosis for 2nd edition

In opinion of 14 participants, employers of students, teachers and managers of Gdynia Maritime University first 2 semester studies MODERN SHIP MANAGEMENT were completed in June 2016 with great success. Many request for the next edition were received by director of post degeree studies. Some remarks and practical experience of 12 months studies give organizers opportunity to few changes in moduls of studies and even correction of ideology of curricula. Picture 5 shows new approach of dr Malcolm C. Willingale to content of Modern Ship Management.

Figure 5 Distribution of moduls for shipmanagement studies

Proposition of new post degree studies in GMU

Fields of interest for future
post degree studies

1. Ship inspection and surveying → together with DNV+GL and PRS
2. Wide spectrum of Hydrography → Maritime Administration, Polish Science Academy
3. Aero/Air Navigation → Airports administration, Sanitary/agro aviation
4. LNG Industry → LNG Terminals, inland LNG
5. Port State Control → Maritime administration, Shipmanagers & shipowners
6. Ship operation and modern port operations → for shore based companies
7. Ship Agency Ship Superindendents → ship management companies, port authority
8. SAR Search and Rescue →
9. Safety management and risk assessment →
10. To be advised …. →

Conclusions

In opinion of authors of this paper we should define a term in Modern Ship Management which arised from following dates and circumstances.

CLASSIC SHIP MANAGEMENT TILL APR. 1995

MODERN SHIP MANAGEMENT FROM APR. 1995

The best knowledge about ship handling contain contained in classic book of dr Malcolm C. Willingale (Pic. 6) [3]

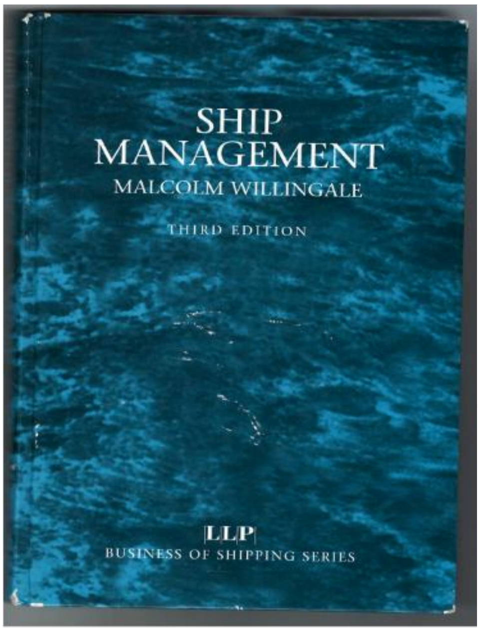


Figure 6 Ship management book by Willingale

The following items should be taken into consideration in actual modern ship management:

1. Much more strictly and quality of Ship inspection, PSC, DNV-GL
2. New geopolitical situation, ex Yugoslavia, East European Block, Ex- Soviet Union, new nations on market
3. Easier transportation, cheaper flights, non-visa requirements, etc.
4. Changes in standard of living (duration of contract, unification of scale wages)
5. Newest International regulations STCW, MLC, ISM
6. Modern communication (computers, global network)
7. New ecological requirements
8. New negative elements (piracy, terrorist, 11th September effect, ISPS)
9. Changes in new fleet structure, containerization, specialized ferries, LNG, etc.
10. New construction, shipyards revolution, dual fuel, CO2/SO2 requirement, etc.
11. Change of price of fuel and other elements of commercial operations.

Companies employers should permanent develop themselves and have to increase their professional knowledge. Doing every day job in most situation in specific area only is rather difficult to follow changes new information and procedures.

This is why post degree studies which practically take part on second half of 1 working day give an opportunity to listen lessons given by top managers of worldwide shipping (Secretary General of INTERMANAGER Mr. Kuba Szymanski, and few foreign managers visiting Polish offices). Part of studies are practical workshops onboard vessels (PSC) training in inspections on special simulator (DNV-GL), analyze of selected “case studies”, special projects, etc. [2]

Actually 30% of lessons were in English language. Organizers intent to increase above to 50%. New edition of post degree studies will have accreditation of prestigious maritime institution for example: Polish Ship Managers Association, DNV-GL, Intermanager etc. The best graduated students from 1st edition would like to participate in workshops with students of 2nd edition.

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Study on the Ideal Ways of Enhancing the Quality of Maritime Education, Training and Research

Col. Dr. G. Thiruvasagam[1]

1. Vice Chancellor, vc@ametuniv.ac.in, AMET University, 135, East Coast Road, Kanathur, Chennai

Abstract It is a well-known fact that more that 90% of global trade is accomplished through shipping and shipping is the back bone of international trade. Without shipping the transport of essential commodities across the globe on a scale necessary to sustain the world is yet to be discovered. Shipping is unarguably the safest, cheapest, cleanest and efficient means of transportation despite the disasters and its consequences through which it had evolved over centuries. Although ship is a single entity, it is a component of the marine environment the rest of them being the person s involved as seafarers taking care of the routine shipboard operations, the architects involved in the design, development and construction of ships, the managers taking care of the commercial, technical and human resources aspect of the ship under the domain of shipping company, the persons involved in the logistics sector, the administrators, policy makers and the most important component at the grass root level but with whom the growth, development and sustenance of present and future shipping industry is entrusted with is none other than the Maritime education and training (MET) institutes.

Keywords: MET, STCW, ISF, Sea Time, Watch keeping.

1. Introduction

Education is the process of facilitating learning or the acquisition of knowledge, skills, values, beliefs, habits whereas training is the one of the methods in pedagogy, the rest being teaching, discussion and directed research. Training *per se* is teaching, or developing in oneself or others, any skills and knowledge that relate to specific useful competencies. Training has specific goals of improving one's capability, capacity, productivity and performance. *"Integrating maritime education and training along with directed research in order to provide a seamlesssupply of skilled manpower to all the components that make up the marine environment so as to sustain global trade by sea is the fundamental principle of every maritime education and training institute".*

2. STCW code – Brief review

The procedure to the accomplish the essence of the fundamental principle is framed as minimum standards in the international convention on standards of training, certification and watch keeping for seafarers (STCW) code 1978, as amended, wherein it contains, in:

- **Part A,** the mandatory provisions to which specific reference is made in the annex to the STCW Convention and which give, in detail, the minimum standards required to be maintained by parties in order to give full and complete effect to the provisions of the STCW convention;

- **Part B,** recommended guidance to assist parties to the STCW convention and those involved in implementing, applying or enforcing its measures to give the STCW convention full and complete effect in a uniform manner.

Under Article I – General obligations under the convention, parties to the STCW code have agreed to take all necessary steps which may be necessary to give the convention full and complete effect, so as to ensure that, from the point of view of safety of life and property at sea and the protections of the marine environment seafarers on board ships are qualified and fit for their duties.

To facilitate homogenous interpretation of the recommended guidance given in Part B, of the STCW code a table explaining the type of competence, expected level of knowledge, understanding and proficiency for the said competency and criteria for evaluating competence is given as below:

Table A-II/1 (of STCW Code)
Function: Navigation at the operational level

Column 1	Column 2	Column 3	Column 4
Competence	Knowledge, Understanding and proficiency	Methods for demonstrating competence	Criteria for evaluating competence
Transmit and receive information by visual signaling	Visual signaling Ability to use the international code of signals. Ability to transmit and receive by Morse light, distress signal SOS as specified in Annex IV of the international regulations for preventing collisions at sea,1972, as amended and appendix 1 of the international code of signals and visual signaling of single letter signals as also specified in the international code of Signals	Assessment of evidence obtained from practical instruction and simulation	Communication within the operators area of responsibility are consistently successful

Despite such revealing mandatory provisions and recommended guidance in the STCW code there still exists laps, gaps and inconsistency in the quality of MET as per BIMCO/ISF manpower report 2015.The parties who have agreed to give full and complete effect to the convention implement it as an expectation of the outcome of training given by MET.

3. Concerns about MET - BIMCO/ISF manpower report 2015

The MET institution survey, 2015 revealed some concerns about a number of issues including the:

- Proportion of trainees who fail to successfully complete their training courses and obtain an STCW certificate;
- Proportion of trainees who obtain STCW operational level certificates, but then only finding sea going employment as a rating;
- Difficulties for trainees in securing pre-qualification sea time;
- Problem faced by MET institutions in providing adequate facilities, instruction and experience to trainees; and
- Lack of quality and competency of some seafarers graduating from MET institutions.

4. Concerns about training standards –BIMCO/ISF manpower report 2015

The following comments from the MET institution and seafarer surveys provide an indication of some concerns that exist about training standards.

"There are no international standards of maritime education and training. The STCW convention is only the outline, and does not define the professional or academic level that graduates achieve" – MET institution.

“There are many institutions with different levels of standards. The job of regulating institutes should not only be of the Administration, but employers too should take this as their responsibility.” – MET institution.

“A global maritime control center regarding the quality and standards of teachers and of training institutes is needed” – MET institution.

“Junior bridge officers demonstrate an over reliance on modern electronic aids to navigation. Basic skills are not covered in college, which is of concern – Master, British

“My biggest complaint is the decreasing quality of new officers.”- Master Bulgarian

Although the comments are personal opinion, as a whole it calls out for a control on the perceived waning quality in the training standards as well as for the intervention of administration to get a better handle on the training imparted by the institutes in their states respectively.

5. Key ways to enhance quality of Maritime Education and Training

Recalling resolution 7 of the final act of the 2010 STCW conference which invokes the promotion of technical knowledge, skills and professionalism of seafarers, the stake holders primarily the MET, the shipping company and the administration have to realize that enhancing maritime education and training is not an independent responsibility but it is an interdependent responsibility.

5.1 Induction

It is imperative for the MET and shipping companies to be cognizant of the fact that the overall effectiveness of selection, training and certification processes can only be evaluated through the skills, abilities and competence exhibited by seafarers during the course of their service onboard ship, hence there should not be any compromise in the established criteria and in the process for the selection of seafarers exhibiting the highest practicable standards of technical knowledge, skills and professionalism.

At the beginning of the program itself the prospective officer (trainee) should be given full information and guidance as to what is expected of them and how the training programme is to be organized. Induction presents the opportunity to brief prospective officers about important aspects of the tasks they will be undertaking with particular regard to safe working practices and protection of the marine environment.

5.2 Training

The shipping company must have arrangements to encourage all officers serving on their ships to participate actively in the training of junior personal.The seafarers who are newly assigned to a ship should take of full advantage of every opportunity provided to become familiar with the shipboard equipment, operating procedures and other arrangements needed for proper performance of their duties.Immediately upon arriving on board for the first time, each seafarer has the responsibility to become acquainted with the ship’s working environment, particularly with respect to new or unfamiliar equipment, procedure or arrangements.

There should be a seamless transition between training imparted ashore and onboard, in a broader perspective the shore based training institutes should precisely map the onboard procedures which are eventually changing from the beaten procedures because of technological advancement.It is extremely important that the prospective officer (trainee) is given adequate opportunity for supervised bridge and engine room watch keeping experience, particularly in the later stages of the onboard training programme.

5.3 Monitoring

Guidance and reviewing are essential to ensure that prospective officers are fully aware of the progress they are making and to enable them to join in decisions about their future programme. Reviews should be linked to information gained through the training record book and other sources as appropriate.Training record book should be scrutinized and endorsed formally the Master and shipboard training officer beginning, during and at the end of each voyage. The training record book should also be examined and endorsed by the company training officer between voyages.

5.4 Evaluation

The MET must ensure that the curriculum is designed to take account of different methods of assessment which can provide different types of evidence about candidates competence, e.g:

- Direct observation of their seamanship activity;
- Skills/proficiency/ competency test;
- Project and assignments;
- Written, oral and computer-based questioning techniques

Assessment of competence should encompass more that the immediate technical requirements of the job, the skills and tasks to be performed and should reflect broader aspects needed to meet the full expectations of competent performance as a ship's officer, like; Anticipate prepare for and deal with contingencies&Adapt to new and changing requirements.

The entire training imparted to the prospective training officer should be comprehensively documented, periodically reviewed and appropriately corrected to ensure complete transformation from a prospective officer (trainee) to a competent officer.

6. Conclusion

The International Maritime Organization (IMO) in its unflagging efforts to defend its twin motto "safe ships and clean seas" have taken constant measures and method to keep the quality of maritime education and training by passing several amendments to STCW code in order stay abreast and at times to outpace the advancement of technology. The spirit with which the code is compiled is vested with those people who are in the capacity of implementing the code and monitoring the changes it is bringing into effect. The ways to enhance the quality of the maritime education and training is existing as a constitution in the STCW code but the key to implement it lies with individual seafarer.

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[2] STCW code including 2010 manila amendments.

IMO E-navigation Concept and MET trends

Vladimir A. Loginovsky, DSc, Professor

Admiral Makarov State University of Maritime and Inland Shipping
vl.loginovsky@rambler.ru, LoginovskijVA@gumrf.ru
198035, Dvinskaya str., 5/7, Saint-Petersburg, Russian Federation

Abstract The e-navigation Strategy Implementation Plan (SIP), which was approved by IMO Maritime Safety Committee (MSC 94) in November 2014 [1], contains a list of tasks required to be conducted in order to address 5 prioritized e-navigation solutions, namely:

- improved, harmonized and user-friendly bridge design;
- means for standardized and automated reporting;
- improved reliability, resilience and integrity of bridge equipment and navigation information;
- integration and presentation of available information in graphical displays received via communication equipment; and
- improved Communication of VTS Service Portfolio (not limited to VTS stations).

The paper reviews the IMO e-navigation papers and current trends related dynamics of MET stipulated by development of SIP, which can affect in the near future the STCW Convention and Code.

Keywords: e-navigation, Strategy Implementation Plan, MET, gap analysis, STCW 78.

1. Introduction

The shipping industry is constantly moving to digital world. As per paper [3], e-navigation is expected to provide digital information and infrastructure for the benefit of maritime safety, security and protection of the marine environment, reducing the administrative burden and increasing the efficiency of maritime trade and transport.

In this context the following questions can be raised: Is adequate MET system needed for seafarers in the era of e-navigation? Do maritime universities ready to meet the upcoming new ICT (Information and Communications Technology) challenges in shipping? Do they ready to equip their students with new thorough knowledge or may be the STCW Convention has enough well developed competencies, which are completely adequate to changing environment and nothing to be done?

The e-navigation SIP introduces a vision of e-navigation which is embedded in general expectations for the on board, on shore and communications elements. The main objective of the present SIP is to implement the five prioritized e-navigation solutions, taking into account the IMO Formal Safety Assessment (FSA), from which a number of required tasks have been identified. These tasks should, when completed in the period 2015–2019, provide the industry with the harmonized information, in order to start designing products and services to meet the e-navigation solutions.

2. Background

IMO has begun to develop Manila amendments and e-navigation concept practically in parallel ways in 2006. Let us recall some facts, which have occurred the last years and which might be linked in the near future as consistent events:

1. E-navigation SIP, which was approved by the Sub-committee NCSR 2 [3] and then also approved by Maritime Safety Committee (MSC) on its 94th session [1] actually represents the initial stage of the development of e-navigation and it is designed for the period 2015- 2019.

2. Resolution 15 [4] “Future amendments and review of the STCW Convention and Code” adopted by Manila Diplomatic Conference in June 2010 recommends, that a comprehensive review of the STCW Convention and Code should, as far as possible, be carried out every ten years to address any inconsistencies identified in the interim; and to ensure that they are up to date with emerging technologies. So, in principle comprehensive changes might be initiated and stipulated in 2020 by the progress of fulfillment of e-navigation SIP, but

3. In 2011 STW 43 noted, that: some training elements, especially those that were, in general, covered by the STCW Convention and Code, might need to be reviewed in the future in light of the forthcoming developments on e-navigation and the revision, updating or development of training elements should only be considered in the future, after having a clear understanding of the potential technical, operational and regulatory e-navigation solutions that would be developed by the Organization [5].

4. IMO HTW 1 meeting of Sub-Committee in 2014 has agreed that it is premature to consider any training requirements on e-navigation, pending the finalization of the e-navigation SIP. HTW 2 meeting confirmed this solution.

5. However, at the same period IMO has developed the Gap Analysis and practical e-navigation solutions with Human Element, which include some important proposals for identifying gaps in training of seafarers and appropriate staff ashore. Some identified gaps might relate to STCW Code and they in turn also can be the basis for future consideration.

Contradictory views were sounded in 2012 during the International conference on e-navigation [6], for example:

6. ICS considers that training, but not necessarily a training course, may be required to introduce the concept of e-Navigation to users;

7. The automation, harmonization and integration driven by the definition of e-Navigation should ensure that training additional to that already required under the STCW is generally unnecessary.

8. E-Navigation improves situational awareness and decision making at sea and ashore. When used in conjunction with other communications and display systems it enables shore organizations to deliver more timely and relevant information to the mariner. And through its many levels of sophistication and scalability it can embrace all levels of system users from recreational craft to the largest and most modern commercial vessels. A drawback is that its use requires that there be a new level of sophistication and equipage on the part of the system users. And this in turn requires new levels of user training and certification.

So, a lot of things in MET are needed to think over and consider before the e-navigation SIP begins to start its implementation.

3. E-navigation and Situation Awareness

The IMO definition of e-navigation concept is as follows [7]: "E-navigation is the harmonized collection, integration, exchange, presentation and analysis of marine information on board and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment."

The following clarification of IMO definition is given in US e-navigation Strategic Action Plan [8]: e-Navigation is not about equipment, but is about the *integration of information*. There is and will be no such thing as an “e-navigation system,” nor will there be a carriage requirement for an “e-navigation box.” Eventually, equipment and systems may be required to be “e-navigation compliant” but such requirements are yet to be developed.

Let us try to combine the sense of definition and clarification above with definition of Situation Awareness (SA). SA is the safety driven *perception of the elements in the environment within a volume of time and space* (navigational area) , *the comprehension of their meanings* (dangers, marks, ships, lighthouses…) *and the projection of their status in the near future* (developing of navigational situation), [9]. In other words SA involves the real-time processing of event-based information coming from an evolving situation in an attempt to understand what is happening, [10].

So, one of the goals of e-navigation, as globally integrated maritime network, is electronically to know what is going on around the ship. In principle, it has the task to support the proper level of Situation Awareness of personnel on board and ashore for safety and security at sea and protection of the marine environment.

One can say that e-navigation concept is also in line with the appropriate provision of STCW 78 and namely “obtaining and maintaining the situation awareness “, which is included into Column 2 «Knowledge, understanding and Proficiency» of STCW Code by Manila amendments (*Tables A-II/1,2; A-III/1,2,6*). In what way the e-navigation concept with its integrated approach can influence the STCW competences? Do only Section A-II, or possibly Sections A-III, A-IV and A-VIII also might be subjected to some changes?

From the viewpoint of training, the integrated information, in spite of human-centered design of equipment, might be less clear for operator than information obtained by traditional non- integrated approach that is why more deep understanding of principles of integration might be needed. It may be the additional subject for MET programs.

4. Gap analysis results: training

HTW2 Subcommittee adjourned the discussion of issues related to the training of seafarers, explaining that by number of uncertainties, but however carried out a gap analysis, allows pre-select the field that can change the training or affect the training of seafarers.

What one can say about the shore-based personnel training in field of e-navigation? If to follow principles of e-navigation, some training programs need to be also integrated with training programs for seafarers? Officers and shore staff should have an opportunity to be trained together. Perhaps, it would be reasonable to develop and include in STCW Convention or ISM Code the requirements for all types of joined training for crews and shore staff.

Some ideas and proposals extracted from gap analysis [3] in the area of e-navigation and related to staff training, both for onboard and ashore are as follows:

Training courses are proposed to be developed[5]:

1) on automated procedure of ship reporting;
2) on procedure of data entry, using harmonized data format and related equipment;
3) on information management system;
4) on familiarization with new symbolic presentation environment (due to lack of standardized symbology of all information required to display on the navigational system);
5) on new communication equipment;
6) for shore based users to be familiarized with the CMDS (Common Maritime Data Structure) and its contents of their own work;

[5] The original wordings of referred document were kept.

7) for shore based users to be familiarized with new presentation and its contents (due to lack of harmonized presentation of domain awareness to improve situational awareness for allied and other support services.)
8) familiarization with the management system for report handling;
9) for shore based users to be familiarized with the information management system and its decision-making support function (traffic monitoring).

In principle, it can be seen that majority the proposals in the list above relate to communication, exchanging and sharing of information. There is no doubt that they are Situation Awareness items, which are included into the STCW Code and worded as “obtaining and maintaining situational awareness”.

Training courses are proposed to be revised:

10) on operation of identification procedure of the communication system;
11) current GMDSS for integrated GMDSS system;
12) on GMDSS should be revised based on the standard operational procedure;
13) on understand the system's automatic action and report to user (due to lack of self-checking functionality of the electronic equipment for improved reliability);
14) on familiarization with the new feature of maneuvering data presentation (due to lack in presentation of maneuvering information/data (engine-room telegraphs) on navigational display;
15) on ECDIS to be familiarized electronic procedure related passage plan (due to lack of standardization for operation of functions to observe the passage plan. Users require standardization on the level of function provided and the operating way of it);
16) on ECDIS as appropriate (due to lack of presentation of calling message of pilot on navigational display. Communication with pilot could be improved;
17) on operation on communication and navigation equipment involved within transfer of information;
18) on general skill on user computer to use the software for digital publication;
19) on Integrated Navigation Systems (due to ineffective access to information);
20) on simple and standardized procedure for priority message;

It can be seen also that majority the proposals of the second list above relate to communication, exchanging and sharing of information.

Mariners and shore personnel are proposed to be trained in the following fields:

21) For proper filtering of information. Some information should not be “filtered away”;
22) Familiarization to status information of each type of equipment. Training to respond the equipment status if necessary;
23) Consideration should be given to the revision of training/education for affected equipment and impact on Bridge Resource Management Training reflecting operational changes and how it is incorporated into practice of navigation;
24) Operator must be trained for operation of data systems;
25) Training should include standards and where to find them;
26) A basic level of relevant language competency should be required ahead of being able to use SMCP (Insufficient use of IMO Standard Marine Communication Phrases (SMCP));
27) Users need to be made aware of the vulnerability of GNSS and the lack of integrity. - users also need to be trained in procedures to be followed if GNSS is disrupted, or in the use of alternative systems;
28) On-line help function should be included in the systems, if available. Familiarization for using of automatic generated assessment results;
29) On-line help function should include self-descriptive information of system's characteristic in view of operational, technical, regulatory and training;
30) Control of software and hardware update should not require additional training of mariners. Human intervention of this procedure should be minimum but there are certain recognition of the certification status;

31) Familiarization for using digital publication on User's computer. Revise the training course for general skill on user computer to use the software for digital publication;
32) Training for a system should be focused to standardized operational procedure of e-navigation Functions dependent on manufacturer or type should be trained and covered by familiarization material and/or on-site training and on-line help function;
33) Stakeholders will need to be trained to comply with data security requirements;
34) Training should be provided for the procedures and use of the equipment both on board and ashore;
35) Identify training required for applying guidance (VTS)- Current VTS hardware may not have the capacity for increased collection, integration, exchange, presentation, storage and analysis of data;
36) Identify training required for the provision of NAS (Navigational Advice and Assistance) and TOS (Traffic Organization) - Current VTS hardware/software may not have the capacity for real time display of vessels' track to provide a NAS or TOS service;
37) Provide adequate training for all communication needs;
38) Ensure training identifies AIS errors and their likely causes;
39) Training for NAS and TOS to be provided to ship and shore personnel. The use of simulation should be considered;
40) All VTS training courses to adopt V 103 model training courses;
41) V 103 model training courses and STCW need to include training in this regard;
42) SAR person should be familiarized with the shared information and its presentation to recognize whole status of SAR operation;
43) On scene operator and coordinator should be advised by the decision support system with enough information for situation awareness;
44) Explicit distress and safety training.

5. Conclusion

So, taking into consideration the proposals above and that e-navigation is about the integration of information, it is getting clear that MET process is waiting challenging changes.

Serious attributions involving SA occur when "Bridge (or Engine room) or Shore based Personnel" error due to loss of SA is listed as a cause of accidents. The results from maritime operations literature survey revealed that 71% of human errors were Situation Awareness related problems, [11]. Failure to mitigate accident due to poor SA also is pointed in frames of e-navigation concept [12,13].

IMO concept of e-navigation might provide ICT revolution initiating and launching the new paradigm of MET system for better SA at all three levels (perception, comprehension, projection) which should be resulted in better decision making on board and ashore for *safety and security at sea and protection of the marine environment*.

In spite of the viewpoint, that now it is premature to consider any training requirements on e-navigation, pending the finalization of the e-navigation Strategy Implementation Plan, for MET universities it is hot time to start the research in e-navigation field relating MET to march in step with Industry and be in advance ready for further phase of comprehensive review of STCW 78 Convention and Code.

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Integrity of Electronic Testing of Mariners

John Tucker [Professor, M.Eng., P.Eng.][1], John Cross [Professor, ONII, M.Eng., P.Eng.][2]

1 Marine Institute, Memorial University of Newfoundland, john.tucker@mi.mun.ca
2. Marine Institute, Memorial University of Newfoundland, john.cross@mi.mun.ca

Abstract. With the Manila Amendments to SCTW that introduce distance learning and web-based learning as valid course delivery systems there have been several initiatives aimed at developing distance courses for mariners. There are ways that content can now be effectively delivered to mariners that allow learning to take place outside the academic setting, most importantly on ship.
However, electronic testing brings with it two potential problems:

- First, the test must be structured so that it provides a fair opportunity for assessment.
- Second, the test must maintain the academic integrity of the evaluation and course.

While electronic testing has been around as long as computers have been in common use, the technology and educational pedagogy is only now beginning to capture the sophistication of a typical test. The delivery of the test is fairly easy, but grading it so that it provides a fair and accurate assessment of a student's capability is much more challenging.

The second problem is that the provider of the test must be certain that the student is displaying their capability. It is naive to think that students are not taking advantage of electronics or other methods to give them an unfair advantage in examination performance. If the examination is taking place at a distance the problem is even greater with the potential for everything from a student "googling" the answer to it not even being the student sitting and writing the test.

For electronic testing to reach its full potential these problems must be addressed. This paper begins with lessons learned from the author's experience in developing electronic questions over the last 5 years and provides some insight and guidance for anyone interested in creating questions. It then goes on to look at how the Marine Institute is currently handling distance testing and the potential for new biometric processes to make distance invigilation stronger and more secure.

***Keywords**:* Electronic Testing, Online Proctoring, Examination of Mariners

1. Introduction

The 2012 Manilla Amendments to STCW opened the door for national certifying authorities to permit Maritime Education and Training institutions (MET's) to deliver certification level training using online or web based. The critical nature of maritime training training and the assessment that must accompany it for certification advancement resulted in this evolution taking a longer time to occur than in most other post secondary education institutions, but the authors feel that this evolution is inevitable.

With the MET transition to online or web delivery lagging most other higher education fields, we are afforded the opportunity to study and learn from online delivery of programs in other areas of higher education and apply those lessons learned to the evolution of our programs and the ways in which we evaluate our learners.

2. The Categorization of MET

Trenholme categorizes online deliveries as being of two distinct types; "Writing-Based" (WB) courses where learners are required to author papers and answer essay type questions, or "Math or Fact-Based" (MFB) style courses in which in which the learners are required to recall facts or perform calculations [1].

WB courses tend to be assessed in a more subjective way where presentation as well as creativity may have an impact on the performance of the learner in an evaluation. A test for academic dishonesty in this type of evaluation would typically be an assessment to determine plagiarism. There are a host of tools and devices to assist in ensuring the academic integrity of WB type evaluations ranging from online plagiarism checkers to student portfolio creation and maintenance tools incorporated into the majority of Learning Management Systems. Sadly, the development of a set of similar tools to prevent academic dishonesty in MFB type courses has not evolved at the same pace. MFB style course evaluations are more objective. The correct answer is, simply, the correct answer. As a consequence of this, an assessment of plagiarism in an MFB type evaluation is not valid.

MET would tend to fall into the category of a MFB type of delivery. Mariners are required to learn mission critical facts and perform objective evaluations in a consistent and timely fashion. This is reflected in the model course content presented in STCW, course deliveries provided by MET Institutions, and evaluations performed to permit certification level advancement as provided by either the MET Institutions or the national certifying authorities.

2.1 Cheating in MET Certification Level Evaluations

It is important to note that, at this time, all certification advancement level examinations of mariners conducted in Canada are conducted using a face-to-face method. In this system, examinees present themselves at an authorized examination centre with appropriate documentation, identification and credentials, and sit to write their examination in an invigilated setting.

In high stakes evaluations such as these, academic honesty is a well-guarded feature of the entire certification process. It is conceivable, however, that even with such a strict and time-tested system, the pressures to perform well on these evaluations can lead individuals to use any means at their disposal to assist them in succeeding in their evaluations.

In the 1980’s, the authors observed a method that was employed to better the chances of success in MET evaluations that was a consequence of poorly designed evaluation databases. It was the case at this time that a limited database of static (unchanging) examinations was employed for certification purposes in Canada. Mariners would write a certification level examination offered by the national certifying authority that was drawn from this limited database, and upon completion they would leave the exam and immediately note the exam questions on that version of the examination. These questions were solved, shared and compiled over time as a set of exam questions that you could expect to see in the certification level examination. Some learners would memorize a set of questions and then take the examination multiple times until they received the exam with the questions they had committed to memory…and pass.

The examination database in Canada has experienced a serious restructuring and updating over the last few years and now draws on a more flexible bank of new questions in the hopes of alleviating the above mentioned issue.

In considering the possibility of offering MET certification level advancement examinations online, as part of a course or not, we must re-evaluate the methods we use to administer and secure the examinations and the writing of the examinations. Providing a less strictly controlled environment for the writing of examinations must be avoided, as it would provide a more tempting opportunity for cheating.

Three factors should be considered as influencing mariners when faced with the perceived opportunity to cheat in an online evaluation:

1. Increasing pressure to advance in certification level. This can come from the opportunity for monetary gains, employment opportunities or status shift.

2. Shifting socio-economic views on the acceptability of cheating on an evaluation. From the examinee's perspective, the mission is to obtain the advancement in certification level. What it takes to obtain this advancement is somewhat irrelevant. From the perspective of the certifying authority, it is imperative that the examinee demonstrate knowledge and expertise in the examination topic area.
3. Anonymity is a factor unique to the administration of online examinations. In the case of online evaluations it is more the perception of anonymity that the examinee may feel when writing an examination with no one else in attendance than the actual fact of anonymity.

Trenholme goes on to add that academic dishonesty observed in an online or web based delivery of a MFB type course is observed as either:

1. Use of an alternate individual, typically an expert, to complete evaluations or assessments.
2. Unauthorized collaboration on evaluations; and
3. Unauthorized coaching on evaluations.

In the context of MET, these evaluations typically consist of requiring the mariner to provide an evaluation or factual data in which the correct answer must be provided in a clear and concise fashion.

Plagiarism is not a factor in MFB assessments as the correct answer is the correct answer. However, the three above-mentioned concerns for academic dishonesty are. For online course deliveries as well as online evaluations to take place, a paradigm must be established whereby there is complete confidence in the academic integrity of all evaluations in the online MET delivery.

3. Structuring Electronic Tests

The purpose of any test is to provide a fair assessment of a student's knowledge and ability. At the most basic level, this is just a recall of facts, however at the higher cognitive levels it requires both a recall of facts as well as assessment of pertinent information and application of a solution algorithm.

In fact testing by electronic machines has been around for over 80 years. The IBM 805 was developed in 1934 and would correct a score sheet placed in it [2]. It would apply a small voltage across the correct multiple choice answer and if a pencil mark was present in that place a small current would flow. The machine would measure the total current flowing and thus the total score for that sheet.

However the digital age has allowed much greater flexibility and sophistication to be employed. The authors were trying various means of incorporating electronic assignments into their classes as a means of reducing plagiarism prior to 2010 [3]. However with the adoption of MapleTA in 2011 for assignments the potential to use it for tests and examinations was first realized. It should be noted that while we use MapleTA, there are a number of similar software packages available that have similar functionality.

The first use of MapleTA for testing was its use to administer a multiple choice type examination in a material science class. It was an obvious candidate since previous examinations in this course were developed from an existing bank of multiple choice questions. However MapleTA allowed a couple of beneficial options. The first was that we could create multiple copies of similar questions (for example a diagram showing a particular plastic manufacturing process and asking what the process was). We could also group related questions together. For example we might have 10 questions related to corrosion. When it came time to make up the exam we would choose the topics we wanted and then the number of questions from each topic (for example we might want 4 questions on corrosion) and MapleTA would create each student an individual test based on how we specified (for example in the case outlined the computer would choose a random 4 out of the 10 corrosion questions). This way tests could be created to target certain areas but also prevent any potential for copying since each student had an individual exam.

Lately, our experience with MapleTA has allowed us to create more sophisticated questions. For example we now have a course in Applied Mechanics running which tests exclusively using MapleTA. A typical question is shown below in Figure 1 where a student is asked to find the centroid and moment of inertia of a complex shape. The dimensions for the shape are randomized within a certain range. For example the thickness of shape 2 can range between 0.5 inches and 1.0 inches in increments of 0.1 inches. In all there are 1,764 possible variations for this question which means in a typical class of 25 students, there is only a 15% chance that two students will get identical questions. However all questions follow the exact same procedure! We call these questions dynamic questions since they change with every student as opposed to a static question where every student answers the same question.

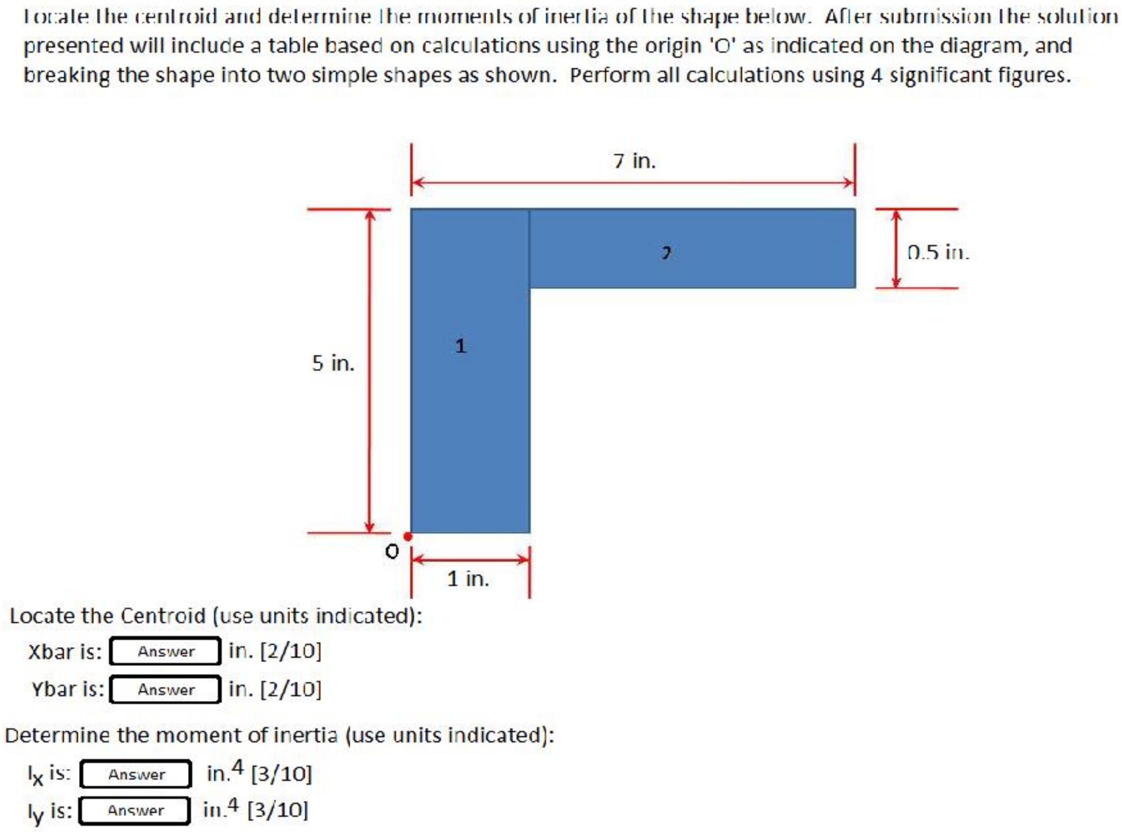

Figure 1 Sample Dynamic Question from MapleTA

The math engine behind MapleTA is very powerful and has allowed us to create questions that do not normally have a calculation based answer. For example to create questions about phase diagrams, the curves were approximated by 4^{th} order polynomials which allow solutions sufficiently accurate to correct answers from students reading tables. Similar things were done in fluid mechanics as well as thermodynamics.

The creation of a static question is a relatively straight forward process where the instructor makes up a question and then answers it. Usually there is not a problem, but if the instructor doesn't like the way the question turns out (too easy or too hard for example) they can change it before giving it to the students.

The development of a static question follows the same process to start with – a static question is created and coded into MapleTA and the solution checked. However then certain variables must be randomized and this requires a number of additional tests. The following is a checklist questions that we apply to the conversion of static questions to dynamic questions.

- Will any selection of the randomized values cause division by zero?

- Will any combination of the randomized values create a non-realistic answer?
- Will any combination of the randomized values cause other physical factors to come into play?
- For multiple choice questions, will any combination of the randomized values result in two or more of the calculated distractors and/or the correct answer to have the same value?

While the creation of dynamic questions is a much longer process than the creation of static questions we see significant benefits in them. To begin with, students can brainstorm as a group yet every individual is forced to do their own work. This is very important since teamwork is a critical skill for them to learn, but at the same time each individual must develop enough confidence to solve problems on their own. In addition the same question can be used multiple times, for example the instructor can solve it in class and then assign the same question for home work but each student will be forced to work through the problem step by step for their individual question. Finally there are tools available that will allow instructors to identify weak or poorly answered questions – this will be expanded upon in Section 4.

4. Assessing Tests and Good Educational Practices

The creation and correction of a test is too often thought of as the end of the instructor's involvement. However due to the importance of training mariners, it is important for MET instructors to continuously review their tests to ensure the evaluation is performing the way it should. To quote Matlock-Hetzel "… some best practices in item and test analysis are too infrequently used in actual practice" [4].

She recommends the following item statistics be used: the p-Value, the d-Value and the p-Biserial. These will be discussed below, but they all require some post-test analysis which is at best tedious and potentially complicated.

When looking at item statistic analysis, electronic testing has two strong advantages. First the records are available electronically and are able to be stored easily, securely and indefinitely. The second is that the digital format makes it very easy to perform the item analysis.

In regards to keeping of student records, electronic testing provides the opportunity to keep student work around as long as you wish. The information is collected as the student performs the exam (note that in our system, the answers are stored on the server so even if the student's computer crashes the information is safe). The storage space is minimal and in our experience the only reason to not keep student records is due to privacy issues. It is hard to imagine a circumstance where student records would be needed after 5 years so we tend to purge student records after five years.

In regards to tracking the performance of test items electronic testing provides some extremely useful statistics which can yield valuable information. By keeping a record of every response to a question as well as the overall grade, a user can identify questions that are possibly misleading.

The question generation software we use generates 5 useful statistics out of which we use 4 to identify potential problem questions. The 4 are: Success rate, p-Value, d-Value and p-Biserial.

The Success rate is the one statistic that Matlock-Hetzel does not use. The reason is that for a test where all questions are either right or wrong then it is the same value as the p-Value. However we use testing for questions where there are multiple parts and thus find both the Success rate and the p-Value useful. The success rate is simply the average score (normalized to a value between 0 and 1) on any particular test item (or question). You can think of it as the average score from all students who were graded on that question. It is useful as a quick check of the validity of the test item. If no one is getting the question wrong (i.e. the Success rate is 1) then perhaps the question is too easy. If no one is getting the question right (i.e. the Success rate is 0) then perhaps the question is too hard or has some other issue with it such as no correct answer.

The p-Value is a measure of the ratio of fully correct responses to the test item to all the responses. Taken with the Success rate it can provide information about the internal structure of the test item. If the p-Value is the same as the Success rate then there are no partial marks being awarded because all students get the question completely correct or completely wrong.

The d-Value is the discrimination of the test item. It is calculated by finding the difference of the p-Value of the top half of students (based on overall exam scores) and the p-Value of the bottom half of the students. It can be a value between -1 and +1. This is useful as rough measurement of how well good students do on a question as opposed to no-so-good students. We would expect students who score highly on the test to be knowledgeable about the subject material and thus would score well on any given item. The converse is true for students who are in the lower half of exam scores. A high positive value is desirable for a typical test item.

The last statistic is the p-Biserial or point biserial correlation coefficient. It is a more sophisticated measure of how well good students do as opposed to the no-so-good students, so it is a better indicator of how good students (and how no-so-good students) do on a particular question. It ranges in value potentially between -1 and +1. A higher positive value generally indicates a test item that is accurate at measuring student performance.

It is important to note that any of the above statistics for the results from an individual class are, by themselves, only an indication of whether a problem exists. An instructor needs to examine potential problematic questions to see if there really is an issue with the question. Figure 2 shown the statistics from a typical class of 21 students.

Item Statistics :

Old Assignment 2 ⚠

Question	Description	Success rate	p-Value	d-Value	p-Biserial	r-Biserial	Count	Correct	Partial	Incorrect
(1)	Problem 1.1 (4)	0.833	0.81	0.096	0.54	0.78	21	17	1	3
(2)	Problem 1.3 (4)	0.714	0.524	0.24	0.434	0.544	21	11	7	3
(3)	Problem 1.5 (4)	0.81	0.81	0.298	0.707	1.021	21	17	0	4
(4)	Problem 1.7 (4)	0.881	0.857	0.173	0.717	1.113	21	18	1	2
(5)	Problem 1.10 (6)	0.667	0.429	0.087	0.429	0.541	21	9	8	4
(6)	Problem 1.19 (3)	0.857	0.857	0.375	0.804	1.247	21	18	0	3
(7)	Problem 1.25 (9)	0.592	0.381	0.615	0.491	0.625	21	8	9	4
(8)	Problem 1.39 (6)	0.857	0.857	0.375	0.73	1.132	21	18	0	3

Figure 2 Question Statistics obtained from MapleT.A.

As can be seen, no question had either a 100% success rate or a 100% failure rate which is an indicator that it is testing student knowledge. The p-Value is showing that there are a suitable range of partial marks being awarded for each question. The d-Values are all positive, but question 1 and 5 show very low values indicating that students in the top half of the class do about the same as students in the bottom half of the class. While not a problem by itself, it does indicate potential problems so we look at the p-Biserial value. The p-Biserial values are 0.54 and 0.43 which both indicate a question which is functioning as it should.

5. Online Proctoring

The issue of proctoring exams is one of the most critical and culturally complex issues in the delivery of online certification level courses. Historically, students taking distance courses were required to travel to an authorized examination centre to write tests and examinations in a proctored or supervised setting. The challenge being that many learners participate in these courses because they lack the ability to conveniently travel to such a centre to participate in course evaluations. This contradicts with the rationale for online delivery and, until recently, resulted in post secondary institution struggling with the question of trusting students to write examinations on their own computers in an unproctored setting or requiring the students to travel to an examination centre.

Advancements in technology have provided some interesting solutions to this challenge. There are many companies who, today, provide online proctoring services. All of these services have standard, common features [5]. The process of taking an online test would typically begin with some form of authentication. This could be in the form having the student input a username and password but may also involve verification of the persons identity using a photo ID and a webcam or facial recognition softward. The test itself typically involves an actual proctor, which could be human or some form of technology which would observe the test taker during the evaluation event. This observation could be of the form where the testees computer (screen) is being observed or recorded as well as the individual being observed using a webcam and a computer microphone. This permits the proctor to observe the test paper, to watch the individual to ensure that they stay at their desk during the evaluation, and it also permits the proctor to listen to the person being tested to ensure they are not in communication with anyone who is unauthorized during the test event.

MUN recently conducted a study and has implemented a policy to manage online proctoring of examinations. Online exam proctoring is now the default method of invigilation for examining students that reside outside the province of Newfoundland and Labrador. Professional proctors use webcams and microphones to remotely supervise students writing exams during their examination period.

The students may write their examinations at home or any quiet location with an active internet connection. The exam is written using a secure lock down browser and the scheduling of examinations is flexible but has to be set up beforehand.

Similar to writing exams in a classroom, students are required to show both their MUN Campus ID Card as well as a government-issued photo ID to the proctor prior to taking the exam. To ensure the privacy of student information, all data is stored in a secure data center in Canada and may be temporarily stored in secure locations outside Canada to facilitate transfer.

There are specific technical requirements that must be met, but they are not onerous or requirements that a student participating in an online course would not already be expected to have.

We can expect uncertainty about electronic examinations outside of a campus to remain a concern, but new technologies are constantly alleviating problems.

More sophisticated and secure means of authenticating and proctoring critical evaluations is that of using biometric techniques to monitor students. The three main biometric systems are: finger prints, facial recognition and retina scans. All provide some degree of certainty that the correct person is sitting at the computer, however there are still potential problems with having unmonitored students taking examinations. In addition, Canada has some of the strongest privacy laws in the country and some of these methods are considered intrusive.

6. Conclusion

With online distance courses becoming almost the norm these days, the use of electronic testing for distance courses must be seriously considered. It provides the convenience of allowing mariners to progress without the challenges of geography that mariners often face. However it comes with a number of potential problems that must be weighed against the benefits.

The problems are that confidence in the test administration and delivery process must be gained at all levels on the certifying side. Everyone from those who administer the evaluations to the certifying authority and IMO must have full confidence in the delivery of online evaluations before this type of testing will be permissible. An additional challenge to be considered is from the perspective of the mariner being evaluated in that they must understand the safeguards that have been put in place to ensure the academic integrity of the test and not feel that, although they are alone in the room while taking the evaluation, they are not being proctored.

The benefits are that it allows great flexibility in administering tests and has the potential to make tests more secure by allowing individual tests to be created, administered and corrected automatically. In addition it allows the instructor to continuously monitor the test's performance to ensure that it is evaluating the way it is supposed to.

While the proctoring issue is significant, we feel that this will soon be solved in an acceptable manner and then electronic testing will allow the convenience and flexibility that mariners will find useful as they progress through their careers.

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Increasing the sustainability of the maritime research and training

Commodore Boyan Mednikarov, Prof.Dr.M.Sc.[1]
Captain (Navy) Kalin Kalinov, Professor Ph.D.[2]
Captain (Navy) Nedko Dimitrov, Associated Professor Ph.D. [3]
CDR Zhelyazko Nikolov, Assistant Professor Ph.D. [4]

1. Nikola Vaptsarov Naval Academy, Varna, Bulgaria, bobmednikarov@abv.bg
2. Nikola Vaptsarov Naval Academy, kalinov.ks@gmail.com
3. Nikola Vaptsarov Naval Academy, n.dimitrov@nvna.eu
4. Nikola Vaptsarov Naval Academy, zhelyazko_nikolov@abv.bg

Abstract. The research actions in the maritime domain today are very High-Tech oriented and require specialised research infrastructure. That is the reason for the necessity to invest in such a research infrastructure in order to keep the cutting edge level of maritime research and innovation.

Because we cannot afford a big amount of money in our budget for acquiring an expensive maritime research infrastructure, the only way to succeed is to conduct project oriented research activities. Proceeding this way, we have to convincingly prove that the research infrastructure will be used on an effective manner to benefit best.

One of the possible ways to reach maximum use of such an expensive maritime research infrastructure is to use it not only for the research activities but for education and training as well. We are gathering experience in this area applying for financing the project “Centre of Competence for the Black Sea offshore support”. It is dedicated to establishment of Centre of Competence in the area of ICT that has the capability to support scientific research in the maritime area and the offshore business developments. At the same time the sustainability of the infrastructure is increased by using it as a simulator in the E&T of personnel for the offshore and nautical industry.

This optimisation is possible because of the use of competence, knowledge and information by means of software and hardware products. The modelling of the processes allows us tosimulate the functions of the real infrastructure and to provide complex standardized realistic and real-time simulation environments for the maritime and offshore industry, used in nautical studies and training facilities.

ICT in the area of simulation is a basis for personnel training and scientific research following the integration of the scientific/educational organization and separate scientists/instructors. We think about three possible areas of application of this infrastructure: simulators; technology transfer; training.

We hope the problem with the sustainability of the research infrastructure we are facing is addressed and resolved best.

Keywords: modelling, simulation, research and training, sustainability, integration

1. Introduction

The Bulgarian high education is close connected to the research, development and innovations (R&D&I) activities due to many reasons.
The most important among them is that R&D&Ihelp the academic staff to keep the level of knowledge and competences up-to date. The development of research and innovations activities in the EU member states and the regions is one of the key tools for achieving the targets under Europe 2020. This is the solid base for reaching a sustainable economic development and social prosperity. As a national priority, as well, our country tries to stimulate R&D&I activities creating appropriate environment in the universities and scientific institutions. This is valid in the maritime area, too.

On the other hand maritime education and training has to follow the global tendencies in the maritime domain[6]:

– increasing role of the automation of the processes and subsequent tendency for professionalization of the activities
– multiagency environment for maritime activities
– enlargement of the maritime activities geographically
– establishment of a common maritime safety and security system

Following the trends in maritime education and R&D&I the developments in the area are logically connected with the complexity approach that allows double use of the capacity - scientific and educational.

2. Modern simulation systems for marine personnel training

The maritime education system in Bulgaria prepares personnel for two major areas – the marine industry and the navy. The users of such personnel demand higher and higher standards for their level of training. A way the maritime education system to respond to the latest requirements and to reflect better the global tendencies in the maritime domain is to facilitate conditions of training as close as possible to the real world. Thus, the acquisition of simulators adequate to the requirements is becoming an important issue for the modern maritime training. Notwithstanding its financial aspect, the solution to this issue is indirectly preconditioned by the development tendencies for the maritime platforms, and directly - by the closely related to that progress prospects for the simulation systems.

2.1 Maritime simulation systems at Nikola Vaptsarov Naval Academy, Varna

One of the most important elements of the training equipment are simulators that allow to conduct training in conditions close to reality. To provide the necessary practical skills of students and cadets from different specialties 11 simulator are used, the majority of which were delivered in the last 2-3 years.The Naval Academy, Varna has a number of trainers involved in teaching and training of maritime personnel. All laboratories are built to the highest standards of learning and using modern facilities and advanced technical realization of leading companies in their respective fields. All teachers are trained and certified by manufacturers.

Simulators take a serious place in the courses under STCW, by meeting all requirements of the International Maritime Organization.

The following simulators are available:

- "Ship bridge" - TRANSAS-NTPRO- 5000
- Complex navigation simulator "Ship bridge" - TRANSAS-NTPRO-3000
- Navigation simulator "Ship bridge" - TRANSAS - NTPRO -5000 + ECDIS
- Navigation simulator "TRANSAS-NTPRO-3000 for maneuvering and radarguidance
- Electronic navigation charts simulator - ECDIS
- Simulator "NORCONTOL"
- Simulator "ERS - 5000"
- Simulator 'GMDSS"
- Simulator “VTMIS”
- Simulator "Watch Naval Officer"
- Simulator "Watch Naval Engine Officer"
- Simulator of information systems for vessel traffic monitoring and managing

[6]Mednikarov B, Transforming Maritime Education:Local Decisions in Global Perspective, International Association of Maritime Universities AGA11, pp. 367-376 [8]

- Simulation complex Information system for monitoring and integrated control of the coastal zone.

A number of laboratories are involved in teaching and training of maritime personnel. Could be outlined:
- Laboratory for preventing and oil spills response
- Laboratory for analysis and efficiency improvement of ship propulsion complex "NAVYSIM BRIDGE"
- Academic Training Workshop
- High Voltage Ship Laboratory (over 1000 Volts)
- Laboratory for marine power systems and electric drives for ships

All laboratories are built to the highest standards of learning and using modern facilities and advanced technical realization of leading companies in their respective fields. All teachers are trained and certified by manufacturers.

Nevertheless, we have a long list of simulators we need on one hand to keep them up-to date and on the second hand – to increase the training capacity of the Academy in order to be adequate to the market situation. This requires allocation of investments, even bigger one that could not be available any time. So we have found an alternative decision for such cases.

2.2 Trends of the modern simulation systems for the maritime E&T

2.2.1. Accounting for the diminished significance of the human factor.

The expected ever-increasing automation of ship control and maritime related processes will diminish the impact of the human factor on the navigation bridge, in the central command post, on the offshore installations etc., and this will lead to the creation of simulation systems facilitating the practice of issues related to:
- work with multifunctional software-supported consoles
- monitoring and control of software and hardware for processing information obtained from various sources
- analysis of data from the on-board computers and the environment and decision-making.

2.2.2. High level of integration – integrating the navigation, communications, firefighting, power plant and other simulators.

This prospect will direct the development of simulation systems toward the creation of virtual ship/installation models to enable simultaneous and joint practice of trainees from different specialties.

2.2.3. Making the working conditions as realistic as possible.

Enabling the realistic recreation of a wide array of factors from the environment – visual picture, weather conditions, noise, ship motions, vibrations, as well as working under time pressure and at involuntary rate.

2.2.4. Modern simulation systems for the naval personnel E&T and research.

Naval simulators play an important part in the preparation of personnel for the Navy. Simultaneously, some of them permit all-level operational and tactical modelling, facilitating conditions for academic research and for studying different scenarios for different operations. Beside the prospects mentioned in the previous paragraph, the expected development of the existing simulators by enhancing their capabilities for modelling and simulation of planning and conducting combat action, as well as enhancing the modelling of different platforms, weapons systems control, using communications and information support systems, electronic warfare, etc.

2.2.5. Technology transfer as a result of the increased importance of the simulation systems in the maritime E&T.

An important way and mean to facilitate technology transfer through simulations is finding, acquisition and utilisation of modern simulation systems. The steady trends in this direction give reasons to conclude that technology transfer is becoming a significant prospect in the context of the subject of this paper. In today's world, the need of sharing knowledge, skills and technology, especially in the marine industry, is ever increasing. Expanding the sphere of possibilities in this aspect can be supported by the use of simulation systems.

3. Capacity building for research, development and innovations

The specific needs that Bulgaria experiences in this area fall into several groups:

3.1. At a national level: increasing investment in R&D&I with a focus on excellent science

3.1.1. Increasing investment in R&D&I and enhancing research excellence.

The statistical data shows[7,8] that in the past seven years, the R&D intensity in Bulgaria increased from 0.45% of the GDP in 2007 to 0.67% in 2013. However, the latter value is still significantly lower than the national target of 1.5% by 2020[9], as well as the current EU average value of 2.06%. The increase in the total intensity is exclusively due to increased R&D investment in the business sector (to 0.43%), while in the public sector there was a decrease - from 0.31 in 2007 to 0.24% in 2012 (the lowest value in the EU)[10]. The main factor for the increase in the total R&D investment was the increased share of foreign funding (both private and EU funding), which grew from 7% in 2007 to 44% in 2011.

These persistently low levels of R&D funding in the country generated an array of negative consequences:[3,11]

- obsolete research infrastructure
- low payment for researchers
- emigration of talented and highly-skilled young researchers (brain-drain)
- significantly reduced interest in a research career among young people, and
- continuously decreasing interest in the study of engineering and natural science subjects. The overall scientific performance in Bulgaria is relatively low, as reflected in various indicators.[3] For example, of particular concern are the declining share of scientific publications featured in the top 10 % most-cited scientific publications worldwide, which are only 3.2 % from all scientific publications for 2009 (the third lowest value in the EU) and the low and falling level of public expenditure on R&D financed by business enterprise (-4.4 % as % of GDP over period 2007-2012) [3].

The level of Bulgarian participation in EU Framework Programmes is also limited. Both the applicant success rate of 16.5% and the EC financial contribution success rate of 10.5% are much lower than the EU averages (21.9% and 19.7% respectively). On the composite indicator of research excellence, Bulgaria ranks 21st in the EU.[3]

To overcome these negative trends Bulgaria needs to increase significantly the funding in R&D activities, mobilizing both public and private investments, with a special focus on research excellence.

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[7]Research and Innovation Performance in Bulgaria, Country Profile 2014 [10]

[8] Data from the National Institute of Statistics for 2013

[9]National Development Program: Bulgaria 2020, adopted with decision 1057/Council of Ministers, 20.12.2012, p. 250 [9].

[10] Innovation Union Competitiveness Report 2013 SWD, January 2014[5]

[11]Innovation Strategy for Smart Specialization, The Republic of Bulgaria, 2014-2020 (draft 17.11.2014)[4]

3.1.2. Market-oriented research to boost innovation capacity and competitiveness

Bulgaria is a modest innovator and remains the poorest performer in the EU-28,[12] due to structural underfunding, difficult procedures to access project funding, fragmented funding in different areas, poor connections between science, education and business, and lack of strategic focus of the interventions in this area.[3,6] It is important to note that the poor performance is grossly affected by the excessively low R&D expenditure in the public sector as % of GDP, by the weak innovation activities of SMEs and by the strong orientation of the Bulgarian research system towards the basic research[13].

There are certain strengths that could be used as the basis for a market-oriented reform:[6,14]
- good traditions in natural sciences
- preserved science schools and high publication rate in specific areas which are relevant to the emerging technologies (physics, chemistry, materials science, biochemistry and molecular biology, medicine, pharmaceutical and engineering sciences)
- cultural diversity coupled with a specific national identity
- pronounced orientation towards international collaboration of researchers
- positive public attitude towards education and science.

Modern and well-equipped research infrastructures are important elements of R&D&I eco-systems.[9] The analysis of the National Research Development Strategy 2020 identifies the following negative trends in the state of play of research infrastructure in Bulgaria:
- outdated facilities and inefficient use of the existing facilities
- lack of advanced approach to the administrative and financial management of the existing infrastructure in base organisations
- lack of professionally trained and qualified staff to operate the facilities and their users
- lack of coordination and complementarity of available modern facilities within a single organisation or in between different organisations
- lack of concentration of equipment and, in some cases, a highly personalised approach and duplication of equipment.

3.2. At a regional level: Improvement of the territorial and thematic distribution of research infrastructure, with a view to regional smart specialization

Bulgaria's research system remains highly concentrated in institutional and geographic terms.[9]The top five institutions, all of them being located in Sofia city region, produce about 75 % of the total publications.[9] The analysis of the current map of research organizations in Bulgaria reveals the following features:

The most active scientific organisations in attracting funding (86 % of the total R&D funding in Bulgaria) and in the implementation of national and international projects are those in Sofia-city region[15]. These organizations have diverse research profiles and are involved in active cooperation with local and international companies.
Relatively high research activity and a clear regional specialisation can be observed in the Plovdiv region. The economic profile of the country's second largest city – Plovdiv, is strongly food- and agriculture-oriented[16].

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[12]Innovation Union Scoreboard 2014 [6]

[13]cf. Figures 1, 7 and 11 in the Innovation Union Scoreboard 2014[6]

[14]Input to Bulgaria's Research and Innovation Strategy for Smart Specialization, World Bank Report, 2013 [7].

[15]Including the institutes of the Bulgarian Academy of Sciences, Sofia University "St. Kliment Ohridski", Medical University of Sofia, Technical University of Sofia and some other universities.

[16]The most active players in the area are: Plovdiv University "Paisii Hilendarski", Medical University of Plovdiv and University for Food Technologies.

The third most developed region in terms of knowledge and entrepreneurial dynamics is Varna[17]. The region is further important for the development of alternative energy sources and the conservation of the natural resources of the Black Sea region.

In the remaining Bulgarian regions there is no clear specialisation of the scientific organisations and their cooperation with the business.

Regionally sited research infrastructure and universities are of particular importance given the potential socio-economic that they can produce[18]. Universities in particular are critical 'assets', mainly in less developed regions where private sector may be weak or relatively small, with low level of research and development activity[19].

3.3 Necessity at institutional level

As noted in the World Bank Report, countries like Bulgaria need a viable, internationally connected scientific system, in order to absorb and economically benefit from the knowledge generated worldwide.[9] Therefore, systemic interventions are needed to support the Bulgarian research organizations and schools of higher education in their international research cooperation. These interventions will find a good basis – almost 50 % of all published articles are produced in collaboration with researchers from other countries.[9] Bulgaria's main partners are from high-performance countries. The efforts in favour of the internationalisation of Bulgarian research should be driven by the objective of achieving results in the areas where impact could be potentially the greatest for Bulgarian economy[20].

Several types of current needs could be identified in this context:
- It is necessary to create and modernize unique research infrastructures which could be included as integral parts of the distributed European research infrastructures
- Bulgarian researchers and research organizations need better and more systematic support in their efforts to be fully integrated in the European Research Area, including the development of future and emerging technologies at European level, as well as the participation in EU research programs, European technology platforms, partnership projects and networks.
- Bulgarian researchers need free and convenient access to the international databases of scientific data and publications, as they could not be fully efficient in their research without such access.

3.4 Possible financing for research infrastructure improvement

However, the strengths must be streamlined to materialize the innovation potential of the Bulgarian research institutionsand to work on their adaptability and sustainability through greater focus on market signals and ways to attract private investors[21,22]. The Operational Program Science and Education for the Smart Growth (OP SESG) should play a crucial role in improving the level of R&D&I and in activating the innovation potential that Bulgaria could move up from 'modest' to the level of 'moderate' innovators. For this purpose, OP SESG will focus the R&D&I financial resources and innovations on the following priority areas:[9]
- Mechatronics and clean technologies

[17]The best performing actors in Varna are: Technical University of Varna, Medical University of Varna and Oceanology Institute of BAS, working in areas such as quality of life, health and environment.

[18]Commission publication 'Connecting Universities to regional growth – practical guide' Sept 2011. [1]

[19]Guide to strategies for S3 – May 2012.[3]

[20]Science and Education for Smart Growth, Operational programme 2014-2020, pp. 12-18 [11]

[21]Study of DG RTDExpert Group, October 2013, sections 4.3-4,4[12].

[22]ERAWATCH report 2012, p. 17.[2]

- Informatics and ICT
- Industry for healthy living and biotechnology, and
- New technologies in creative and recreational industries.

The expected financial intervention by OP SESG to support research infrastructure improvement is app. 13M Euro – 15M Euro per Centre of Competence (CoC). Thus supporting the market-oriented R&D activities and mainstreaming the financial interventions from OP SESG in the priority sectors aims to improve the competitiveness of Bulgarian research system and overall economy.
The modernisation of research infrastructures can have important positive effects in several aspects:
- improving the opportunities for cooperation between leading scientific organisations and the business
- much higher quality of staff training in modern technologies
- improving the opportunities for involvement of Bulgarian scientific teams in European networks for development of new technologies in key enabling areas, which have been identified as priorities for Bulgaria and for the entire European Union.

In this context, it is crucial that universities are not seen only as islands for academic and fundamental research but as potentially strong contributors to the local economy including employment and industry[10]. They should become key players of regional specialisation and build the capacity to cooperate with businesses in the priority areas identified.

The negative trends, mentioned above, underpin a number of important issues whose solution requires a systemic approach. First, it is necessary to prioritise infrastructure investments which contribute to specialisation in the priority areas. Second, it is necessary to set up a national system for the use of large research infrastructures, created with public funds – with publicly available map of the research equipment, clear rules of its use, broad access for public organisations and businesses, maximum efficiency, and a unified system for the distribution of public results. Third, it is necessary to support the leading regional universities and scientific centres to adapt to the new priorities - this will require a modernisation of their laboratories and research equipment to improve their capacity for research and to allow them to provide relevant, business oriented services.

4. Integration of the maritime research and training trough theCentre of competence concept

Nikola Vaptsarov Naval Academy (NVNA) decided to benefit from the OP SESG establishing Centre of Competence (CoC) for the offshore support at the Black Sea region. The subject was chosen after analysis of the level of the offshore explorations and further actions and existing centres on the topic worldwide.

According to the developed CoC concept paper the mission of the CoC will provide practice-oriented scientific and educational/training support to the development of the strategic area of the maritime offshore industry, subsea actions and related support and supply activities, the national policy for training of highly qualified personnel for the European maritime economics.

The functional areas for the scientific activities will be:
- Offshore and related support and supply activities
- Subsea actions and engineering support
- Support and supply fleet
- Oil spill management.

As the analysis reveals the need for creation and development of a leading research centre it has to be equipped with modern research infrastructure and equipment, able to conduct top-level research and innovations at European level, with focus on offshore actions support.

The research activities will be focused on the optimisation of the functional parameters and control of the offshore installations, support fleet and oil spill response. As general, the acquired machinery samples will be used to prepare software (simulations) models of different type of equipment, installations and sensor systems. These models will be tested in a virtual environment in order to find a way to provide:

- Optimisation of the functional parameters of the authentic complexes
- Creation of the optimised models of education/training
- Determine the opportunities for new technologies and sample installations implementation.

Important role of the CoC is the development and the test of virtual models and sensor systems used in the area of ocean engineering and in education/training the personnel for the offshore industry.

A unique nature of the approach is that the CoC is proposed to be as a network of collaborations and partnerships between the academic and non-academic, public and private sectors. This will keep the existing unique research and training specialization and expertise of the institutions as well as of individual researchers, and will create a synergy of efforts that will allow further improvement of the existing capacities and avoidance of resource duplication in reaching the goals. Inclusion of a business cluster in this network will bring a benefit in correct needs identification and issues addressing, as well as to achieve knowledge and technology transfer, market oriented research program in order to improve the competitiveness of Bulgarian research system and overall economy.

Table 1 Expected specific outcomes of the CoC

2 years	5 years	10 years
R&D infrastructure improvement; 5 doctoral researches in the area of offshore support launched	Completed 4 doctoral programs Cooperation and participation in international joint R&D teams	Completed 2 research project and generated 4+ Publications with impact factor
Generate 2 R&D activities on offshore industry request	Completed 2 R&D activities on industry request; stabile training environment	Conducted R&D on yearly industry request; Continuous training.
Accredited: - Master program - Doctoral program	Graduated masters and doctoral degree; Min 30% women involved;	Young specialists educated and trained in offshore area

The expected benefit of the CoC operation will be complex. Both sides – researchers and users (business) will directly benefit from the CoC initiatives, and indirect ones will be for the society and regional/national economy. The benefits will include:

- coordinated policy for scientific and innovation activities
- modern research and innovation infrastructure
- integrated institutional research environment
- excellent training opportunities
- favorable age profile
- interaction between research/training institutions and companies.

The general outcomes include:

- networking collaboration and partnership between the academic and non-academic public and private sectors in the area of offshore support
- successful knowledge and technology transfer
- strengthening the synergy of the scientific organizations' efforts and key economic entities leading to overall economic development of the region
- Preparation of next generation researchers and training needed for the offshore industry.

The specific outcomes refer to the objectives and future expectations are defined in table №1.

5. Conclusion

The upgrade/modernization of the scientific infrastructure of the academies and research institutions is needed and planned based on the conducted analysis of the current status and the level of ambition at national level. The financing will be used for the establishment of modern research center (CoC).

The developed concept paper for CoCfor the Black Sea offshore supportstresses on the need to acquire the necessary scientific infrastructure in the area of maritime and offshore actions and organizational establishment. At the same time this infrastructure has to be maintained and upgrade during the life cycle. Not to forget that the modern technologies are rapidly evolving and therefore grow old very quickly. Using the software simulations (as part of the scientific infrastructure) for the training purpose out of the research time (that expect to be significantly lower) will increase the sustainability of the research infrastructure and will guarantee incomes that may be used for maintenance and upgrade during the life cycle. Thus integration of research and training on common infrastructure will increase its sustainability and effectiveness compared with the separate conduction.

The opportunity to acquire research infrastructure could be motivated and supported better by involving it in the training and qualification activities. This way the integrity of the scientific infrastructure will be the main guaranty for itssustainability, i.e. the integration of the research with the training and qualification activities.

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Distance Learning for Egyptian seafarers: a critique

Prof. Capt. Hesham M. Helal

Maritime Postgraduate Studies Institute, AASTMT
hhelal2000@aast.edu - Miami, P.O.Box 1029, Alexandria, EGYPT

Abstract: Maritime industry is one of the most important international industries as the majority of the global cargo is transferred onboard ships. It is organized through a group of international instruments such as; Conventions, Resolutions, Decrees, and Codes that give great cares for the three elements. Even though, the International Maritime Organization (IMO) prove statistically that more than 80% of the marine casualties occur because of human errors, which gives more emphasis to the importance of human element engaged on jobs either at ports or onboard ships [2].

This paper will focus on seafarers, the most important element of the maritime industry, from the education and training point of view. As, seafarers need to update their certificates (Mandatory Courses) every 5 years, in addition to the upgrading studies for the officers, and of course all of these courses should be done, otherwise the seafarer will not be able to renew their seaman book or Certificate of Competency (COC) to get a job onboard. Moreover, the fees for these courses are often slightly high, not only the course fees, but for seafarers who do not live in the same city they have to spend extra expenses to pay transportation and accommodation.

Thus, time and expenses represent tow major problems facing seafarers, as they should attend these courses in person at a maritime institute or Academy. Some countries like NORWAY considers the Computer Based Training (CBT) where seafarers can take the courses in their place without attending the courses physically in any institute, but this system is not applied in many countries like EGYPT. This might suggest a real need to solve this problem which may require using Distance Learning (DL) as a tool for all seafarers registered or graduated from EGYPT or from other ARAB States. Students may be asked then to attend the training sessions and exams to fulfill the administration requirements and also comply with all international regimes, saving most of the expenses for their transportation and accommodation.

Keywords: Maritime Industry - international instruments – Distance learning- Seafarers

1. Introduction:

In order to look for a job onboard, a seafarer should hold a valid Certificate of Competency (COC) in maritime field. Sometimes, the time for upgrading and getting mandatory courses required for a seafarer may conflict with his/her job schedule, leading in most cases to job loss. This represents one of the main problems in this regard. Moreover, relatively high course fees and the indirect expenses, such as transportation and accommodation, represent another major problem to seafarers.

To get around these difficulties, some countries provided Computer Based Training (CBT), where seafarers can take his courses at any location without attending physically in any institute. But this system is not commonly applied in many countries including EGYPT, which addresses the real need for other mechanisms to solve this problem [8]. Distance Learning (DL) represents one of these solutions. In this case, applicants will take part of the course through DL, whereas the training sessions and examinations will be completed at the maritime institution, in compliance with the national administration requirements and international conventions, resolutions, decrees and codes. This particular alternative, that is DL, seems to be promising and will, therefore, be the main theme of the current endeavor.

Moreover, the international bodies encourage member states to use Distance Learning, as IMO in the last amendments to the Standard of Training, Certification, and Watch keeping (STCW 1978) convention in its amendments in 2010 in Manila encourages member states to use modern training methodology including distance learning and web-based learning [3].

Also, the World Bank is now actively promoting the quality and relevance of tertiary education, while in the past the World Bank was emphasizing basic education and provided only ad-hoc support for tertiary educational development [11].

Furthermore, the opportunities offered by DL, facilitating both mandatory and upgrading maritime study, and reducing geographical constraints regarding travel and access. Thus, it could be the most efficient expansion route for tertiary education, as United Nations educational, Scientific, and Cultural Organization [9] clarified that one of the major benefit of DL lies in its potential for making knowledge and skills accessible to: Indigenous peoples and others located in remote, rural areas who do not have conventional access to higher education institutions and where there is often a shortage of well-prepared teachers and other educational professionals.

The purpose of this paper has two primary objectives. The first objective is to examine the relationships between on-campus studies in the maritime field including academic approach to deep learning to comply with the national and international requirements and to cope with the modern technology used recently at sea, and Distance Learning. Second is to explore the individual effects and benefits from the deep approaches to learning in distance education environments when delivering short courses (mandatory courses) and upgrading studies in the maritime field.

2. Seafarers' Problem:

Although many theorists develop theories about Distance Learning, but those theories are not suitable to be implemented as it is in the maritime field, which means they need some modifications to be capable to be used in this field. For example, Moore suggested that instructors must change their behaviors by changing their course structure and course dialogue, while in the maritime field the instructors disabled to change the course structure as they have to follow the course structure issued from the domestic administration and IMO [6].

Despite, the huge number of seafarers, they are suffering from lack of job opportunities, which has been reflected on their disability to pay for the courses needed to upgrade their certificates or to get the mandatory courses. In addition, they must comply with all conventions issued from the IMO and ILO and to be familiar with all required codes, resolutions and decrees as well, that means to get job opportunities they must be qualified and updated for these opportunities and able to compete with other nationalities. Usually, they attend these courses in maritime institutes but the majority of those seafarers are not living nearby those institutes or even out of the country, which cost them a lot of money not only for fees but also for transportation and accommodation.

Thus, they need an alternative method to fulfill these requirements rather than attending these courses in institutes which may be done through Distance Learning. Distance Learning up to now is not used in the maritime field in EGYPT and all studies depended on the traditional learning on-campus, but developed DL theory or new one may be a solution to overcome the seafarers’ problems of education.

3. Importance of DL for Seafarers:

The spread of technology, using of computer and computer-based communications are the major reasons nowadays for depending on distance learning as an alternative method of traditional teaching in classrooms [1]. Distance Learning gives opportunity to people who are disadvantaged from attending class while these courses are essential to seafarers. Several significant models were developed based on different theories that explain important aspect of DL. In explanation of the concept of DL, Wedemeyerclarified that DL is quite a different concept than traditional teaching in school as it's physically separated from a teacher by means of communications through print, mechanical or electronic devices [10].

Thus, Wedemeyer put a concept or legislation for administrator, program planner, teacher and officials in governments and industry for a modern approach of education. Also, Moore (1990) built his theory (transactional theory) on Wedemeger theory as he believes there is a distance in the relationship of learner and teacher in the educational enterprise, which is not geographic, but educational and psychological as well [10].

From the statement of Moore it is clear that his concept in education was based on a social consideration rather than physical consideration which fits with the nature and circumstances of seafarers' life [5]. Thus, Moore's theory contributes to DL by recognizing the industrialization of education, which depends on the number of the audience, so in the case of the maritime field especially in Arab Academy for Science, Technology and Maritime Transport (AASTMT) the mass of audience is expected to be suitable for establishing the use of DL programs for seafarers as most of them are not only located away from the campus in Alexandria, but also sometimes they are located overseas from Arab and/or African countries. Furthermore, Perraton defined distance education as;

> *"distance study is a rationalized method involving the division of labor of providing knowledge, which as a result of applying the principals of industrial organizations as well as extensive use of technology, therefore facilitating the reproduction of objective teaching activity in any numbers, allows large numbers of students to participate in university study simultaneously, regardless of their place and occupation"*. [7]

Moreover, DL should be defined as a whole education, not only just a separation between teacher and student in space and time, which could be bridged by communications technology. The most common problem in teaching is the absence of the dialogue between the teacher and the students, which may occur even in the traditional teaching in the classroom, so the solution not in the face-to-face relationship but it is the way of creating a relationship between both of them, so DL may be considered as a product of postindustrial information culture. In other words, rather than traditional teaching for example in the maritime field tried to standardize marine sciences and instructions to make seafarers capable of performing routine job, DL role is to respond to individual differences and fulfill the national and international requirements as diversified as possible.

This brief review looks to the maritime field and the problem facing seafarers in Arab countries. Maritime institutions have thought of expanding the intake of new students despite the rising costs and quality of teaching. This needs from administrators and officials in government to find out alternatives in education methods, such as to consider the reliance on distance education to meet these challenges [6]. However, teachers and administrators are familiar and experts in on-campus maritime studies and are capable to deliver these courses (short courses & upgrading studies) and evaluate them, but there has been little research about the influence of distant learning and the institutions' ability of providing quality learning experiences in the institutional environment.

4. Case study:

Two studies has been chosen, the first for the examining the effects of instructional format for both DL and traditional education, which this paper discuss. While the second has been chosen because of the society circumstances and the age range of the population of the study, which is similar to seafarers' circumstances.

BUCCI, conducted a study to examine the individual and interaction effects of instructional format (distance education and on-campus environments) and academic disciplinary affiliations on deep learning [1]. Data has been utilized from the Faculty Survey of Student Engagement (FSSE) Indiana University. The FSSE has collected data from 630 institutions and 160,000 faculties since its first offering in 2003 and provides valuable information about faculty behaviors, perceptions, and expectations, particularly regarding their influence on student engagement. The sample for this study consisted of 6,396 faculty students in four-year institutions across the United States. This population included all faculty teaching distance education and a 20% random selection of one-fifth of faculty teaching in the classroom instructional format who responded to the 2010 and 2011 course-based FSSE. In all, the sample population included 2,125 faculties who instructed in distance education (33.2%). Although a wide range of faculty disciplinary representations were included in this survey, including 85 unique disciplines and represented by each of the six Holland disciplinary environments and one “other” category, the largest number of respondents were from the Social disciplinary environment.

- The results indicate that faculty reported a moderate to high emphasis on deep approaches to learning in both distance education and classroom environments. However, the results also indicate that instructional format, and distance education in particular, have a significant predictive relationship on the extent to which the faculty emphasizes deep approaches to learning. Likewise, the results suggest that faculty disciplinary environments also have a statistically significant relationship with the extent to which faculty are likely to emphasize deep approaches to learning in distance education. With the increasing growth of distance education offerings across higher education and increased concerns about quality in the learning environment by government agents and institutional administrators, an emphasis on recruiting tenured faculty to instruct in alternative instructional formats would serve as an important contribution to educational quality.
- Only 449 of the 6,396, or about 14% FSSE participants in distance education were tenured or tenure-track faculty. Although many institutions have increased their reliance on distance education over the previous 20 years, the descriptive results from the surveyed faculty indicate that faculty instructed in almost two-thirds fewer distance education offerings than in on-campus courses. In other words, on-campus courses represented the dominant instructional format in the surveyed institutions in this sample, and within the surveyed population, tenured and tenure-track faculty represent a small proportion of faculty who instruct in distance education.
- Overall, this study shows that faculty is more likely to emphasize deep approaches to learning in distance education environments than in on-campus environments, that disciplinary environments are likely to influence faculty emphasis on deep approaches to learning in distance education, and that both instructional format and discipline are likely to impact faculty emphasis on deep approaches to learning.

KEMPexamined the relationship between determination in distance education and resilience, life events, and external commitments [4]. His study showed that there were approximately 10,000 registrations signed up for an undergraduate distance course at Athabasca University in January 2000. Students were considered to be first-time distance students if they met the following conditions: (a) they were registered in one undergraduate distance course as of April 1, 2000; and (b) this was the first undergraduate distance course in which they had been registered at Athabasca University. Students who were between the ages of 30 to 45 only were included in that study to control for the essential variable of age. After the approval by the Ethics Review Sub-Committee, a random sample of 460 undergraduate students, who were between the ages of 30 to 45 and registered in their first undergraduate course was attained from Athabasca University student records, a procedure following the approval by the Human Subjects Sub-Committee. Students who participated were asked to complete the Resiliency Attitudes Scale, the Life Events Inventory, and a questionnaire all included in a questionnaire package.

- A student at Athabasca University has six months to complete a three- or four-credit course, and 12 months to complete a six-credit course. Students can work at their own pace and complete courses as quickly as they like. The questionnaire packets were mailed on April 25, 2000 to students who had registered in their first undergraduate course as of April 1, 2000.
- Data were gathered from student records on February 5, 2001, to check if the students enrolled did in fact complete the course. Of the 460 students, 124 completed and returned the questionnaire package, other packages were discarded due to being spoiled or incomplete. The resulting 121 completed packets generated a response rate of 26.9%. This response rate is considered adequate for mailed surveys, consequently there was no follow-up notification through postcard.
- All respondents were registered in a 3- or 4-credit course, with the exception of four students who were registered in a six-credit course. As of February 2, 2001, 57 students (47%) had successfully completed the Athabasca University course in which they were enrolled, and 64 students had not. Of this second group of non-completers,

(a) 38 did not begin work on their course,
(b) 19 withdrew from their course, and
(c) 7 received an academic failing grade.

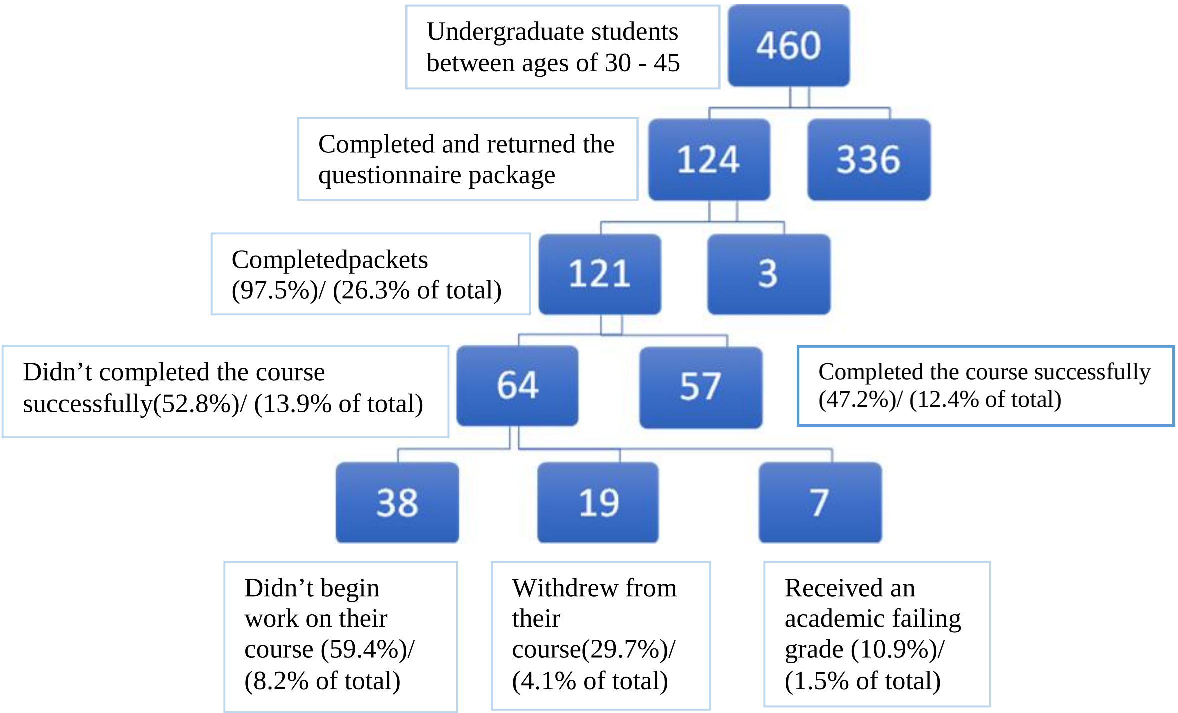

Figure 1 Sample population distribution

- None of the students registered in a six-credit course completed their course; three did not initiate work on their course and one withdrew from the course. More than half of the students in the non-completer group (53%) had previously taken a distance course. For the most part, external commitments—in the form of personal, family, home, financial, and community commitments—were not found to be significant interpreters of persistence (or lack of persistence) in distance education.
- In other words, students with high levels of commitments in these areas were no more or less likely to complete their Athabasca University course successfully, in comparison to students with lower levels of commitments in these areas.
- This study contributes to the field of inquiry relating to persistence in adult distance learning by providing insight into the resilience skills employed by adult students who successfully completed their first course at Athabasca University. The field is widened to include better predictors of adult student persistence. Additionally, this study adds to the understanding of the application and limitations that prominent theories of persistence have in relationship to distant learner populations. Finally, the results provide practical efficacy by offering an evaluation guide for distance education institutions to respond more effectively to the needs of adults. The study may help adult students, faculty, and administrators better understand persistence and dropout in undergraduate distance education.

5. Conclusion:

This paper illustrates seafarers' problem regarding certificate renewal and upgrading necessary for their career development. This requires them to attend courses on-campus, resulting in loss of time and expenses for course fees, transportation and accommodation for those who leave away from the campus, which is sometimes in a different city or even country. Thus, the suggested solution to this problem lies in DL, since the other solution of CBT is impossible, as it is not recognized by the authority. DL can be used, as it is also recommended by the IMO.

To make sure of the results of using DL as a solution for seafarers in Egypt two case studies have been discussed and results of both are recognized, which proves that using DL in both cases was a better solution. However, a limitation of the present research is that it does not include a case study for seafarers, as no relevant studies were found in the maritime field. Similarly, it does not include statistics in Egypt or in the maritime field, which will be undertaken by the researcher in future studies.

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Session 3B

HUMAN RESOURCHES

&

CULTURAL AWARESS

Opportunities and advantages for oversea seafarers human resources development in Vietnam

Dinh Xuan Manh[1], Dao Quang Dan[2]

[1]*Vietnam Maritime University, Professor, Captain, Vice-Rector, dxmanh@vimaru.edu.vn*
[2]*Navigation Faculty, Vietnam Maritime University, daoquangdan@vimaru.edu.vn*

Abstract: Despite of the increasing demand of seafarer markets in the world particular in Northern East Asia, Singapore, European countries…, the annual number of Vietnamese exported seafarers has just fluctuated around 2,500 per year over last 20 years. It is the modest amount compared to Vietnamese population and potential. There are a lot of limitations, difficulties and challenges in exporting Vietnamese seafarers.

This paper presents fundamental problems and challenges. However, apart from these difficulties and challenges, Vietnam has many advantages in developing labour resource for exporting Vietnamese seafarers to the world labour market. Vietnam should take these advantages to overcome challenges and dilemmas, otherwise these problems would turn into long–term problems which are really hard to recover. This paper will focus on analyzing opportunities and advantages of Vietnam in developing human resource for exporting seafarers.

Keywords: human resource, seafarers, seafarers export, opportunities, advantages, limitations, challenges, STCW78/2010.

1. Introduction

Many researches, analysis which have been carried out by individuals, prestigious organizations in the world maritime industry showed a serious concern related to the severe shortage of seafarers in the international seafarers market, especially officers at present and in the future. [1],[2],[3],[4],[5].

In Asia, ASEAN is the large labour resource providing a considerable amount of seafarers to the international seafarers market at present and in the future. There are many similar features between the two ASEAN members, Vietnam and Philippines, such as population, GDP, economic-social development rate…. However, while Philippines occupies the biggest amount of exported seafarers over the world, Vietnam, with many remarkable advantages in comparison to other countries in the region, consisting such as the crucially strategic location; the golden population structure is predicted to last in next 20 years (the population in Vietnam is 91 millions) and Vietnamese young seafarers desire to work for the international prestigious shipping companies, particularly working onboard ships of large fleets in developed maritime countries…, has exported 2500 to 3000 seafarers annually over last 20 years, a quite modest quantity compared with its potential.

Meanwhile, the quality of management and operation in Vietnamese shipping companies are limited with many weakness and shortcoming. Additionally, these shipping companies suffered from income losses, decreasing scope of business, even bankrupt due to economic crisis in recent years. These problems which led to low salary, long-term delayed payment as well as poor compensation to seafarers. The above-mentioned reasons result in increasing significantly the number of seamen who want to abandon their career and the quality of seafarers is decreasing.

However, by ratifying and implementing MLC 2006 showed the determination of Vietnamese government in developing seafarers resource and Maritime Transportation Industry.

Promoting seafarers export is really a right policy because, firstly, it will create more job opportunities, improving economic-society condition and building up Vietnamese seafarer trade mark in the international seafarer labour market; secondly, it plays very important role in improving not only the quality of Vietnamese seamen but also maritime transportation in Vietnam.

Vietnamese seafarers basically can meet all international ship-owners' requirements because they are trained, well educated and certificated in accordance with STCW 78/2010 standards. However, the major reasons that the number of Vietnamese exported seamen is quite small and much lower than its potential are the cutthroat competition from opponents when Vietnam merges deeply and widely into the international economy, and on the other hand the Vietnamese seafarers is not so qualified.

Therefore, it is completely necessary and practical to study the potential of Vietnam in order to turn the potential into opportunities and advantages in intensifying seafarers export issue.

2. SWOT Analysis

2.1. Strengths

- Vietnam in general and costal cities in particular are with abundant labour resources which meet not only the demand of socio-economic development but also the demand of supplying overseas labour including seafarers.

- With young age structure and with tradition of hard-working and inquisitiveness, Vietnamese labour will have abilities to meet the special requirements of exported seafarers at a large quantity if they are educated and trained properly.

- The economy tendency of shifting to service operation in many regions in Vietnam releases a large amount of agriculture labour that would be reserve labour force for seafarers resource as well as overseas safarers. Higher salary for seamen working for international shipowners in comparision to those working for domestic shipping fleet or those working in other careers is an advantage and a strong point in attracting and developing overseas seafarers.

- Management system, policies system which support in developing seafarers resource and Maritime Education Institutes, Maritime Training Centers has been completed and will promote its ability in the stage of developing.

- Vietnamese seamen has mastered smoothly huge vessels owned by international shipowners including Handy size, Panamax, Capsize size vessels. The number of seafarers working onboard these ships is increasing, even there are crews who works onboard these vessels are all full Vietnamses. This is a clear affirmation that Vietnamese seafarers have sufficient ability and qualification to master almost vessels with different types and sizes at the international level.

- Generally, Vietnamese seafarers are good at accquiring specialized knowledge and foreign language quickly, and they are easy to merge with a multinations crews.

- Vietnamese students in general and maritime students in specific are men of intellect, intelligent, eager to learn, especially always desire to master new cutting edge technologies.

2.2. Weaknesses

- The weakest point as well as the biggest challenge in exporting seafarers in Vietnam is the low-quality seamen, the unprofessional behaviour leading to low competition ability. The reason for this problem obviously is that the relation between quantity and quality of Vietnamese seafarer is not inadequate.

- Almost offices at different management levels in maritime industry in Vietnam, Maritime Training Center as well as crew manning companies/agencies have not built up a strategy for expanding exported seafarers.

- Awareness of the role of exported seamen resource in the national economy falls short of expectations, even in the maritime filed, this role is not properly considered. In addition, crew manning companies/agencies have not paid much attention to training and providing further training for seamen working overseas. It can be clearly seen that the issue of increasing seafarers resource for exporting hasn't been mentioned in developing plans or strategies.

- Vietnam hasn't made specified policies for developing export seafarers resource including a policy of overseas seafarers education, recuirtment and an other of encouraging to expand export seamen resources.

- Governmental offices, minitries, policies system haven't proven their roles in developing export seafarer resources.

- The domestic business environment is facing with a lot of difficulties. The Vietnam legal system in general and shipping sectors in particular have not been fully sufficient to cover all operation in maritime and shipping industry..

- Several Maritime Education Institutes, Maritime Traning Centers (MTCs) are small-scale ones, poorly equiped training facilities and the quality of education and training is not really good. These things leads to different education and training qualities among Maritime Education Institutes, MTCs in Vietnam.

- Most of Maritime Education Institutes, Maritime Training Centers haven't any plan to train and educate seafarer according to international shipowners' requirements.

- An other considerable concern is that the financial capital for expanding export seafarers resource is quite limited.

- The shipowners' roles is underestimated, a larger proportion of shipowners haven't participated in traning and educating human resource for overseas seafarers and they also haven't made any plans for improving their overseas seamen.

- Problems such as poor financial capacity, poor management, unprofessional working manner, poor advertisement and negotiation with foreign shipowners… are challenges that many crew manning companies/agencies deal with. In particular, they don't have any strategies to enchance the competition ability. These weakenesses results in the crew manning companies/agencies' ability of integrating into the international seafarers supply chain is restricted. Furthermore, the mentioned weaknesses could lead these companies/agencies to the limitations in the international integration mind.

- Vietnamese seamen's discipline, working skills and English ability are not really good, especially the working manner and attitude are not as professional as seamen from Philippines, India… To solve this problem, it will need to renovate training and education works

- Vietnam haven't had its own Seafarers Association

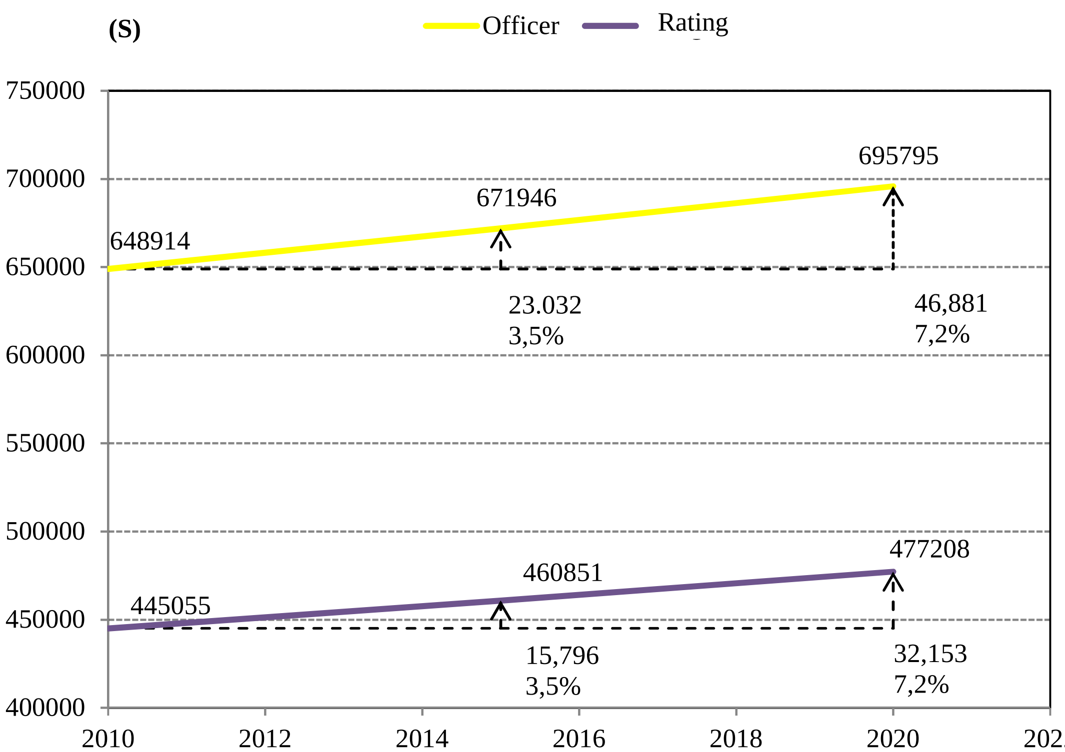
- Crew manning companies/agencies have limitation in consolidating and expanding the seafarers export market. They are in experienced and don't pay much attention to advertising and creating their trademarks in the dosmestic and international markets. Since these Vietnamese companies/agencies haven't got any supports to promote their trademarks in overseas markets, it is quite difficult for them to approach the reputable foreign shiponwers.

- Finally, the information system of seafarers market has remained many weakenesses and restrictions.

2.3. Opportunities

Nowadays, no barrier for seamen to join the international seafarer market provided that they have to meet the requirements of the International Convention of Standard training, Certification and Watch-keeping for seafarer 1978, as amended 2010. The seafarer market now is opened worldwide. It enables shipowners, seafarer managers to employ seamen from any countries in all over the world. Ships with multinational crew are popular now.

If the number of seamen in need in the year 2020 is calculated by adding the amount of crew at 2010 with increasing of 7.2% per year (the amount of seafarer in 2015 raised by 3.5% to that in 2010), the shortage of officers and ratings in 2020 would be 32,153 and 46,881 respectively. (See Fig 1.1)



[Reference:3]

Figure 1.1 Estimated demand for the world's seafarers by 2020

In case, the number of seamen in demand is calculated by addingthe amount of crew at 2010 with the average growth rate per year of the world fleet from 2010 to 2020 at presumed 0.7%, included compulsory crew manning for each types and sizes of ships as well as and the reserved quantity of seafarers about 50%, the estimated demands of seafarers for the world fleet in 2020 is illustrated in table 1.1 below:

Table 1.1 The predicted demand for seafarers in 2020

	2000÷7999 GT	8000 GT and over	Subtotal	Backup (50%)	Total
Officer	110647	207492	318139	159069	477208
Rating	138309	325554	463864	231932	695795
Total	248956	533046	782002	391001	1173004

[*Reference*:3]

With above figures, it can be clearly seen that Vietnamese seafarers export has great opportunities to develop.

According to many researches as well as the facts, the source of seafarers supplying to international seafarers market in the future would come predominantly from Asian countries, especially ASEAN countries. Besides cheap labour cost, those seamen who comes from East and South East Asia have good relations with countries that having long developed-history of maritime industry.

Several foreign markets and shipowners always give priorities to Vietnamese seafarers in comparison to other countries in region. For example, Japanese shipowners have been attracting a large amount of Vietnamese seamen.

Maritime Labour Convention (MLC) 2006 took effective as from 20th August 2013. This convention guarantees that every seaman who works onboard ship would have a satisfied living and working environment regardless of their nationality and ship's flag nationality. With a better working and living condition, especially more adequate salary, it is believed that education and training seafarers for exporting would have been developed significantly.

Furthermore, seaman unions in all developed maritime countries are members of the International Transport Workers' Federation (ITF). Thus, Vietnamese seafarers working onboard vessels which are registered in these countries will receive not only high salary but safer working and better living environment as well.

Vietnam has good opportunities to approach to many internationally potential markets for deployment seafarers without discrimination.

As a contracting party to many IMO conventions and integrating into many agreements, Vietnam has to complete it's legal system with market mechanism orientation and perform them effectively.

Vietnam is equal with other countries on drawing up their global trade policies and for a more equitable and rational economy order. Vietnam has to protect benefit of country, companies and seafarers.

By merging into world economy which improves the domestic economy reform and process of economic reform in Vietnam is more comprehensive and effective.

By contracting and approving many international trade agreements which has lifted Vietnam to a new level in the world and it enables Vietnam to execute it's foreign policy effectively.

Besides, this could create more jobs with appropriate salary to Vietnamese seafarers who are suffering from the economic crisis as the domestic sea transportation is dealing with a lot of difficulties. Meanwhile, the international seafarers resource is seriously insufficient, particularly officer positions. We should take full advantage of this opportunity in order to strongly step up seafarers export issue.

2.4. Threats

Threats in developing seafarer export that Vietnam has faced with are really major issues. The threats can be mentioned as below:

First of all, at present and in the future, all countries in all over the world, especially developed ones are giving priorities to professions that require high qualified labour resources. This will result in differences between demands for labour recruitment. This trend also occurs in marine transportation, seafarers should be high qualified and skilled in order to master the up-to-date technologies [6] that are increasingly applied in the shipping industry. Competition in the seafarer export market will be keener, with various competitors in wider and deeper scale.

Second**,** Vietnamese crew manning companies/agencies are in small scale, therefore, it is quite difficult for them to deploy Vietnamese seafarers abroad deeply and widely. This makes Vietnamese crew manning companies/agencies unstably and unable to control the seafarers market. Furthermore, their management ability is really not so good which results in low competition of Vietnamese seamen, especially it could be more difficult when merging into the international economy.

Third, almost Vietnamese crew manning companies/agencies haven't had a sufficient preparation before signing a contract. They haven't anticipated all problems that might occur in performing the contracts. They have been lack of knowledge in terms of international shipping laws and practice. Therefore they haven't been prepared well in advanced for any internationally commercial claims or disputes. On the other hand, legal consultant service has not been used often. This leads to many difficulties and disadvantages, even loss for Vietnamese crew manning companies/agencies if any international claims or disputes occur.

Fourth, dispite Vietnamese economy has deeply and widely integrated into the global economy and signed many international commercial agreements such as FTA, TPP, AEC…, many crew manning companies/agencies have low financial ability, small scale business, unprofressional and poor management and haven't made a strategy to improve their competition when they take part in the global seafarers supply chain. Because of limitations in ability and strategy, Vietnamese crew manning companies/agencies will deal with many challenges in competiton in the global market, even lose in Vietnamese market.

Fifth, the thought of sea carrier as only a short-term carrier is quite popular among Vietnamese seafarers. Many seafarers consider this sea career is just a temporary job so they just complete their works indifferently without progressive attitude. Some of them don't have any plans to elevate their professional knowledge and foreign language to enhance their seafarer skills while the requirements for maritime safety and security, and marine environmental protection applied to seafarers are increasing severely.

Sixth, increasing modernization and globalization in the maritime industry requires seafarers to own good specialized knowledge, working at sea experience, foreign language (English), good physical condition and professional manner. However, seafarers from Vietnam are just good at theory only, their working skills, English ability and physical strength are not as good as seamen's from India, Phillipinnes…

Seventh, the growth of Vietnam econimic has improve living standard. Seafarers job is not much a high-paid jobs in comparing to other jobs ashore. A quite large quantity of experienced seafarers including officer at management level resign from this career and looks for suitable jobs ashore.

Eight, the overwhelmed factors of Vietnamese seamen in competition with other countries such as cheap labour cost… no longer exist. Vietnam now have to encounter serve competitions from Philipines, India and some raising countries which have numerous seamen resource, are well-qualified, highly-disciplined and are willing to receive a competitive salary.

Ninth, due to the growth rate of the domestic shipping fleet, the demand of seafarers is rasing. This leads to the shortage of high quality seafarers, especially officers at management level for exporting.

Finally, the demand of transportation including maritime one begins to surge due to the global economic recovery. After a time of reducing the fleet, shipowners have started to recruit more highly qualified seafarers for further development.

2.5. Building combined strategies S-W-O-T

Combination between Strengths and Opportunities: With inherent strengths particularly young working-age population, inquisitiveness, harmony, and a part of Vietnam seafarers has good experiences, has proved their ability in operating many different types of extremely large vessels including ones owned by international shipowners. Besides, the numbers of seamen who had been trained and educated is quite large so it could provide for the global seafarers market a large amount of seafarers after a short time of retraining. Furthermore, the desire of working for famous and prestigious shipowners that have strong attraction to Vietnamese seafarers would last for a long time, at least over decades.

If Vietnamese seafarers force are properly oriented and invested, they will take this opportunities effectively for developing the export seafarer resource quickly in order to meet the quality and quantity of the international seafarers market demand. To achieve this goal under the condition of strength and advantage mentioned above, both Vietnamese crew manning companies/agencies and seafarers need to strengthen their position in the traditional markets as East-Northern Asia, Singapore, then expand to the potential markets including Europe, North America.

Combination between Weaknesses and Opportunities: All Maritime Education Institutes, Maritime Training Centers, crew manning companies/agencies and Vietnamese seafarers always eager to cooperate with international reputable shipowners. These advantages will create a new direction for Vietnamese seafarers and this tendency also help crew manning companies/agencies' and maritime officies' operation to be more professional as well seafarers will gain better reputation. Although all crew manning companies/agencies and seamen are willing to cooperate with foreign shipowners, they haven't well prepared in every aspects for a good cooperation results. If Vietnamese government and its departments take full advantages of these opportunities to issue policies and to models supporting for training and exporting seafarers, eliminate unprofessional factors in the seafarers supplying chain operation, invest more money to enhance the human resource quality, it would be believe that weaknesses could be minimized and no longer exist.

Combination between Strengths and Threats: Any labours including overseas seafarers always consider two sides of the same coin when they made their decision to be a seafarer. They have to think about whether the amount of money that they earn could be enough to afford their family's life after resigning from this career and whether this amount of money is better than that they could earn by doing other jobs. With strengths, Vietnam will build up a model of export seafarers with good salary and compensation which makes seafarers satisfied and attract more young and high qualification seafarers to join export seafarer market. Apart from salary, compensation and allowance…that are provided by the international shipowners, Vietnamese government also need to issue preferential policies to encourage overseas seafarers. If these things could be done, it is ensure that seafarer export work would be able to overcome all risks. Since, according to income and currently average development rate, attraction of working for international famous shipowners to Vietnamese seamen would last in at least several decades.

Combination between Weaknesses and Threats: In progress of developing and integrating into world shipping, it can't avoid elimination. Maritime Education Institutes Maritime Training Centers, crew manning companies/agencies, and seafarers that are at low quality and poor competition will be eliminated. Vietnamese organizations, crew manning companies/agencies and seafarers need to aware clearly of this because joining the international market means that competitions with many rivals from many regions in the world not only from Vietnam.

In spite of abundant number of seafarers and good qualification, Vietnamese seafarers are not so at unprofessional manner which is represented by skills and working-attitude. Vietnamese seafarers' working attitude and attitude towards shiponwers is not really good. Because of skills, especially attitudes, the quality of Vietnamese seamen is not high, just stopping at a passing-level. To meet the requirements of foreign shipowners, it is essential to set up inadequate mind and attitudes towards shipowners and operators among seafarers. Seamen must recognizes that their benefits and rights are attached closely to that of shipowners, operators. They should consider vessels as their own house.

Vietnamese seafarers' low awareness and attitude are at restriction in their perception. To create overseas seafarer force which could satisfy foreign shipowners' requirements and prove Vietnamese seafarers' trademark in the global market, it is necessary for Maritime Education Institutes especially Maritime Training Centers and Crew manning companies/agencies to reform training and education syllabus in order to enhance seafarers' professional manner and improve their onboard working skills and attidutes. Establishing an internationally professional mind in seafarers' thought will overcome weakness, control threats and finally improve strengths.

3. Advantages in developing seafarer resource for exporting in Vietnam

Apart from mentioned strengths and opportunities, Vietnam is holding unique overwhelmed factors in developing overseas seafarers recource that can't be found in other countries.

3.1. Geographical location of Vietnam

At location of the west of Eastern Sea, with more than 3,260 km coastline, Vietnam is contiguous to seas in the East, South and South West, from Mong Cai in the North to Ha Tien in the South West. The expanded area to the East and South East in the East Sea which belongs to Vietnam's sovereign. It has continental shelf, islands and archipelagos. Vietnam also has sea area of more than 1,000,000 square meter with it's sovereign, sovereign right and jurisdiction. The sea area is 3 times bigger than land area. Additionally, the Eastern Sea is an important sea area with a strategic location of region and in the world. where main shipping routes passing through with the goods value of 5,000 billion USD transported annually. Eastern Sea have played an important role in developing strategy of the East Sea countries as well as other powerful maritime countries in the world.

Every year, about 70% of imported oil and 45% of exported commodities in Japan; about 60% of imported-exported goods in China have been carrying through this route. Especially, Singapore economy mostly depends on the Eastern Sea.

3.2. Golden population

According to Vietnamese Statistic Directorate, as of 01/01/2016, Vietnamese population is in "golden period". The workforce aged 15 years old and above is 54,61 million which was 185,000 people higher than that in the same period of 2014, consisted of 51.7% male, 48.3% female. Vietnam is one of countries having the youngest population in the world, the workforce aged 15-39 years old is 51.0% including 26,7% in group aged 15-29 and nearly 15% in group aged 15-24 [4]. This group is believed to be highly potential to learn new knowledge and skills in order to be high quality workforce.

3.3. Political issue

Vietnam is a country which is always has a good stability in politics- society. It is the essential factor to help Vietnam being consistent with economic developing policy and having a long lasting peace. Meanwhile, most countries in ASEAN, except Singapore, have dealt with many political problems that caused serious loses in economy of these countries. It is, therefore, obviously that Vietnam's stable politics is a great guarantee for remarkable success in process of reforming in Vietnam.

3.4. The Vietnam young workforce

With hard-working, studiousness, enthusiasm and ambition, Vietnamese young generation is now quite willing to take risks to learn and start new things.

Vietnamese workforce and seafarers are highly competent to meet strict requirements given by international employers as well as shipowners when Vietnam is merging widely and deeply into global economic community. This is clearly proven by impressive performances of Vietnamese seafarers on huge vessels and number of Handymax, Panamax and Capsize vessels with full Vietnamese crew is increasingly significant.

Vietnamese seafarers have ability to learn new professional knowledge, foreign languages, and to adapt themselves to be harmony with other seafarers who come from different countries and have different cultures. All things they need to do now is being confident to learn and use the existing potential which maritime education and training centers provide and to gain necessary knowledge to prove that Vietnamese seafarers would be able to compete against with other countries in seafarer market.

It is used to say that the cheap labour cost of Vietnamese seafarers was one of competitive factors. However, it is no longer suitable nowaday. Vietnam is now competing against with countries which have good reputation in maritime field such as Philippines, India. Furthermore, seafarers coming from China and Myanmar who could provide the international labour market with skilled, disciplined and low cost seafarers are raising as remarkable rivals. For these reasons, Vietnam should uphold its inherent advantages so called inner ability which is existing in each Vietnamese seafarer. Inner ability factor, creativity and adaptability, optimist that are typical characteristic of Vietnamese.

Nowadays, in Vietnam, not only students who just graduate from Maritime Universities or Colleges but also experienced and skillful seafarers desire to work for foreign shipping companies and shipowners. According to the survey carried out by group of researchers in Vietnam Maritime University, Maritime College No.1 and other Maritime Training and Education units, all students and learners really want to work onboard vessel owned by prestigious foreign shipowners after graduating because of deserved salary, professional working environment, and equitable in evaluating their performance and in promoting. Maritime students, who are well trained and educated, eager to study new cutting-edge technologies. They would be optimize their ability when working in professional environment. Therefore, all students who just graduated from Maritime Universities or Colleges, desire to work in professional and disciplined working environment in the beginning of their career. This will give them good opportunities to practice what they have studied and to gain valuable experiences, knowledge and receiving good salary deserved to their effort.

There is a trend now in Vietnam economy that service sectors are increasing. This release a large amount of labours from agriculture which is a good reserved workforce source for exporting seafarers. Seafarer working overseas or for foreign shipowners would get higher payment to those one working on board domestic vessels. This is really a great advantage to attract more and more labour for exporting seafarers.

4. Conclusion

By making use of opportunities and advantages to overcome difficulties, challenges toward to further successes, Vietnam is completely able to be a major seafarers supplier to the international seafarers market. Otherwise these advantages will be passed and these obstacles would grow up and become long-term problems that it would be very difficult to recover. Vietnam used to miss these opportunities and might miss once again a good chance to create jobs for young and intelligent labour who is willing to be trained and educated to become high quality labour. The period of golden population will last 25 years, and then Vietnam will be entering the period of the old population. Therefore, if Vietnam makes use of these opportunities effectively, it will have sufficient accumulation for social security to meet the increasing demand when the population gets old. Conversely, Vietnam will deal with many difficulties and challenges when the golden population opportunity ends and the old population period begins.

Developing the Vietnamese seafarers resource for exporting will play crucial part not only in enhancing the quality of Vietnam seamen but also in developing a sustainable sea transportation industry in Vietnam in accordance with deeply and widely merging into the international economy.

Opportunities and advantages in exporting Vietnamese seafarers are scientifically analysed which will enable Vietnam to build up a strategy for improving seafarer export resource. Furthermore, these analysis help seafarer employers, particularly international shipowners have reliable information to evaluate situation and to make decisions on investing in the potential Vietnamese seafarers market in order to solve the problem of seafarer shortage effectively, economically and sustainably.

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Language Barriers, Cultural Differences and International Cooperation between Maritime Institutions

Professor Qi Chen, Ph.D

Massachusetts Maritime Academy, 101 Academy Drive, Buzzards Bay, MA, USA
qchen@maritime.edu

Abstract. For eight years, the Massachusetts Maritime Academy (MMA) of the USA has been engaging in a student exchange program with the Shanghai Maritime University (SMU) of China, and later, in 2013, extending it to the Dalian Maritime University (DMU) of China. The MMA-SMU/DMU exchange program, conducted in two countries which differ greatly in culture, history, economic systems, social values and government structures, has become a huge success, and is greatly applauded by the faculties, administrators, students, and other maritime institutions. Almost 300 students from both sides have participated in the program and nearly all have demonstrated a strong capability to overcome the language barriers, adapt to the new environments, achieve hugely in the job market and their subsequent career development.

This paper presents an empirical analysis of what accounts for the success of the exchange program, how the participating students outperform in the international programs and their subsequent achievements in the job market. Applying a case-study methodology, drawing on the school-wide surveys and the data collected over the course of eight years, this paper examines how the setup of the MMA-SUM/DMU exchange program helps students overcome cultural shock, promotes language proficiency and fosters leadership qualities. The findings indicate that the culturally sensitive arrangements of the program, such as the rooming of a visiting cadet with one from the home school, and the free selection of classes at the host institution, play a crucial role in its continuing success. Further, the findings suggest that the program has been very effective in helping the participating cadets enhance their self-confidence, broaden their global visions and adapt to new environments with ease and grace. And the school–wide cultural awareness and job market success motivates more cadets to participate in the MMA-SMU/DMU exchange programs.

The successful experiences of the MMA-SMU/DMU program are applicable not only to the maritime universities of the USA and China, but also to similar institutions located in other culturally diverse countries, like the UK and Vietnam. When the participating cadets prove that they can survive and perform well in two completely different cultures, they demonstrate that they have acquired the necessary and sufficient skills to be successful within any type of job they are offered. And this is exactly what potential employers are seeking of all graduating maritime cadets nowadays.

With the on-going development of the exchange program and the availability of additional data, more rigorous statistical analysis could be applied to the research, generating more significant conclusions. To do so would unquestionably help further enhance the MMA-SMU/DMU exchange program.

Keywords: International programs between maritime institutions, Cross-cultural education, Cultural adaptability, Language proficiency.

1. Introduction

Since the spring term of 2009, the Massachusetts Maritime Academy (MMA) of the USA has been engaging in a student exchange program with the Shanghai Maritime University (SMU), and later, in 2013, extending it to the Dalian Maritime University (DMU) of China. The MMA-SMU/DMU exchange program has been conducted in two countries which differ greatly in culture, history, economic systems, social values and government structures, it imposes a huge challenge for the participating students to survive and be successful. Nevertheless, it has been well proved that MMA-SMU program provided students with strategies to move from shock to cross-cultural adaptability, which in turn, will make the students, as Hutchings, Jackson & McEllister refer to the new style employees to be cosmopolitan, multilingual, multifaceted and be able to operate across national borders (Hutchings, Jackson & McEllister, 2002, p69). Almost 300 students from both sides have participated in the program and nearly all have demonstrated a strong capability to overcome the language barriers, adapt to the new environments, achieve hugely in the job market and their subsequent career development.

This paper presents an empirical analysis of what accounts for the success of the exchange program, how the participating students overcome language barriers, outperform in the international programs and get their subsequent achievements in the job market. Applying a case-study methodology, drawing on the school-wide surveys and the data collected over the course of eight years, this paper examines how the setup of the MMA-SUM/DMU exchange program helps students overcome cultural shock, promotes language proficiency and fosters leadership qualities.

The paper is structured as follows: Section II identifies challenges facing the MMA-SMU/DMU Student Exchange Program. Section III explains the culturally-cautious setup of the exchange program. Section IV presents the positive experiences of visiting MMA cadets in China and their subsequent job market success. Section V offers a conclusion.

2. Challenges facing the MMA-SMU/DMU Student Exchange Program

Since the year 2010, the Massachusetts Maritime Academy has sent cadets over to Shanghai Maritime University every spring term and starting from 2013, to DMU. Each year, MMA accepts roughly twenty Chinese students to study at the MMA campus. The following table gives us the numbers of the participating cadets from MMA from the year of 2010 to 2016. In the meantime, SMU always sends pretty much the same number of cadets over to MMA year after year, so does DMU.

Table 1 Participating MMA cadets in the MMA-SMU exchange program 2010-2015

Year	2010	2011	2012	2013	2014	2015	2016
MMA Cadets To SMU	11	16	17	22	19	20	19
MMA cadets to DMU				5	4	5	7
Total number of cadets to China	11	16	17	27	23	25	26

Data sources: MMA registrar's office

Table 1 shows a clear rise in the numbers of participating cadets of the MMA-SMU exchange program in the last three years. And yet the MMA-SMU/DMU student exchange program does conduct in two countries which differs so much in many aspects, which imposes huge challenges for participating cadets, administrators and faculties of the institutions in both countries.

2.1 The Cultural difference between the East and the West

Chinese society is centered on the doctrines of Confucianism with the key philosophical concepts of human-heartedness (ren), rightness (yi), propriety (li) and filialitty (xiao). Human-heartedness suggests that ren is what makes us human, it is a matter of feeling as well as thinking, and that should be the foundation of all human relationships. Yi informs us of the right way of acting in specific situations so that we will be in accord with ren. It is thus both a major disposition to do what is right, and an ability to recognize what is right, and functions like a kind of moral sense or intuition.

Although ren is the basis of humanity and, therefore, the ultimate guide to human action, Confucius recognized that more immediate and concrete guides to action are needed in everyday life. These concrete guides he found in the rules of propriety (li) governing customs, ceremonies, and relationships established by human practice over the ages. Xiao, or filiality, is the virtue of reverence and respect for family, as the family constitutes the immediate social environment of a child. In the family, the child learns to respect and love others, first parents, brothers and sisters, and relatives, then, by gradual extension, all humankind.

Those philosophical concepts evolve into the four basic principles of traditional Chinese cultures: unity between nature and human, people oriented, vigorous and promising, harmony and neutralism. And the four basic principles decree people to follow the doctrine of Golden Mean, requiring people to live by the felicitous middle between the extremes of excess (too much) and deficiency (too little). What lies the proper distance between these extremes is believed leading to a personal embodiment of virtue and resulting in a well-ordered society.

Hugely influenced by the Chinese value system, the participating Chinese students demonstrate, like all the other Chinese, characteristics of collective-oriented, hierarchical and high-uncertainty- avoidant society, such as pursuing the success and well-being of the larger group rather than individual benefit, interdependence rather than independence, valuing long-term social relationship rather than short-term accomplishments, modesty rather than insolence, diligence rather than indolence, respect for authority, elderly and superior, discouragement of conflicts, greater fear of failure and risk taking.

On the other hand, the western culture is centered upon the principles of freedom, liberty and equality. It emphasizes the worth and dignity of individual activities and personal success, encourages risk-taking behavior and change, value autonomy and independence, fewer social obligations, confrontation being acceptable, delegation of authority and minimum deference for superiors. Therefore, it is well expected that the Chinese exchange students, coming from such a different cultural background and being blended into the new environment in a swift period of time, would unavoidably experience a "culture shock" when collectivism, familism and hierarchy of the East meet with individualism, rationality and secularism of the West.

The term culture shock was first introduced by anthropologist/economist Kalervo Oberg (1960) as a "disease" suffered by individuals living in a new cultural environment. According to Oberg, culture shock resulted from the loss of well-known cultural signs and symbols, causing individuals to experience anxiety, frustration, and helplessness. To be aware of the stress and difficulties cultural differences might impose on the participating Chinese students, the MMA-SMU program is to be designed in such a way as to make the cultural shock to the minimum.

2.2. The Unique Features of the Two Engaging Maritime Institutions

The two institutions, MMA and SMU, are quite different in their scales and their comparative advantages, though both are playing a leading role in fostering maritime professionals. The exchange Program gives a challenge to both schools, and yet provides an opportunity to bring out the potentials of each school and benefit the other.

Shanghai Maritime University is the key maritime institution in China, enjoying a high reputation internationally as an excellent center of maritime education and training. SMU consists of 14 colleges, 45 undergraduate programs, 62 master, 11 doctoral and 2 post-doctoral programs, currently retaining approximately 21,000 students pursuing these programs and over 1,000 faculty members. The cadets at SMU are well-known for their diligence, persistence and virtues.

The SMU exchange students, selected from a large pool of candidates to participate in the MMA-SMU exchange program, are a group of the elite cadets with all the fine qualities to be expected in maritime students. These young Chinese students, though adhering to traditional Chinese value system, have been impacted more or less by the western cultures, ideology, arts and trends. One student puts it in her personal statement: "I grow up seeing American movies, TV series and shows. My most favorite ones are So You Think You Can Dance, Transformers and Heroes. And I really look forward to seeing America with my own eyes." The exposures to western cultures, such as involving in other international programs, world travels, attending international schools in China, reading western books, watching western movies, and listening to western music, help the Chinese students understand the western society and recognize its value systems.

There are two more common characteristics about the Chinese students which facilitate them blending in the new environment: being fluent in oral and written English, and coming to MMA as a group. The Chinese students are required to take English from elementary schools (some even from kindergartens). The English proficiency greatly enables the Chinese students communicating smoothly with MMA cadets and performing to their potentials in the classroom. Furthermore, different from other individual foreign cadets studying at the academy, SMU students come as a group of 20, which gives them much cushion to minimize the cultural discomfort if they do experience any.

Massachusetts Maritime Academy is a principal maritime educational institute in US with the focus on seagoing programs like Marine Transportation and Marine Engineering. For over 100 years, it has been preparing women and men for exciting and rewarding careers on land and sea. As the nation's oldest and finest maritime college, MMA challenges students to succeed by balancing a unique regimented lifestyle with a typical four-year college environment. In the past two decades, the academy expanded the majors to include Facilities Engineering, Marine Engineering, Energy System Engineering, Marine safety and Environmental Protection, International Maritime Business and Emergency Management, consisting of 7 undergraduate and 2 master's programs. MMA has long gained the reputation of high quality faculty and facilities for education and training purposes, especially in the sea going majors. However, as a state college, the great majority of cadets enrolled are from Massachusetts and other local areas in New England, a region in the North-Eastern corner of the United States. The academy has shown, more or less, the features of homogeneity and conservativeness.

Therefore, when proposed for the exchange program, both MMA and SMU believe that it is in the mutual interests to launch the program which would fully utilize the potential of both schools, the excellent SMU students and high quality faculties, and educational and training facilities at MMA.

2.3. The Challenges for visiting Chinese cadets to MMA

When MMA cadets visit SMU/DMU, the classes offered in China are taught in English, though MMA cadets are required to take two semesters of Chinese. The Chinese visiting cadets come to MMA, academically they are treated as MMA students, taking classes offered by MMA professors here and in English. So language barrier become a big issue for Chinese students. A survey was conducted in June 2013 of 21 Chinese visiting cadets at MMA, the following table sums up the answers to the question, "What is the biggest academic challenge you face this semester at MMA?"

Table 2 Answers to the questionaries' (June 2013)

Category	Answers
Language barrier	Understanding classes fully, writing papers in English, reading lots after classes, answering questions in classes
Cultural shock	Getting use to American way of learning and American way of life

3. The Culturally-Cautious setup of the exchange program

In this section, we will present the establishment of the exchange program between Massachusetts Maritime Academy and Shanghai Maritime University, and explain how the cultural differences have been addressed and the comparative advantages of both institutions have been fully utilized.

3.1 Roommate assignment

To better understand each other, SMU exchange students are teamed up with American cadets for the dormitories, that is, one American cadet is assigned to be the roommate of one Chinese visiting cadet.

To be the roommate of a Chinese student, MMA cadets have to go over a selection process and meet the following criteria, such as successful completion of three semesters in residence at MMA prior to hosting a student from China, a cumulative GPA of at least 2.5, to currently enroll in Chinese classes with the intension of either going over to China as an exchange student, or simply being interested in China, to have excellent standing with the Regiment of Cadets.

It has proved that the roommate arrangement is a meritorious practice. Company officers at MMA take great effort to pair the roommates with the same major of studies, comparable personalities and similar hobbies. The American roommates turn out to be the primary cultural mentors for the entire stay of the Chinese students. They give Chinese students constant advice on the lists of "Please do" and "Please do not", bring them home for weekends and birthday parties, show them nearby attractions to let them experience the American way of life. On top of being such wonderful cultural guides, American roommates also help Chinese students see quickly the unique features of MMA instructional method and class organization. At MMA, it is strongly encouraged to have interactions between teachers and students in the classroom, and students express their ideas freely. This is quite different from what Chinese cadets used to have back home: classrooms are more likely to be the teachers' solo shows and students, to a huge extent, take in the teachers' lectures passively.

For many American cadets, it is an eye-opening experience for them as to host a Chinese visiting cadet. One MMA cadet wrote that he also "benefits from them being here". Another cadet said that "my roommate has become one of my dearest friends and I don't want to see him leave. This experience has been excellent and I could not ask for more."

The following table shows how Chinese visiting cadets thought about their American roommates and how important to have an American roommate in their adaptation to the new environment.

Table 3 Answers to the question: How do you like to have an American roommate? (June 2013)

Evaluation	1 (lowest)	2	3	4	5 (highest)
Percentage of respondents	0%	0%	0%	22%	78%

It is so obvious that Chinese visiting cadets benefit hugely from having an American roommate, as one Chinese student wrote, "it is a perfect opportunity for cultural exchange and practice of English". Another student said that "they (American roommates) are extremely wonderful! They have given us lots of help to get used to the life here and take us to their homes to experience American family life."

3.2 Free selection of courses

The MMA-SMU exchange program started with two majors, Marine Transportation and International Maritime Business in 2009 and now expanded to four adding Marine Engineering and Marine Safety & Environmental Protection in 2012. The participating Chinese cadets come to MMA the second semester of their junior year. They are encouraged to take the course designed for the semester, but not restricted to those courses. The Chinese students tend to select two kinds of classes: the courses complementary to what they have taken before, like Advanced Seamanship, Stability & Trim, Vessel Chartering & Brokerage, and courses which enhance their understanding of the society, like American Government and Western Civilization. After SMU students overcome the initial difficulty, English terminology and class organization, they excel at their performances. Academic achievements and hard-working spirit of the participating SMU students win the respect of MMA professors and classmates. Consequently, the Chinese students feel more at ease and being accepted. Just like one Chinese cadet posited, "Once I do well in the classroom, I am so much more confident and happy here."

3.3. Trips outside campus

To let exchange students be familiar with American way of life, it is agreed upon by the two institutes that MMA would take the SMU exchange students on tours to New York City and Washington DC, and some other tourist spots in Massachusetts, like Plymouth Plantation, State House, visits to Woods Hole Oceanography Institution, sport games in Boston, like Celtics, and Patriots games.

3.4 Separate orientations

To help Chinese students adapt to the new environment quickly and successfully, MMA designs a one-week orientation before the official start of an academic year. MMA would also be engaged in school-wide cultural awareness activities, including a demonstration of Chinese history, economic growth, folk art and foods.

3.5 Cultural Awareness in a broader environment

As the world becomes increasingly globalized and integrated, cultural interactions and mutual understandings have been a new norm in societies. It has been an accepted notion that it will benefit both sides, either two countries, or two institutions, when to embrace differences rather than reject them and cooperate rather than go separately. As a result, American society has gradually become more culturally tolerant, less racially tensioned and less ethnically discomfort. The school like MMA has become more accepting and more accommodating. The following two tables present the surveys conducted at MMA which show the trend.

Table 4 Answers to Questionnaires (MMA)

Survey Questions/ Answers	Positive	Negative	Neutral	Year
The impact the China program would impose on MMA?	81.9% 84.5%	0.9% 0%	17.4% 15.5%	2011 2013
What do you think of the Chinese students?	75.2% 78.1%	0% 0%	24.8% 21.9%	2011 2013

Table 3 shows the results of two surveys conducted at MMA in the year 2011 and 2013, with 109 and 102 respondents respectively. It is clearly showed that more than 80% of the responding cadets believed that the MMA-SMU/DMU program imposed positive impact on MMA and none think negatively of the visiting Chinese students.

Table 5: Do you prefer American professors to foreign-born professors (MMA)

Answers	Prefer American Prof.	Prefer Foreign Prof.	No Preferences	Time of Survey
Percentage	18%	9%	73%	May 2015
Percentage	25%	4%	71%	Sep. 2015

We can see that more than 70% of the participating cadets have no preference between American-born professors and foreign-born professors. Table 3 sums up the results of two surveys conducted in May 2015 and September 2015 with 33 and 53 respondents respectively at MMA. It clearly shows that the on-going process of globalization and interactions between countries and peoples has brought positive changes towards the cultural acceptance and mutual understandings, especially among young generations.

4. Positive Experiences of Visiting Cadets and job market success

Most of MMA exchange students are juniors, only a few would go as sophomores. Usually they will graduate the following year after spending one spring term in China. At this point we only have four groups of MMA cadets graduating from the academy since the exchange program started in 2010 and most received good job offers upon graduation. In this section, we will look at the companies who offered the exchange cadets jobs during their senior year and how much their experiences in China contributed to their current jobs and later promotions. We see three trends clearly from the available data collected by the Office of Career and Professional Services of the academy: companies that employed the cadets tended to be large with many international elements, cadets received decent salary offers, and they are on steady rising track of career development.

Here we would like to look into two cases of the program participating cadets who visited SMU in the year of 2010 and see how the China experience help the cadets gain fine qualities and their success in the job market.

Myra, the first female who went to China in 2010, received a job with SpecTec upon her graduation as a regional sales manager. SpecTec is a premier provider of asset management solutions for the marine, offshore & energy, defense and yachting industries all over the world. Her responsibility is to identify and evaluate sales opportunities in the United States, Canada, and Latin America. After working at SpecTec for two and half years, Myra switched to DNV GL Group, the world's largest ship and offshore classification society of the maritime industry, a leading technical advisor to the oil & gas industry, and a leading expert in the energy value chain including renewables. The company has 16,000 employees across 300 sites in more than 100 countries and gains revenue of EUR 2,500 million per year. Myra works as Sales Support Manager and she loves her challenging and rewarding job.

Johnathan was offered a job as a technical coordinator by Canada Steamship Lines (CSL). CSL is a Montreal-based company which brings highly-efficient, gravity-fed, self-unloading capability to bulk shipping and transshipment markets throughout the world. Only two years out of college, White has completed project work in China for CSL International and is now based in England, working for CSL Europe and their Technical Operations Director conducting analysis and development of fleet wide operational, financial and energy efficiency improvements. The young graduate also assists in development of a monitoring system to improve the CSL Europe safety program. As the front page article of MMA website put, "this young grad hopped on CSL's sturdy corporate ladder and started climbing!" Currently Johnathan works as the Manager of Strategy and New Business Development at the headquarters of CSL in Montreal of Canada.

The salary range of the two cadets fell into the range of $50,000 -$75,000. When we compare the whole academy's salary range reported for the year of 2011, which includes the seagoing and non-seagoing graduating cadets, it is obvious that the 2 cadets stand out for not only the prestigious companies they work for, but also the salaries they received upon graduation. The following graph shows the salary range from 81 MMA seniors graduating in the year of 2011.

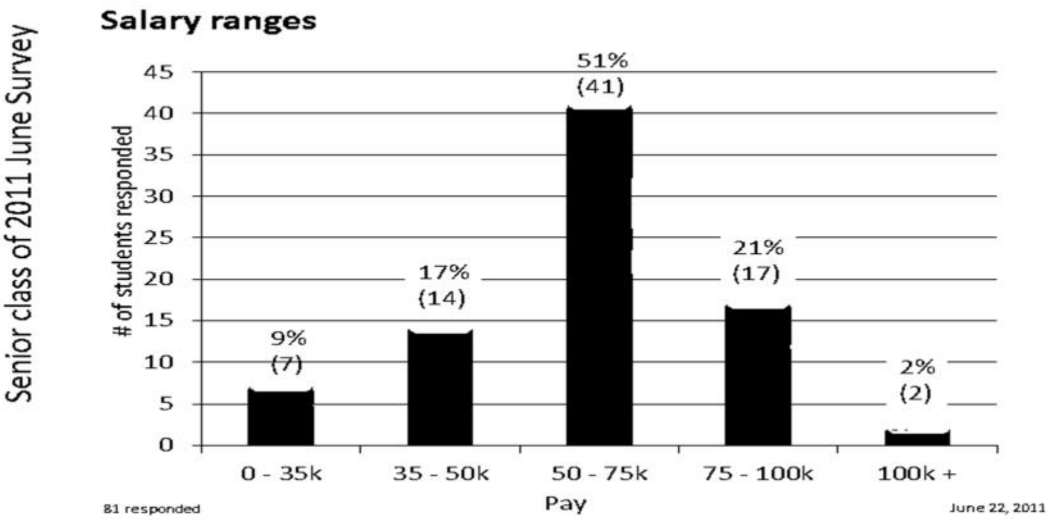

Figure 1 Salary range of MMA seniors in 2011

5. Conclusion

The data and analysis show that the international cooperation between two maritime institutes, such as the MMA-SMU/DMU student Exchange program, would be very effective to help the participating cadets enhance their self-confidence, broaden their global visions and adapt to a new environment with ease and grace. The successful experiences of the MMA-SMU program are applicable not only to the maritime universities of USA and China, but also to the institutions located in two other culturally diverse countries, like the UK and Vietnam. When the participating cadets prove that they can survive and perform well in two completely different cultures, they demonstrate that they have all the necessary and sufficient skills to be successful within any type of job they are offered. And this is exactly what the potential employers are seeking of all graduating maritime cadets nowadays, as what Schneider & Brasseux refer to, the capability to operate "across national borders somewhat like James Bond" (Schneider & Barsoux, 1997, p. 157).

With the on-going development of the exchange program and availability of additional data on the female cadets at MMA, more rigorous statistical analysis could be applied to the research, generating more significant conclusions. To do so will unquestionably help us to see how the exchange program enhances cultural awareness, educates maritime cadets to embrace the differences, and fosters leadership qualifications of cadets of maritime institutions.

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Women seafarers as minority organizational members

Assistant Professor Dr. Momoko Kitada[1], Associate Professor Dr. Lise Langåker[2]

1. World Maritime University, Fiskehamnsgatan 1, 21118 Malmö, Sweden; mk@wmu.se
2. Stord/Haugesund University College, Bjørnsonsg. 45, 5531 Haugesund, Norway; lise.langaker@hsh.no

Abstract Women constitute a minority among employees on merchant cargo ships [1]. There is an existing body of research concerning women as minorities in several industries, for example, in engineering [2] and police [3]. Less is written, though, concerning women at sea in the perspective of the organizational context they enter into when becoming ship operational personnel. This paper explores questions from organizational perspectives, based on the interviews with 15 men and women working in the maritime industry in Norway. A significant part of a ship's organizational context lies in its status as a total institution [4] in which people work as well as reside, and where organizational members are cut off from the outside world for periods of time. Within this organizational context, how do women as "others" [5] find their place and what challenges do they seem to encounter? The paper also argues whether the presence of women potentially may create a type of disorder which might disrupt the existing male-dominated organizational culture [6]. Gender becomes sensitive within a shipboard workplace where a total institution is particularly vulnerable when it comes to possible disordering effects created by "otherness". In order to illuminate these research questions the paper looks at how women create their gender identities [7] on board as well as expectations from fellow employees concerning their identity enactment. It appears that organizational humour, language and cultural artefacts are important aspects in analyzing the situation of women as minority members in a total institution. Finally, the paper reflects upon the seeming organizational silence within the maritime industry concerning women as minority organizational members. The research suggests the necessity of leader/captain acknowledgement of organizational cultural issues emphasizing gender. Such an acknowledgement could be looked upon as positive means of recruiting and retaining women as ship operational personnel.

Keywords: women seafarers, minority issues, total institution, cultural disorder, identity, behavioural rules, leadership awareness

1. Introduction

Women constitute a marked minority among the world's maritime work force. Figures estimate women constituting 1 or 2 % of the total seafaring work force [8]. According to the ILO study in 2003, the number of women differs between different countries, from Sweden (23.3 %) to Italy (1.2%). In Norway, where this study is situated, it was reported that a female participation of seafaring was approximately 10 % [9]. It is not unreasonable to assume that these numbers have grown in favour of more women entering to the industry since 2003. The more recent study published in 2011 explains that women represent 1.07% at deck officer level and 0.28% at engine officer level among the six countries of Bulgaria, Germany, Lithuania, Norway, Sweden, and UK [10]. Hence, it is appropriate to argue that the maritime sea-based industry lags behind most business areas when it comes to female participation.

This general lack of gender balance in the industry is a worldwide issue. Nonetheless, the scope of this paper is limited to a glimpse into the Norwegian sea-based maritime business. Norway's maritime sector might be a particularly interesting study object since Norway is known as – and like to portray itself as – a country where gender balance is a goal in multiple parts of society including work life.
Another research interest in this paper is to shed light upon women seafarers on cargo vessels as minority members of an organizational culture. This approach is to bring forward knowledge of circumstances that might be essential to an understanding of issues concerning being "different" within a work environment. Such questions become emphasized by the fact that a sea-based work environment is

more than a mere work environment – it is also an environment where organizational members spend their leisure time in what Goffman calls a total institution [11].

The focus of our study is to explore into being "different" and being "the others" when it comes to gender and gender identity in a male-dominated environment. The paper will look into some of the critical questions: (1) What challenges in such a situation might pose for individual women seafarers as well as an organizational culture on board a ship?; (2) What expectations do women seafarers encounter from both themselves and their fellow employees?; and (3) Is there any way in which the presence of women might create some form of organizational and cultural "disorder" that can be challenging for everyone involved? Finally, the paper will reflect upon the seeming organizational and industry silence concerning these issues.

2. Being a minority in the workplace

The term, 'minority' is used in different contexts with reference to, for example, gender, race, ethnicity, religion, sexual orientation, disability, disease, social class, locality, and nationality. These attributes are often intersectional and present a complex community space that they belong. For example, African American women fire-fighters have at least two factors to be categorised as a minority, that are being African American; and being women. The research show that African American women fire-fighters experienced discriminations because of their two elements [12] [13].

There are a number of studies on minority women in the workplace, such as police [14], Navy [15], carpenters and engineers [16]. The common claim as a minority group of women in such traditionally male-dominated workplaces is gender-related challenges and cultural biases. A stereo-typing against women in physically demanding jobs or high-risk occupations is likely to imply that women cannot perform as well as men do. It results in the situation where women have to prove their competencies even better than their male counterparts. The study into the occupational culture of engineering shows that women had to work hard and suppress emotions to 'become one of the guys' [17].

The case of women seafarers is similar to the above-mentioned stream of research, however only a limited number of literature is available. Some of the completed studies focus on female cadets rather than women who actually repeat a cycle of signing on and off aboard ships. Though maritime education and training (MET) plays an important role in introducing women into seafaring professions, voices from women seafarers who know the reality of work life should be heard much more intensively. The knowledge that women seafarers have created would be a useful source of feedback to improve a strategy of encouraging female cadets to go to sea.

3. Ship as a total institution

With a number of reasons, seafaring is a unique occupation which accommodates a specific work culture and environment for both men and women. Shipboard life is still contained in modern shipping where the number of crew is smaller, typically 17 seafarers on a vessel, and very little free time is allocated both at sea and in port. Seafarers work and live in the same limited space to share. Their onboard life is extremely routinized and scheduled. It is a total institution, as Goffman theorizes [18], which exercizes absolute control over seafarers' onboard lives, including their behaviour and language.

One aspect of ship as a total institution will be the presence of hegemonic masculinity. A hierarchical structure on board a ship, a Captain behaves like a father of *his* crew which resembles a classic norm of patriarchy [19]. Shipboard organizations are gendered in terms of the way seafarers' identities are constructed. Hegemonic masculinity is symbolically positioned on board ships within discourses that produce and reproduce gendered operation of work within the organizational culture. Such positioning is problematic when women enter seafaring professions as their 'difference' may create a disordered orgasm within the ship organization. Geldalof [20] implies this phenomenon as 'tensions between locatedness and dislocation are played out through both discursive representations of 'Woman' and the activities of women', hence the narratives of women's identity repeatedly position 'Woman' as 'place'. This notion matches the understanding of onboard organizational culture where the majority is men; and the minority women if there *is* a woman on board - and even so, she will be considered to be in a 'wrong' place which is not common for women at all. In this setting where the absence of femininity is evident, it may be a challenge for women to be a part of the crew unless they choose to be 'one of the boys'.

Culture determines what the appropriate behaviours are for men and women in the context of organizations [21]. The impact of ship's culture has been observed in women seafarers' lives in various ways. Kitada's [22] research exhibits how women seafarers tend to develop their identity management strategies over time. 'Sameness' strategies are typically employed when women enter a man's world of seafaring work, for example, they attempt to hide their feminine qualities by wearing buggy clothes and without much make-up. In a more intensified format, some women decide to adopt masculine behaviour, such as swearing to present themselves as one of the boys. 'Difference' strategies are, on the other hand, not to compromise their behaviour to a masculine way of decision-making and practices, but rather to stick to their own best way. The study reveals that this process of women's identity management is being affected by the seafaring culture.

4. Methods

This study is based in 15 in-depth interviews with men and women working in the maritime industry in Norway. The interviews were conducted in 2013 – 2014 and took place as explorative semi-structured interviews with the main intention of looking for possible barriers for female participation in the sea-based maritime industry. The interviewed persons all have experience from the sea for longer or shorter periods. Some of them are at present ship operational personnel, some are working in land-based maritime positions.

From this limited data material it is not possible to generalize any results. When we nevertheless will argue that our data constitutes a valid basis for an analysis of women seafarers' organizational life, we build upon a long tradition of the value of qualitative case studies within the organizational sciences [23]. We hence look upon our informants' stories as valuable information in order to illuminate women seafarers' position as minority members in a sea environment.

The goal of this research is to try to understand the contextual dynamics that take place within this organizational setting. Analyses of the data material allow us to gain knowledge concerning organizational traits that seem vital for an understanding of gender minority issues aboard a ship. Although the study is set within a Norwegian context, it is our hope that our findings and discussions will be of interest not only for a Norwegian audience but also for the international maritime industry as women seafarers in a minority organizational position are found all over the world.

5. Women seafarers – one of the boys?

Several researchers have studied work life from the perspective of women as minority organizational members. It seems that regardless of occupation and culture, certain general organizational traits can be found when women enter into work domains dominated by men. The study conducted by Kvande discusses the construction of femininities in engineering organizations [24]. In line with other writers, Kvande finds it significant for women when entering the engineering business to become "one of the boys", to become a "social man".

One of our female informants says:

> *"On my first ship, I was met with skepticism and given a rough time … I felt I was tested out more than the men were. I don't think there should be different expectations for women."*

Kvande discusses the dilemmas facing women when negotiating their status and identity in male-dominated organizational contexts. She utilizes the concepts of "sameness" and "difference" to illuminate possible strategic choices women hold when entering into such work domains. Our research interest is whether women seafarers are obliged to become "one of the boys" or whether it is an option to choose "difference" as a strategy:

> *"I have seen one woman who came on board and the first thing she did was to enter the crew quarters and remove the pictures of lightly dressed women from the walls. She didn't want such pictures at her place of work. But was this necessary? By the way, she didn't last long on the ship,"* a female first officer told.

This female officer apparently chose the strategy of being "different" without much success and understanding in the work environment. Is it easier to accept "sameness" and become "one of the boys" in order to become accepted and achieve a good working life on board? Our data suggest that this might be the case.

Also, the minority position may lead to a struggle for seafaring women to prove themselves competent in order to gain respect from their colleagues [25] [26]. Due to this position and the following high organizational visibility, women tend to look upon themselves as symbols of their gender, and this "proving" of capabilities is not an uncommon feature of "the others". Both authors point to how women on board have to prove their worth to become accepted and respected as co-workers. These statements are shared by our informants:

> *"It is wrong – and probably not uncommon – to have special demands and expectations concerning job performance towards women seafarers"*, argued one informant, a female first officer.

> *"A woman would have to be extremely competent … to do all tasks in an almost perfect manner. I guess a strong woman could survive in such a work environment"*, a male shipping company administrator stated.

Conclusively so far, it seems the female minority position induces special work demands couples with a need for mental and social strength in order to be fully accepted by their male colleagues.

6. Women's "otherness" seen from an organizational perspective

Gherardi and Poggio [27] discuss the "otherness" situation experienced by female employees in a predominantly male work, and their research is much in line with what Kvande [28] and also our study has shown: It seems to be expected that women take on a "sameness" identity in order to become integrated into the work environment. What also is explored in Gherardi and Poggio's [29] work is a possible explanation for why this generally seems to be the case: Is it viable to argue that women's entry into male-dominated workplaces in itself may undermine traditions? Research by Alvesson and Billing [30] echoes this question in their discussion of how beliefs and values concerning what is "natural" and legitimate ways of behaviour and language are set within the organizational culture. In line with other researchers, they argue that a stable organizational situation may become somewhat shattered when "others" enter.

Is it then viable to argue that the entering of "others" into maritime work environments – consciously or unconsciously – may provoke skepticism or even resistance towards female participation? And will the male organizational culture be "defended" by for example the use of coarse language and sexual comments in which women as a group are targeted? The mentioned authors argue that female employees instinctively may try to "solve" this complex situation by seeking more or less to conceal their gender identity in order to prevent conflicts and leave the male gender culture alone.

Thomas' [31] research from a maritime environment underlines these arguments by showing that women seafarers have to accept sexual jokes and language while they simultaneously are expected to downplay their femininity for example in the way they dress when being off duty. We find it legitimate to argue that when fulfilling such incongruent expectations, women's gender enactment contributes to preserving the existing male-dominated organizational culture. From this perspective, Gherardi and Poggio's [32] affirmative answers to the cited questions along with Thomas' [33] and Alvesson and Billing's [34] observations constitute valuable organizational perspectives to shed light on women's position on board a ship. As an analytical tool, it helps us to comprehend that possible male skepticism and expectations towards female colleagues at times has less to do with a dislike and discrimination of women but more to do with a dislike of something – here: women seafarers – threatening the stability of their organizational culture.

Our informants support this reflection by their shared perception of change in the maritime work environment if women become part of the crew:

> *"It makes a difference when women are employed on board. It has to do with how you behave … sometimes life on a ship can be almost childish when it comes to language use and nonsense with only men present … you have to speak in a different manner when there are women"*, a male captain argued.
>
> *"The conversations become different, both in style and content when women come into the work environment"*, a female first officer maintained.

Conclusively so far, it seems fair to argue that the organizational culture enters a change phase when women become employees on board. For some organizational members, this will be positively received, while others will regret the cracks in their up-to-then stable on board culture.

7. Female sexuality as the ultimate disordering element?

It was unexpected for us to find that quite a few of our informants talked about sexuality on board when describing women's positions as minority organizational members. This theme was not part of our initial research topic, but it proved to become important due to informants' reflections. Based on the information of sexuality's "presence" on board, it is rather interesting to find that few – to our knowledge – academic writers have been occupied with this subject. One exception is the Swedish ethnographer, Ingrid Kaijser [35] who discusses sexuality on board by utilizing the categories "visible", "secret" and "invisible". Even though the categorizing of sexual behaviour is not a theme of our analysis, Kaijser's work is important to us in the way it acknowledges that sexuality can be found on board a ship.

Our findings point to specific behavioural expectations regarding female sexuality in order to protect the organizational order on board from unwanted disruptions. Such behavioural expectations are argued by both women and men among our informants and are widely shared among these. The activation of female sexuality seems to be the utmost example of how women's gender enactment may threaten the stability and culture of a ship's work environment.

> *"There have been situations where sexual relations have developed between men and women on board. Then maybe jealousy has developed…. That is maybe why they say that women should not work at sea"*, a male captain maintained.

A female first officer told about the advice she had given to a young female seafarer:

> *"What do you consider wise behaviour if you want to be respected as a colleague and nothing else? Do you think you ought to sun-bathe at the swimming pool wearing a bikini?"*

A former male captain, now a shipping administrator, put it this way:

"It is mainly the women who are in charge of this sexual play. It is their responsibility to decide their behaviour. Then they must understand the consequences if they …"

The same informant talked about a fellow captain, now retired:

"He didn't want to have women on board. He wanted peace. He knew what it could mean to have …"

Other informants claimed that women's age is important when it comes to sexuality and life on board. One of the interviewed male captains remarked that captains might prefer women seafarers to be more or less middle-aged, because:

" … young girls can't handle all the attention they get … at sea for weeks and months".

When analyzing our data material, it is quite obvious that the responsibility for sexual behaviour on board is placed upon the female minority, and indeed accepted by the women as well. In general, it seems that women are expected to conceal parts of their female identity while on board in order not to raise emotional and sexual tensions among their male colleagues. Such tensions within the life of a total institution may be very harmful for the necessary organizational stability, it is claimed by many of our informants.

8. Women seafarers as minority organizational members: A silent topic?

Based on well-known leadership literature in which organizational culture is discussed (for example Schein) [36], it would not be unreasonable to imagine that the challenges of integrating minority organizational members into the work environment would be a topic of systematic leadership attention within the maritime industry. Our informants were asked about the state of the art concerning this, but none of them could remember any occasions in which issues concerning women seafarers had been formally discussed, neither on their ships nor generally in the industry.

"I don't know whether we will put this on our agenda … I have to acknowledge that this is not something we have been concerned with," said a male shipping administrator when asked if women seafarers was an organizational topic of interest.

"The maritime industry is not occupied with the existing gender imbalance and what this possibly might mean for the few women on board," another male administrator maintained.

After having told several stories involving women and sexuality on board, a former captain, now administrator, said:

"What I talk about now is something we do not openly talk about … but I do hear some stories which are quite sad. But these stories mostly stay on board, they do not often come to our knowledge at shore".

It is important to emphasize that the informant did not talk about sexual abuse, but rather of situations in which women seafarers in his opinion had not taken proper responsibility for avoiding that sexual relations had developed. His phrasing leads us to suggest that in his company, taboos existed concerning openness about what sexuality might mean both for individuals and for life in general within the total institution of the ship.

Our informants confirm that organizational discussions about the minority position of women seafarers are not to be found on the formal agenda. When they at the same time are occupied with organizational culture issues and the work environment on board, it seems viable to point to an interesting paradox in their approach: Through the silence concerning women as minority members, it becomes difficult to address the organizational challenges of having employed someone (i.e. women) who are different from the mainstream male employee. The challenges are similar to those found in other gender-imbalanced industries and they do not disappear if they are looked upon as non-existing, not of interest or even as taboos.

9. Conclusion

The Norwegian maritime industry – and the maritime industry in general – have to decide whether it will be a future business strategy to employ and retain more women seafarers. If the answer to this question is positive, then our paper has come forward with knowledge that we believe is vital for the successful implementation of such a strategy.

In this paper, we have shown that to be part of a minority group at a workplace can be challenging both for the individual and for the organization. Women seafarers' experience of being a minority is not personal but common in such work organizations. Hence, this paper has extensively provided the evidence of advantages of approaching this situation as an organizational rather than an individual issue. By doing so, the individual responsibility of behaving like “one of the boys” will be lifted from the women seafarers, and their male colleagues will be relieved from the individual responsibility of trying to act well-intentioned within organizational processes of which they – quite naturally – have limited knowledge. From this, we find it vital that maritime organizations acknowledge the challenge and responsibility following from having minority members as part of their work stock at sea. On the contrary, such an acknowledgment will be misleading if it merely focuses on existing poor practice. What it needs to give attention is rather a lack of knowledge concerning what it means to be part of a minority in any workplace.

This research highlights *silence* rather than words that distinguishes the way in which the maritime industry copes with the topic of women seafarers and their minority position. In fact, key participants who referred to the existing organizational minority challenges in this work are the local leaders – i.e. the sailing captains. If the industry wants to hire and retain more women on their ships, it is vital in our opinion to end the silence and openly talk about and discuss issues like the ones we have commented upon in this paper. Such a discussion does not suggest that the industry or individuals are to blame for the present situation. To the contrary, it suggests that improvements for the benefit of the industry have to include open discussions without some topics being looked upon as taboos.

Lastly, it is our concern that little research has been done concerning women seafarers as minority organizational members. It is our conviction that more research within this field will contribute to broader knowledge about a topic that is strategically important in the future of the maritime industry.

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Study over the increasing of situational awareness and the culture of safety among younger officers

Professor Radu Hanzu-Pazara[1], Professor Gabriel Raicu[2], Lecturer Anastasia Duse[3], Lecturer Loredana Hanzu-Pazara[4]

1. Constanta Maritime University, hanzu@imc.ro, Mircea cel Batran Street 104, 900663, Constanta, Romania
2. Constanta Maritime University, graicu@imc.ro
3. Constanta Maritime University, anastasia.duse@yahoo.ro
4. "Ovidius" University of Constanta, loredanapazara@yahoo.com

Abstract Two aspects count most on board of all ship today: safety and security. There are many rules and regulations stated on this issues containing requirements on managing different situations, on the way of approach a safety or security situation, and most important of all, on how to prevent these events. But, all these are coldly established for understanding and application when is necessary, without taking into consideration variant human behavior. Based on these observations, we can emphasize the importance of rules, regulations and procedures, but only after testing the situational feed-back. Basically, all situations involving ship's safety and security are treated as potential risks, before being recognized as a real threat. It's important to increase the crew situational awareness into identifying and assessing the risks and to establish a culture of safety in order to prevent future dangerous situations. The question that arises is how are we capable to obtain the same average of understanding and response for a considered risk?

In the study we evaluated the understanding and addressing situations of risk for ship's safety, by using simulations of different events to be faced at sea like stranding or collision situations, piracy attacks and terrorist threats. We included seafarers with different levels of training and experience on sea, from cadets and young officers – considered less experienced or in the beginning of their seafarer carrier, up to seafarers with considerable number of years on sea.

Present paper presents the methods used in the study and the results obtained on human response over different risky situations, on the way that situational awareness and culture of safety influence the assessment process for these conditions, the influence of experience and what are the optimal solutions to be considered in accordance with present evolution of maritime industry and procedural requirements for ship safety.

Keywords: Safety, awareness, culture, younger officers, study.

1. Introduction

Today, the maritime industry is focused on increasing the safety and security in all sectors and at all levels. This increase is based both on technical development and also on changing the human behaviour. The time when only the technical measures were taken into consideration is no longer available. Studies about the impact of technology on safety in different industries have shown that the improvement of equipment alone, without a proper increasing of human awareness, is not efficient. The technology can bring a lot of advantages on safety matters, but only if it is controlled by aware operators, able to understand the meaning of "safety".

To define safety is important for every seafarer, because the understanding of this concept generates a secured working environment for all on board persons. A person able to perform activities in safe manners for him, will be able to offer safe environment for others. But, if you will not be able to define what is safe for yourself, there will be really difficult to offer a protected environment for the others.
To be safety aware is not a characteristic of the "older" seafarers only, it must be seen as a basic concept for all seafarers. For a seafarer is important to be aware of possible dangers in most of the situations.

Any activity that has to be performed must begin with a risk evaluation, that aware the person involved about what can happen, which is the best way to approach the job and what is necessary to be done in order to avoid possible dangerous conditions. If these considerations will be taken into account for all activities performed on board, the number of dangerous situations, near misses and accidents will be very much reduced, and the maritime industry will no longer be considered as dangerous as it is today.

The relationship between situational awareness and the culture of safety is well known: is difficult to be aware about the risks without knowledge. A good safety knowledge will make the seafarers more aware about the risky situations for life, ship and environment.

For these reasons, the meaning of any maritime education and training institution is to guide the students to complete their training in ship safety and security, and to be able to bring their contribution to the ultimate concept of "safer ships, safer seas".

2. Situational awareness and maritime safety

Like in many other industries, for the maritime, a good situational awareness means to have always a right and clear perception of your surroundings, to be able to understand what's happening around you and how all of these will affect the ship [1]. Situational awareness refers to the capability to maintain a constant vigil over important information, to understand the relationships among the various pieces of information monitored, and to project this understanding into the near future for making critical decisions.

On board, regardless department affiliation, the seafarers must constantly maintain situational awareness in order to ensure safe operations. A healthy dose of situational awareness is essential to make informed decisions, act in a timely manner, and ultimately ensure operational safety, even on sea or in harbour. Studies over the maritime incidents have high lightened that the loss of situational awareness plays a significant role in incidents attributed to human factor. Different studies made by United States Coast Guard revealed that human factors accounted for 54% of the medium and high severity incidents and about 40% of the low severity incidents. Also, failures in situational awareness or task performance accounted for 69% of the medium and high severity human incidents. The same studies have shown that only 5% of the cases were attributed to mechanical problems [2].

To avoid inclusion in these statistics is important to know how to establish a good situational awareness, including the following considerations [3]:

- *to be aware of your situational environment* (ships in the transiting area, necessary communication with coastal stations or other ships, water depth, tide, current, weather, sea state),
- *to be aware of the status of your ship's systems*,
- *to have mode awareness (*know the own ship configuration, including equipment and systems),
- *to keep a time horizon (*always allow time for unplanned events or emergencies),
- *to maintain spatial orientation.*

According to Endsley [4], the situational awareness can be organized in three levels of information processing. The first level, *perception*, is fundamental. Without basic perception of important information, the odds of forming an incorrect image of the situation will increase a lot. At this level, the seafarer perceives the status and the dynamics of the relevant elements in his environment and a typical error would be the missing of critical information [5].

At second level, the *comprehension*, situational awareness as unitary construct, goes beyond mere perception. It is ssurprising how people combine, interpret, store and retain information. At this level, there is an integration of multiple pieces of information and a determination of their relevance to the person's goals. In this stage, the seafarer will evaluate and integrate the existing information. It is required for him to understand the information in relation to the relevant objectives and goals [5].

At the last level of situational awareness, *projection*, person is developing the ability to forecast future situational events and dynamics; this marks persons who have the highest level of understanding of the situation. In the final stage, the seafarer uses his perception and comprehension of the present situation to approximate what will be produced in the near future [5].

Regarding to the situational awareness levels, an analyse of the incidents occurred in offshore industry that included 135 cases, revealed that 67% of these were resulted from lack of perception of critical information (Level 1), 20% due to failure to comprehend the real situation (Level 2), and 13% were attributed to inability to project what will happen in the near future (Level 3) [6].

Regarding maritime safety, the situational awareness involves both a temporal and also a spatial component. *Time* is an important concept in situational awareness, being a dynamic construct, changing at a tempo dictated by the actions of seafarers, task characteristics, and the surrounding environment. As new inputs enter the system, the seafarer incorporates them into this mental representation, changing the plan and actions as necessary to reach the desired objectives. The situational awareness concept also includes the *spatial* knowledge about all the events and activities developed in locations of interest for seafarer. As example, the officer on the watch on the bridge has to be aware about the location and extent of the maintenance activities that take place on deck, in order to protect the seamen from any dangerous situation.

Presently, building of a firm situational awareness on maritime safety has faced an entire set of challenges, which must be considered in process designing [7]. The first challenge is to gather information on the situation around you and second one, to have the capability to identify the critical situations.

Thus, the concept of situational awareness includes perception, comprehension, and projection of situational information, as well as temporal and spatial components.

Important is not to forget that activities on board ship are made in most of the cases as a team work and situational awareness have to be treated as a whole for the entire team members. The team situational awareness is based and depends on the level of safety awareness for each member of the team and the level of safety awareness shared between team members. These aspects provide an accurate operating picture of those aspects of the situation common to the needs of each member of the team [8].

Regarding the team situational awareness, Endsley and Jones [1] describe a model intending to conceptualize how teams develop high levels of shared safety awareness across members, a model suitable to be used for those on board activities based on team activities. The factors considered to help into building a strong team and to share situational awareness are requirements, devices, mechanisms and processes.

The team situational awareness requirements represent the highest level of comprehension of information, of selecting the most important aspects that should be shared, including personal assessments and projections. There is also information on team member’s activities and capabilities.
For situational awareness devices are considered the devices available in different working compartments for sharing information, including direct communication, visual or audio displays or a shared environment.

Team situational awareness mechanism represents the way of processing information by team members, like shared mental models, which support their ability to interpret information in the same way and make accurate projections regarding each other’s actions. To have capacity to use a shared mental model can help a lot to increase communication and coordination in team settings.

The situational awareness processes are the degrees of involvement of each team members into effective processes for sharing necessary information, like a group norm of questioning assumptions, checking each other for conflicting information or perceptions, setting up coordination and prioritization of actions, and establishing contingency planning among others.

Related to this, in our study, we tried to recreate the situations possible to be met on the bridge during navigation and to find how different trained level seafarers manifest their situational awareness. We checked if practical experience and good knowledge about the events around offered the opportunity to take better decisions on ships control.

In the study, the team intended to identify the key factors characteristic for the evaluation of situational awareness level. We have been observing the way of using the perception, comprehension, and projection of relevant events.

3. Study on risk perception and reaction among younger officers

A good analysis of the maritime activities will reveal that many are characterized by a medium to high level of risk. It is well known that any risk can be assessed and managed in good conditions, if it is recognized. The real problem, when introducing humans in the work equation, is how they evaluate and recognize the risk value.

In risk evaluation and safety measures an important consideration is given to situational awareness and safety culture. Both have the meaning to create and improve the sense of good and safe work.

3.1. Aims of the study

The study was initiated to get explanation on how the situational awareness and the existence of a safety culture among the ship crew can contribute to increasing of ship safety and security. As research method was used simulation techniques combined with questioning technique and discussions, for a more complete explanation of decisions and results.

The study was realized using Constanta Maritime University’s simulation complex together with the support of our students and collaborators from maritime industry. Also, we received support from medicine faculty colleagues, to understand different psychological aspects of decision making process.

The main goal of the study was to understand the human response over different risky situations, and the influence of situational awareness and culture of safety on the assessment processes, considering the people involved experience in these situations. In the same time, was intended to found the optimal solutions to be considered according to the present evolution of maritime industry and procedural requirements for ship safety.

3.2. Methods

For analysis of situational awareness in different sailing conditions were included 30 students with variable periods of practice on sea or no practice, 10 students with more than 2 years of experience on sea as helmsmen or able seafarers and 4 Master licensed with more than 5 years of experience in this position. For the students were created simulation scenarios for some possible dangerous or difficult to be managed situations, and interviews, for the Masters were used professional discussions and opinions based on own experience in these kind of situations.
The situations considered for simulations were navigation in restricted visibility with risk of collisions, possible piracy attack in isolate ship condition, engine failure in bad weather conditions, loss of the steering system during a channel transit and fail of the electronic charts system during transiting of a heavy traffic area.

For a better analyse of the participant's situational awareness, part of the simulations were performed by students alone, others in a bridge team format. When the simulations required a team format, members of the team were chosen with different level of experience.

Procedure: Students were given no instructions other than as per normal procedures. Immediately after starting simulation, there were included heading changes in short succession. On re-commencing the simulation after the first freeze, students were instructed to continue with their simulation as planned. During this segment various radio calls were made, some of which were relevant, others incidental to the task. The relevant calls advised of traffic information, and of changing weather conditions. After different situations of system failure (engine failure, loss of steering system, failure of electronic charts, etc.), the second questionnaire was administered. On continuing the simulation, additional calls were made to advise of deteriorating weather conditions, restricted visibility, risk of collisions, piracy attack, etc.

The final questionnaire was instigated about 5 minutes prior to simulation termination.

This arrangement was agreed to allow to: analyse how are used perception, comprehension and projection according to the classification levels of situational awareness, which is the role of goals and goal directed processing attention and interpreting the significance of perceived information, the role of information in increasing of the situational awareness, the role of expectations in directing attention and interpreting information, the heavy demands on limited working memory restricting situational awareness for students without onboard experience or a short one, the use of mental models for providing a means for integrating different part of information and comprehending its meaning and pattern matching to schema, that provides rapid retrieval of comprehension and projection relevant to the recognized situation.

3.3. Results

The resulting error scores ranged from 1 (best answer score) to 10 (worst answer score). Categorical responses were scored as 1 (accurate) or 10 (inaccurate). The scores were then averaged across items for each of the three questionnaires to form three general scores (G1, G2, and G3), and across all items to form one overall G-score (G). Best inclusion for situational awareness scored the minimum average points (best attitude of situational awareness and minimal errors).

Questionnaires were including six pattern questions for the 3 factors – 3 for timing and 3 for spacing – for each of the freeze moments. (6 minimal score = best answers over all; 60 maximal score = worst answers over all).

Median age was 25,73 (differentiated on experience into subgroups according to experience/practice onboard). All participants were deck students/personnel.

After completion of the simulated situations, during interviews and discussions with the participants, there were requested explanations for reactions and decisions in different situations of navigation, there were given solutions and it was created the framework for understanding how situational awareness, good information and the sense of safety can influence it.

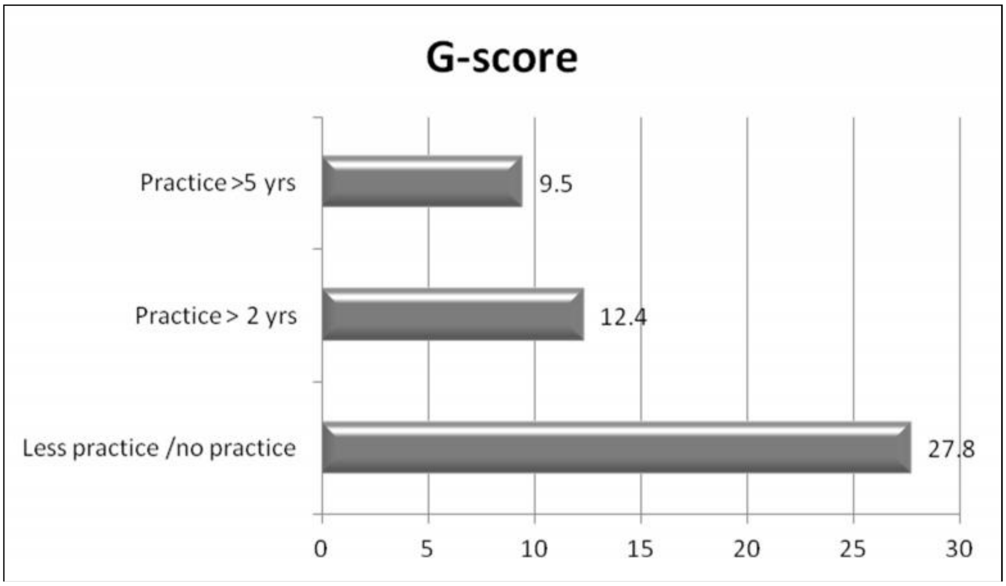

Figure 1 Mean value for general awareness score in subgroups

The best general score for situational awareness was recorded in the subgroup of participants with a longer period of sailing (Figure 1) compared with those with less practice or no practice at all (9.5 vs.27.8)

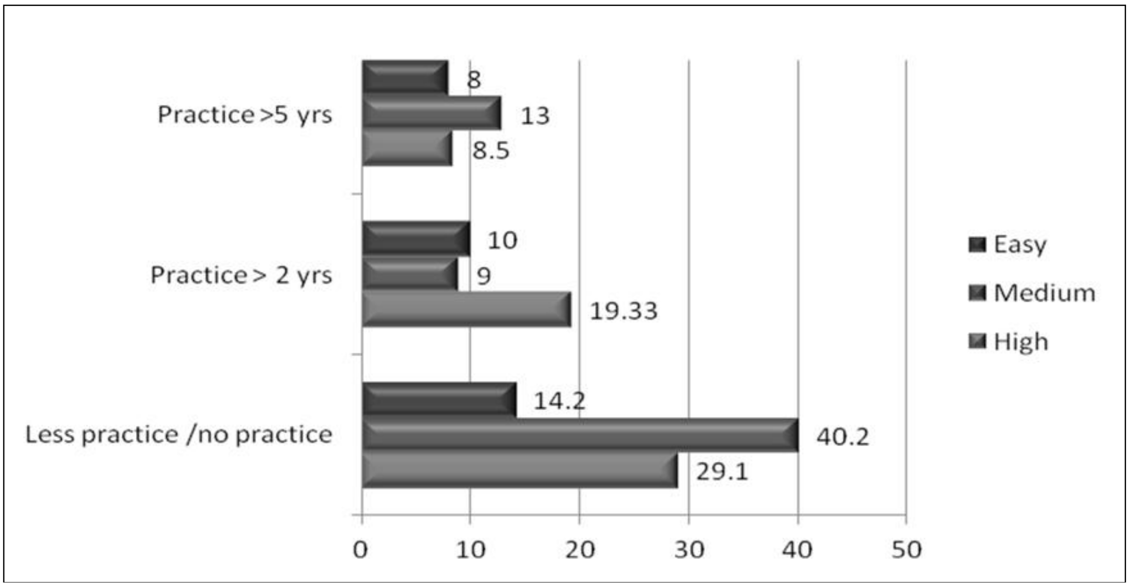

Figure 2 Mean general awareness score in subgroups according to incident level (high, medium, easy)

An interesting observation was made during evaluation of general awareness score according to incidents level. With the exception of experienced group, scores were higher (poor) in case of high and medium severity incidents, compared with easy situations. A similar trend was found in case of both experienced and non-experienced subgroups in case of medium severity incidents, where the scores were worst (40.2 and 13). Only the subgroup with incipient practice prooved the best awareness score.

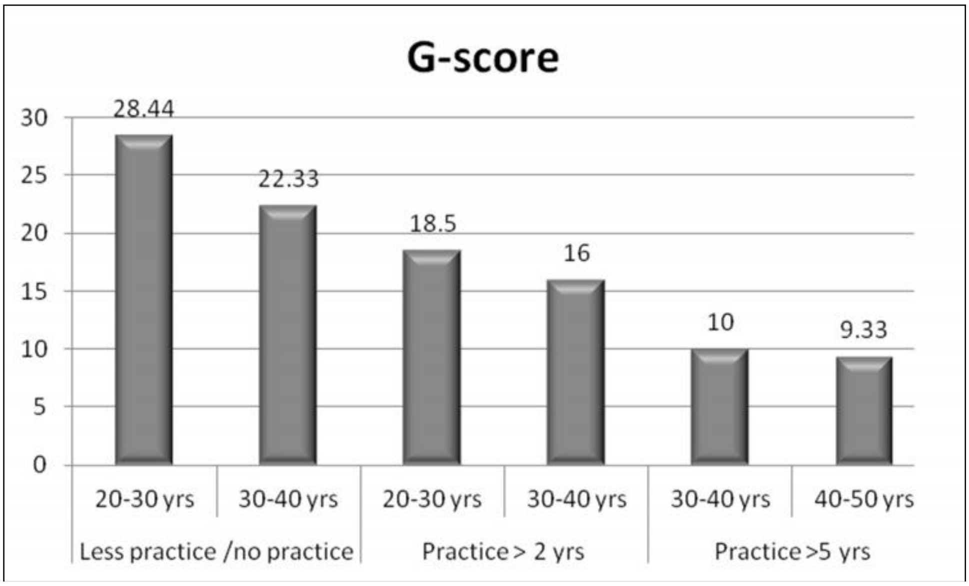

Figure 3 Mean value for general awareness score in subgroups divided by age

A general analyse of the results showed that situational awareness is related to knowledge and understanding of different conditions and the environment where are produced, leading to conclusion that experience is an important part of the process. (Figure 3)

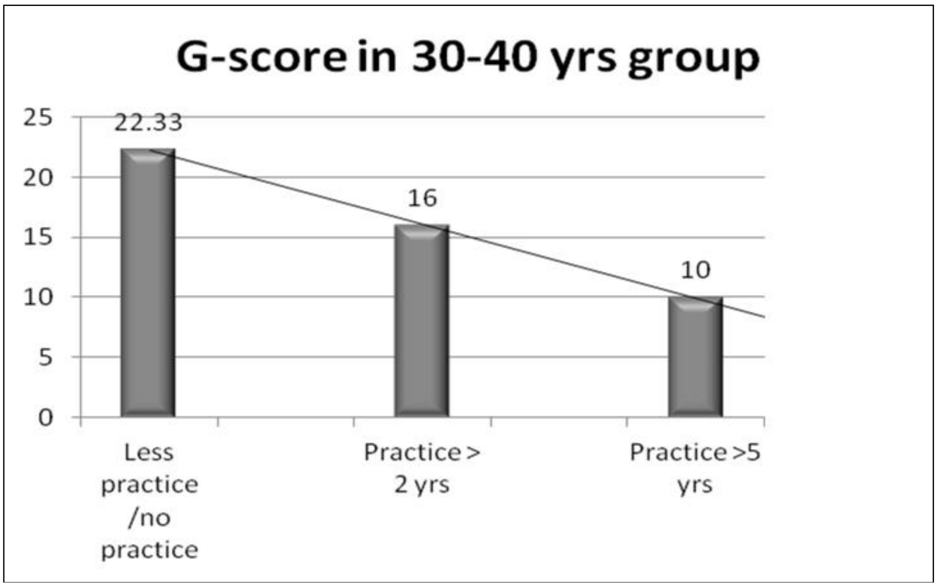

Figure 4.Improvement of general awareness score in subgroup adjusted by age

An adjustment made by using the age as sub-grouping, revealed that the situational awareness is improving according to increasing periods of practice on board ships (figure 4); a similar finding was reached by simple age separation that high lightened increased responsibility reached at median age of 30 – 40 years (Figure 4).

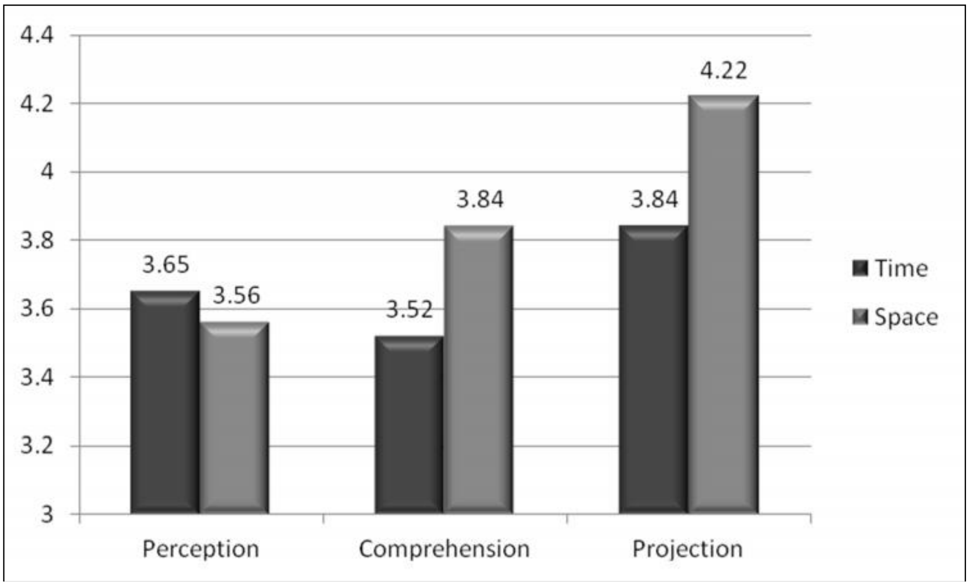

Figure 5 Value of general awareness score correlated with situational awareness indicators

Maybe the most important analyse was given by the correlation in between the three major indicators of situational awareness: perception, comprehension and projection. Worst scores were found in managing space comprehension and projection (3.84, respectivelly 4.22), but not in the perception of space. Related to second factor, most errors were found in time projection.(Figure 5)

3.4. Discussions

A review of the incident reports has identified the missing of a safety culture as the main cause of the maritime accidents. This reason lead to necessity to have in place a Safety Management System as a good practice and to implement safe working practices and attitudes through the development of a positive safety culture.

Therefore, the importance in assessing the social processes behind the safety performance of the maritime has been acknowledged. Accident investigations have moved away from a focus on proximal circumstances operating at the individual level, to investigating more latent, systemic organizational or managerial flaws. Collaborative efforts in assessing maritime safety culture have been undertaken in an effort to potentially reduce the number and severity of maritime accidents or incidents.

During the last decades, specialized literature used different definitions for safety culture. In 2000, Guldenmund [9] define safety culture as “those aspects of the organisational culture which will impact on attitudes and behaviour related to increasing or decreasing risk”. In a report on safety culture, the UK Health & Safety Executive [10] defining as “the product of individual and group values, attitudes, perceptions, competencies, and patterns of behaviour that determine the commitment to, and the style and proficiency of, an organization’s health and safety management.” In 2008, Von Thaden and Gibbons [11] defined safety culture “the enduring value and prioritization of worker and public safety by each member of each group and in every level of an organization”.

The literature on safety culture often distinguishes between safety culture and safety climate, where the result of a safety culture survey is called “safety climate” to show that it is a snapshot of the organization taken at a certain point in time.

As defined, “Safety Culture” represents an organizational environment where are promoted self-regulations to ensure that each individual, as part of the organization, takes responsibility for those actions designed to improve safety and increase the performance [12], or, that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, safety issues receive the attention warranted by their significance [13].

Considering the definitions, the basic element of the concept is the people. In the maritime context, the considered person can be any crew member, the responsibility being related to his position on board. As crew member, all persons on board ship have to understand their responsibilities on the safety of life, ship and environment. These responsibilities should come from rules and regulations and as a normal behaviour also.

Most important thing is to be able to understand and define the term "safety" in a particular meaning. In the moment when a person is able to understand the right sense of the term, is capable to generate safety environment for the others. This ability is in a close relation with the level of knowledge and performance on duty of the person.

A healthy safety culture on board might be promoted and reflect by four factors [14]:

- senior officer commitment to safety,
- realistic and flexible customs and practices for handling both well-defined and ill-defined hazards,
- continuous organisational learning through practices such as feedback systems, monitoring, and analysis, and
- care and concern for hazards shared across the workforce.

Today, most of the personnel engaged in maritime activities, when are asked to define their personal vision on "Safety culture", reply with many different answers, including [15]:

- Awareness of potential dangers and to make others aware
- Hazard awareness
- Legal, social and personal responsibility
- Developing a set of safety behaviours
- Ensuring passenger and crew safety at all time
- Avoiding harm and injury
- Developing a good communication
- Improvement of the systems and procedures
- Good training on risk assessment
- Right mindset
- Proactive (prevention) rather than reactive.

Even if, as present or future seafarer, is thinking that already have a successful safety culture, should be care that all time there is room for improvement. Striving for excellence is the key and cornerstone to any safety culture.

Essential things like safety culture are often based on good and bad examples. Regardless how many procedures and safety measures will be taken to prevent and mitigate any perceived risk, the human error means that mistakes will be made and is important to know how to handle these situations to have a success safety culture. A great leader once said, "All men make mistakes, but only wise men learn from them [15]."

For a right understanding and usage of the "safety" and "safety culture" terms, is important to be explained and exemplified from the initial maritime training stage. Here, the training institution have a great role in creation of the sense of safety, to build from the beginning a strong safety culture among the future seafarer. A mature safety culture ensures that the working environment cultivates safe attitudes and benefitting safety performance.

The goal of a positive safety culture is the fostering of professional behaviour in routine and emergency situations, but assessing behaviour is not straightforward because:

- People have a tendency to change their behaviour when they know they are being watch,
- Apparent routine behaviour may not be sustained in an emergency, or stressful situations,
- Behaviour assessment can be very time-consuming
- Behavioural assessment requires corroboration by assessments of attitudes and values.

Attitudes, values and opinions should be drawn out as they are central to most definitions of safety culture.

4. Conclusions

Safety and security will remain the main concerning of the maritime industry. It's important to increase the crew situational awareness into identifying and assessing the risks and to establish a culture of safety in order to prevent future dangerous situations. Proposed model is emphasizing the necessity of quantifying the level of situational awareness in the continuous education and training of maritime personnel. The best general score for situational awareness was recorded in the subgroup of participants with a longer period of sailing compared with those with less practice or no practice at all, emphasizing the importance of experience in a definite practical occupation, even if the subgroup with incipient practice prooved the best awareness score in case of risk situations (signal of decreased awareness for routined seafarers). Maybe the most important analyse was given by the correlation in between the three major indicators of situational awareness: perception, comprehension and projection. Worst scores were found in managing space comprehension and projection (especially in time projection), but not in the perception of space, showing a promising possibillity of improving the ability in a close relation with the level of knowledge and performance on duty of the person, implicitly generating safety environment for the others.

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Cultural Intelligence and Awareness in Maritime Education: A Case Study

Dr. Bani Ghosh, PhD in Economics, Professor

Department of International Maritime Business, Massachusetts Maritime Academy
101 Academy Drive, MA 02532, USA
Phone: 508 830 5000 x 2112; Email: bghosh@maritime.edu

Abstract Cultural intelligence is the ability to accurately decipher seemingly ambiguous situations in cross cultural environments. In a world, where crossing geographical boundaries is routine, and more so in the context of maritime transportation, this happens to be a very relevant topic for discussion. As globalization has rendered the maritime business environment more complex, diverse and competitive, the ability to function effectively in different cultural contexts is now critically important. It is common knowledge that cross cultural skills are best developed through experiential learning e.g. by studying or working in a foreign culture where one learns by trial and error. This paper is based on a case study tracing US maritime college student learning experiences that take them to two locations in Asia, namely Singapore and Malaysia. This initiative was part of an experiential learning program. The International Maritime Business (IMB) program at Massachusetts Maritime Academy (MMA) undertook this initiative to enhance the knowledge base of its student body who typically work on the shore side of the shipping industry. This is also critical because, although the seafaring side of the shipping industry experiences a cultural immersion due to their job description, as they visit various ports around the world, the shore side maritime professionals are generally recruited from the corporate headquarters with little cultural cross pollination. In this initiative, students spent three weeks in these locations during the month of February, 2016 under faculty supervision. They learned about the port infrastructure and maritime activities in those locations and were required to write a paper on their observations. During their stay in the two locations, they also experienced complete cultural immersion. Many of these students had never stepped out of the US prior to this. Upon their return to the US, the students were surveyed on their experiences revealing some interesting findings about cultural intelligence and awareness. The paper discusses the design of the program leveraging existing partnerships, the preparatory phase, the actual experience and post experience cognition as expressed in the survey.

***Keywords**:* Cultural intelligence, cross cultural communication, experiential learning

1. Introduction:

It is commonly understood that success in a globalized economy depends significantly on cultural awareness and adaptability. Cultural competence is commonly defined as the combination of knowledge, attitudes and skills necessary to effectively interact with culturally and ethnically diverse populations. One should have knowledge of culture, history, traditions of these populations. As for attitudes, one should be aware of diverse values, beliefs, and behaviors, be accepting of cultural differences and should be able to reflect on one's own socio-cultural background and personal biases or tendency to stereotype. The skills element focuses on communication skills to interact with diverse populations and overcome language barriers and also the adaptability to adequately respond to culturally diverse situations. Research indicates that those kinds of awareness and abilities can be measured and evaluated. They are quantified as cultural intelligence quotient, or CQ. First introduced by two business researchers, Christopher Earley and Soon Ang[1] , in their 2003 book, '*Cultural intelligence: Individual interactions across cultures*', it measures the capability to function effectively in a variety of national, ethnic and organizational settings. This form of intelligence has been tested by academic researchers in more than 30 countries over a decade. In a world, where crossing geographical boundaries is routine, and in a profession like maritime business where the sun never sets, cultural intelligence is a vital aptitude and skill. In this paper, an attempt has been made to underscore the importance of cultural intelligence in maritime business education.

Section 2 provides a brief description of cultural intelligence and its relevance in maritime education. Section 3 presents the motivation behind the development of cultural intelligence through experiential learning in the International Maritime Business (IMB) curriculum at Massachusetts Maritime Academy (MMA). As a case study, Section 4 describes a student learning experience in two locations in Asia, namely Singapore and Malaysia. It outlines the survey findings used to test the impact of the study tour on the cultural intelligence of participating students. Section 5 provides conclusions.

2. The Relevance of Cultural Intelligence in Maritime Education:

Organization management textbooks have several anecdotes of expatriate managers facing severe professional problems due to lack of cultural intelligence. Ethnocentrism or the belief that one's native culture and ethnicity is superior to all others is considered to be a major roadblock in managerial and organizational contexts. This is linked to several personnel problems like recruitment difficulties, high turnover rates, low employee motivation and even expensive lawsuits. Current and future managers need to overcome this ethnocentric bias through greater cross cultural awareness, education and international experiences of cultural immersion. Given the number of cross-functional assignments, job transfers, virtual teams and distant postings, most managers are likely to experience in the course of a career, a low cultural intelligence quotient (CQ) can turn out to be a significant disadvantage.[2] In fact, University of Michigan professor Jeffrey Sanchez-Burks'[3] research on cultural barriers in business found that job candidates who adopted some of the mannerisms of recruiters with cultural backgrounds different from their own were more likely to be made an offer.

While general businesses continue to grapple with CQ issues, the matter is even more critical in the maritime context which is perhaps the most global sector in the world. Given the international and geographically dispersed nature of the maritime industry, the skills required are more complex than in regular domestic businesses. Not only are ships being operated by multinational crew members, the business of shipping on the shore-side is also truly global. Addressing issues of cultural competency is of utmost importance in this field and must be treated as a core component of the maritime curriculum.

Michael Ircha[4] in his 2006 paper, '*Maritime education in cross cultural settings,*' explores several problems of misunderstandings and misinterpretations among people having different worldviews in a maritime context. His paper discusses cross-cultural dimensions including conflicting information, time/space issues and resulting emotional responses. This is followed by a review of the adjustment problems faced by international students and instructors studying or teaching in other countries. The paper concludes with a discussion of the facilitating factors that help instructors ensure effective learning in cross-cultural settings.

The importance of CQ in the maritime context was also recognized by Graham Benton and Timothy Lynch[5] in their 2014 paper '*Globalization, cultural intelligence and maritime education*.' The authors discuss the initiatives taken by California Maritime Academy in assessing and improving student CQ in a maritime educational institution.

In 2015[6], Momoko Kitada discusses the same issue in her paper '*Promoting cultural awareness through welfare in maritime education and training.*' Kitada emphasizes cultural awareness as becoming increasingly important, because it facilitates smoother communication and mutual understanding among the multinational crew, and thus, contributes to the safe operation of ships. It is commonly understood that better communication and mutual understanding among the crew members should help reducing human errors in marine accidents, which are known as the major causes of catastrophes at sea. Kitada's study also found that an early exposure to different cultures while cadets study in a MET institution helps to foster soft skills to negotiate and harmonize with other nationalities of the crew.

This paper underscores the importance of cultural intelligence not only for the seafaring students in a maritime institution but also those students who end up working on the shore-side of the maritime industry. It identifies three broad cultural competence domains:

1. General knowledge: This includes knowledge of culture, history, traditions, values, and family systems of culturally diverse populations.
2. Reflection ability: For culturally competent individuals, reflection is required for insight into one's own understanding of prejudice and cultural frames of reference
3. Culturally competent behavior: Communicate and work effectively with individuals from various cultural backgrounds and ethnicities.

Section 3 discusses the various international experiences that students at MMA are exposed to in order to enhance their CQ in the aforementioned domains. It focuses on a specific initiative undertaken in 2016 in Singapore and Malaysia and discusses its impact on participating students.

3. MMA Initiatives to Enhance CQ:

MMA engages in a number of international experiential learning initiatives for its students that are listed below:

- The sea going license track students of MMA complete their sea going experiential training aboard the training vessel T.S. Kennedy and other commercial shipping voyages. The cruises are accomplished in the following order on the following vessels: Academy training ship, training or commercial ship followed by Academy training ship. This experiential element is an integral part of the academic curriculum for the license track programs. This gives an opportunity to travel to international ports and work alongside multinational crew in commercial vessels.

- However, a non license track, shore based major like IMB also has a significant experiential learning component. The emphasis on curricular design is aligned to the educational philosophy of the Academy: Learn–Do–Learn. The original framework of the curriculum was based on the following model. Through academic coursework, students learn the concepts and principles of international maritime business. They then apply this learning in a professional context. In order to graduate, students need to complete a minimum of two internships and an international experiential learning program. Based upon that experience, students then improve and adapt their understanding of the concepts and theories of maritime business.[7] Apart from these, there are semester long study abroad programs that allow for a deeper cultural immersion.

The following experiences help students in the IMB program at MMA develop their cross cultural and global awareness by visiting other countries, learning and observing international maritime business in practice at various ports and related maritime interests.

i. Semester long study abroad programs at Shanghai Maritime University (SMU) and Dalian Maritime University (DMU).

ii. An internship in Panama City, Panama, to learn about the operations of the Panama Canal.

iii. International short term experiential learning programs:

In an increasingly global environment, it is critical that business professionals learn about globalization and international business practices. Similarly, it is important that maritime business professionals learn about shipping and maritime industries in a global context and develop their CQ. These experiential learning programs, designed specifically for upper division IMB students, provide a first-hand international experience. In the learn-do-learn tradition, the centerpiece of this course is a 3 week faculty-led field study in a selected country absorbing the practical and cultural implications of international business or maritime business. The course is designed to provide a series of preliminary sessions leading up to the experiential portion and will conclude with an integrative and reflective segment. Thus the three phases of the IMB experiential learning include preliminary pre departure instruction, travel logistics to an international location, and post-travel reflection. The IMB international experiential learning course is geared towards enhancing cultural awareness and global business competencies. The various opportunities and destinations are listed below:

a) Liverpool (UK)

This program is being conducted in a partnership with Liverpool John Moore's University (LJMU) and the University College of Southeast Norway (HSN). Students from the three institutions will be part of this experiential learning project. The experience will provide the students with an industry insight into contemporary issues and trends and develop understanding of the different market segments in the maritime sector with special emphasis on port infrastructure. The maritime industry comprises of a high cultural disparity. This challenges the efficiency and safety performance aboard a vessel as well as port operations ashore. Enhancing both the future onshore and offshore crew's cultural competence will allow maritime operations to be carried out in a more efficient and safe manner. Making students from three different countries work on joint projects will enhance the ability to work on cross-cultural communication skills, teamwork skills and business culture skills.

b) Ol Pejeta Conservancy (Kenya)

The corporate partner in this initiative is the world famous Ol Pejeta conservancy. The students work hand in hand with the conservationists to provide new alternative office practices and refine and tweak daily operations. As they go about their daily work schedule, they quickly adapt to their new environment and gain cultural insight. This also provides a fantastic opportunity for several community outreach programs and enhance cross cultural awareness.

c) Guácimo (Costa Rica)

Our academic partner is Earth University. The program has an emphasis on maritime business, agri-business and sustainability. There are several hands on activities planned during the three week stay including visits to the ports of Puntarenas and Limon and local plantations that provide the ports with agricultural cargo. The program provides significant multicultural exposure to our students.

d) Singapore and Johor Bahru (Malaysia)

The Corporate partner in Singapore was NOL (Neptune Orient Lines), the parent organization of APL (American Presidents Lines) and the academic partner in Malaysia was NMIT (Netherlands Maritime Institute of Technology).

Education is a key pillar in developing talent for the long term sustainability of the maritime industry. Recognizing this, APL became our corporate partner and hosted IMB students at the NOL Corporate office in Singapore. For a week, APL staff from various fields share their insights, expertise and invaluable experiences on land and at sea with these aspiring maritime professionals. They cover topics ranging from liner operations, chartering, technical services, special cargo, to branding and LEAN application. APL also facilitates visits to Lloyd's Register Quality Assurance, PSA Singapore and Maritime Port Authority to deepen the learning experiences. Through these visits, students get to better understand the diverse roles each stakeholder plays in ensuring high levels of productivity, efficiency, sustainability and progress in the culturally diverse global maritime industry.

In Johor Bahru, Malaysia, the students learn about port infrastructure and the fierce competition between the regional ports. They visit several maritime businesses in this region as well. They learn about the cost advantage of Malaysian ports versus the tremendous efficiency of Singapore. Students write a paper and prepare a presentation on regional port infrastructure for the faculty and selected students of NMIT. As in the other initiatives, the scope for enhancing cultural quotient is significant.

These experiences are not just fantastic educational opportunities for students; they also pave the way for better trained and culturally sensitive prospective employees for maritime companies that have a global presence.

4. Experiential learning and cultural immersion in Singapore-Malaysia

As a case study, this paper focuses on the last one mentioned above; the trip to Singapore and Johor Bahru, Malaysia. In this initiative, students spent three weeks in these locations during the month of February, 2016 under faculty supervision. Students were given preparatory assignments to familiarize themselves with the port infrastructure in that region. [8]They learned about the port infrastructure and maritime activities in those locations and were required to write a paper on regional port competitiveness in Singapore and Malaysia. During their stay in the two locations, they also experienced complete cultural immersion. Some of these students had never stepped out of the US prior to this trip. Upon their return to the US, the students were surveyed on their experiences revealing some interesting findings about cultural intelligence and awareness.

There are several reasons why an international maritime business program may wish to conduct a survey of student cultural competence, particularly in cross cultural global initiatives. First, it may want to validate its understanding of the ethnic and cultural awareness of the student body. Further, it may seek to identify the unique attributes of a given cultural group to ensure effective communication. Additionally, the survey may reveal opportunities for improving cultural capabilities. Most important, the very act of conducting the self-assessment is a statement to the stakeholders that the IMB department values diversity and desires to increase its cultural competence. This survey will help us evaluate where we are in the spectrum of cultural competence and whether, these international initiatives enhance diversity awareness and cultural awareness of our students. The findings will suggest actions we may take to improve our cross-cultural competence.

The Cultural Competence Survey comprised of 10 questions that attempted to assess cultural intelligence in the aforementioned categories: general knowledge, reflection ability and culturally competent behavior. The objective was to see if the experiential learning opportunities had a positive impact on cultural intelligence.

a) Although there was a preparatory phase prior to departure, all students agreed that their knowledge and understanding of the diverse cultural profiles of Singapore and Malaysia improved significantly as a result of the trip.

b) Students were able to reflect on their prior understanding of the cultures of Singapore and Malaysia and how that perception altered (if any). Most students wrote about how their perception about Singapore altered after their visit. In spite of the very traditional Asian roots, students were quite surprised by the significant western influence in Singapore. They had renewed respect for the impact of regulations on the development of the nation. Students also wrote about how warm and welcoming the Malaysian hosts were although several of them had prior concerns about Americans being negatively viewed as rather arrogant. They wrote about how friendly their hosts were in both locations. Much of their prior trepidation and concern disappeared as a result of the visit.

   Students wrote at length about their experience and two excerpts are given below:

   ‘I do believe I have a better understanding of cultural and ethnic diversity. This is because I have visited an area of the world that is very different from mine. Growing up and staying in one country of the world may make a person complacent with their beliefs and living standards. Traveling to Singapore and Malaysia allowed me to see similarities and differences for myself, and not just in a book or on TV.’

   ‘Yes, I found that many Muslims and Chinese were the most kind and generous people that I have ever met. I believe that this is a common problem back in the US, and people should be more knowledgeable and respectful of other cultures and religions. Additionally, I now understand the subtle social and culture differences in Asian countries that differ greatly from those in the US. I learned many things that I would not have learned in a classroom or in a textbook. I am now a much more humble and appreciative person because of my experiences. I also found that the hospitality in Singapore and Malaysia was unmatched by anywhere in the world. The local people were extremely respectful and polite to everyone in the group at every place that we visited during our trip.'

c) In their response to survey questions, students provided examples of how such an exposure enhances their communication skills and prepared them better for the global workplace. One of them mentioned 'I think this trip will be beneficial for me in future career prospects. This is because I have experienced the culture in this area of the world. If I were to apply for a job that required spending time in Singapore or Malaysia, I think I would look like a better candidate than someone who hasn't. There are many ports in Malaysia, and Singapore's main business is the maritime industry. These areas are great spots for potential job opportunities.'

In all these categories, a higher level of cultural intelligence was acknowledged by students after participating in the international experience. In a scale of 1 to 10, 10 being best, all students gave a score of 7 or higher when asked to rate the importance of the Singapore Malaysia trip as a tool to improve their cultural competence. The students commented that the program could be further improved with greater interaction with local students.

The outcome of the survey provides some guidance for curriculum development, as it allows us to understand what curriculum elements need to be improved and what are didactically the most natural places to address the missing issues. For example, this could provide insight if there is training which explicitly addresses reflection around one's own prejudices or cultural values. If such training is non-existent, it should be added to the existing reflection piece. The assessment outcomes could serve as a baseline score that can be used as a benchmark in a subsequent assessment later on, after curriculum improvements have been realized. However, this was only a rudimentary first step in outcome assessment. Greater resources should be directed toward a more sophisticated collection and interpretation of data. Several tools are available in the market today such as the Intercultural Development Inventory (IDI) which provides an individual profile report for each student and a customized development plan for improving cultural competence.[9] This will need to have a qualified administrator who will need to be certified. This cultural competence assessment will be a valuable addition to existing curriculum assessments and measures of cultural competence.

5. Conclusion

Today's maritime students are exposed to a world that require considerable cross cultural understanding and recognition that education is far more than learning facts about specific disciplines while sitting in a classroom. Based on the generally accepted premise that learning occurs through experience, international experiential learning can be a critical component of education in maritime institutions. However, we need to integrate this carefully into our curriculum. As Montrose (2008) wrote, 'The importance of an international experience for the purpose of language development, cultural immersion, service projects, discipline-specific studies, or enhancement of a student's world view cannot be underestimated. Although there is little doubt about the benefits and importance of encouraging students to participate in study abroad, in many cases there is a lack of integration between the experience and the learning or educational value that can be derived from it.'[10]

In the present era, the importance of an international experience for the purpose of cultural immersion, discipline-specific studies and enhancement of a maritime student's world view cannot be underestimated. The purpose of this paper was to demonstrate that with the help of strategic partners, it is possible to identify opportunities that will strengthen the cultural competence of maritime students.

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A career capital approach in the training and development of merchant marine seafarers: The case of South Africa

Samrat Ghosh[1] , Dr. Shaun Ruggunan[2]

1. Australian Maritime College (University of Tasmania), sghosh@utas.edu.au, Australia
2. University of Kwazulu-Natal, Ruggunans@ukzn.ac.za, South Africa

Abstract: The South African state in 2014 launched a maritime focused economic revival programme known as operation 'Phakisa'. Inspired by Malaysia's 'Big Fast Results' method of economic revival, the South African state, hopes to treble the maritime sector's current R60 Billion-Rand contribution to the economy by 2033. Part of the strategy is for the maritime sector to create between 800,000 and 1 million direct jobs. This is part of a wider African renaissance of the continent's maritime economy. The purpose of this paper is to assess the extent to which job creation of merchant marine seafarers is possible within this broader economic strategy. This paper argues that the ambition to grow South Africa's seafaring labour market to 19,000 by 2019 may represent political rhetoric rather than reality. It does not fully take into account a dysfunctional secondary and tertiary education system, and a racialised and iniquitous labour market. This paper argues that a more sophisticated understanding of career choices of potential seafaring cadets is needed. Drawing on a sample of 120 South African cadets at various levels of their academic training the paper demonstrates that the biggest predictor of whether young people chose a career at sea is dependent on them having a family member in the present or past that has also worked at sea. Given that black South Africans were not allowed to train as officers until 1994, and that black officers only entered the labour market in significant numbers recently, there is limited generational history of seafaring amongst the current cohort of black cadets. Further students are making career decision based on instrumental decision making processes rather than viewing the occupation as a 'calling'. The qualitative data allows us to apply the theory of career capital as a more sophisticated way of understanding career choice amongst cadets. The paper concludes that policies targeting greater racial equality in the labour market, quality teaching in mathematics and science, and greater experiential education and exposure to occupations at sea ought to be pursued. A focus on these will increase the chances of operation 'Phakisa' succeeding.

Keywords: Training, Seafarers, Policy, South Africa, Career Theory

1. Introduction

The South African state in 2014 launched a maritime focused economic revival programme known as operation 'Phakisa'. Inspired by Malaysia's 'Big Fast Results' method of economic revival, the South African state, hopes to treble the maritime sector's current R60 Billion-Rand contribution to the economy by 2033 (Operation Phakisa, 2014). Part of the strategy is for the maritime sector to create between 800 000 and 1 million direct jobs. This is part of a wider African renaissance of the continent's maritime economy. The purpose of this paper is to assess the extent to which job creation of merchant marine seafarers is possible within this broader economic strategy. Operation 'Phakisa' is a policy intervention aimed at aiding South Africa to achieve goals set in the National Development Plan first promulgated in 2011. The intervention is based on two specific sectors of the economy: the 'oceans' economy and the health sector. For the purpose of this paper, we will focus on a component (growth of seafaring labour) of the oceans economy component of the policy strategy. The Oceans Economy pillar of operation 'Phakisa' is composed of (1) Marine Transport and Manufacturing, (2) Offshore Oil and Gas Exploration, (3) Aquaculture Work and (4) Marine Protection Services and Ocean Governance (Department of Planning, Monitoring and Evaluation, 2014). A common thread running through these four ocean economy priorities is the need for a reservoir of maritime labour and specialised seafaring labour to support the deliverables across these streams. Seafarer training and development is not explicitly stated as part of Operation Phakisa's goal but is rather seen as an aligned goal to support the development of these four maritime sectors. The South African International Maritime Institute (SAIMI) contends that seafarer training and development is key to 'for the successful implementation of the

Operation Phakisa" [as well as to] to grow South Africa's participation in the "blue economy' (SAIMI, 2014).

This paper argues that the ambition to grow South Africa's seafaring labour market may represent political rhetoric rather than reality. It does not fully take into account a dysfunctional secondary and tertiary education system, a racialised labour market and the pragmatic political dynamics of a global labour market. We believe that a career capital approach (that emerged from the qualitative part of this study) captures a more nuanced understanding of training and development of South African seafarers than the states rhetorical and over simplistic promise of growing seafaring numbers exponentially. For example, the national cadet training scheme rarely exceeds training more than 140 cadets per annum (and this is before these cadets have secured training berths). Our paper cautions that whilst the job creation goals of operation 'Phakisa' may be laudable, especially given South Africa's 26% official unemployment rate, more exploratory work needs to be done that examines key bottle necks in producing cadets as well as well as the psychological and sociological profiling of potential cadets that will allow for effective recruitment and retention strategies.

2. Method

We engaged in a mixed methods study. The quantitative part of the study employed a cross-sectional survey using a self-developed questionnaire to provide an insight into the biographical details of student cadets at a South African University. Some items included in the data collection instrument were quasi-adopted from similar studies carried out in Brazil (Lobrigo & Pawlik, 2012) and; Greece and China (Pallis & Ng, 2011). The study sought to elicit information; apart from the demographics profiles, about the prospective cadets' sources of funding for their studies, the importance of funding for their eventual graduation, the awareness levels of their chosen careers and likelihood of them remaining in their chosen careers at sea after graduation. After acquiring the results from the quantitative study, we followed up with six focus groups from the same sample of students. The focus groups were purposively sampled and consisted of six participants per focus group, accounting for a total of thirty participants for the qualitative component of the study. The aim of the focus groups was to probe participants and investigate their reasons for becoming seafarers as well as to obtain a more nuanced perspective on their career commitment, career motivation, and career choices.

3. Participants and Setting

The quantitative part of the sample census sampled a population of 120 undergraduate cadets and 108 usable questionnaires were obtained recording a 90% response rate. The majority of the respondents were male (63.9%) while females constituted 36.1% of the population with about 20% already in employ as seafarers (16 male and 6 females). In addition, the majority of the participants were in their first year of study (53.7%) and only 13.9% of the sampled students were in their final year (see Table 4). Most of the participants were black Africans (86.1%) followed by mixed race and Indian students who constituted smaller percentages. The majority, specifically 80 out of the 86 respondents who were not already in employ as seafarers indicated that they were the first in their families to pursue a maritime career with the majority of the population citing family (20.4%), the media (19.4%), friends (19.4%) and their high school teachers (14.8%) as their main sources of the maritime career awareness. The mean age of the sample with this study was 21.81 years. Most importantly, Table 1 also shows the registered student cadets' career track aspirations.

		Gender		
		Male (Frequency)	**Female (Frequency)**	**Total Frequency**
Race	B. African	56	37	93
	White	2	0	2
	Mixed Race	4	0	4
	Indian	6	2	8
	Other	1	0	1
T/Berth Secured	Yes	16	6	22
	No	53	33	86
	n/a	53	33	86
Career Aspiration	Deck Officer	23	14	37
	Seafaring Cadet	8	7	15
	Navigator	15	7	22
	Marine Pilot	12	7	19
	officer of the watch	3	1	4
	Master	3	2	5
	Marine Surveyor	1	1	2
	Missing	4	0	4
Total		69	39	108

Mean Age	**Median Age**	**Stan. Deviation**	**Range**	**Minimum**	**Maximum**
21.81	20	4.73	32	17	49

Table 1 Demographic Characteristics of the participants (N=120; n=108)

4. Data Collection Instruments

Career Motivation Scale [CMS: Noe et al., 1990; London, 1993**]** is a quasi-adopted and modified 19-item measure which emphasise feelings and attitudes related to work and career. A sample item is: 'I can adequately handle work problems that come my way.' Noe et al.'s (1990) items focus on behaviours. A sample item is: 'To what extent do you spend your free time on activities that will help your job?' Reasonably high convergent validity has been found between London's (1993) and Noe et al.'s (1990) scales suggesting that the two measure the same construct (London & Noe, 1997). We combine the two measures in order to investigate both attitudes and behaviours of CM. Previous studies reported a Chronbach's coefficient α of 0.84 for this scale (Day & Allen, 2004). The Chronbach's alpha coefficient for the overall CMS and subscales with this study sample was ranged from 0.61 to0.74.

Career Commitment Scale [CCS: Meyer, Allen & Smith, 1993) is an 18-item measure of affective, continuance and normative occupational commitment (six items in each scale). Five items were negatively phrased, and were reversed scored. The items were modified to apply to the seafaring profession. Responses to these items were on 5-point scales ranging from 1(strongly disagree) to 5 (strongly agree). Meyer et al.'s (1993) reported coefficient alphas ranging from .73 to .87 for these scales. In this study, only the overall CCS was adopted because it had an acceptable level of reliability (α<0.70).

5. Data Analysis

Statistical analysis was carried out using the Statistical Package for the Social Sciences programme (SPSS version 22) described in Pallant (2013). Both descriptive and inferential statistics were used to analyse the data. Thematic analysis was used to reduce and report the focus group data. Only selected results are reported since the institution at which the study was conducted has embargoed results until the full report is presented to them.

6. Ethics

Full ethical clearance was granted by the University of KwaZulu - Natal's ethics committee and each participants signed an informed consent form.

7. Relationships between variables

Results from the Spearman's rank-order correlation tests showed that students' motivation, as measured by the career identity and career planning scales is practically (medium effect) and significantly related to career commitment. The relationship between these measures could indicate that students who have a more positive attitude towards their future as seafarers and identify with the profession are more likely to be more committed than those who don't. In other words, students who scored high in planning for achieving realistic career goals, who reflect an idea of where their seafaring career is going or take extra courses related to the programme, stay abreast with developments in area of specialisation or volunteer in career related assignments are more likely to be committed to their career when they start working as seafarers. Interesting to note is that, all the personal characteristics included in this study except race did not show any significant relationship to either motivation or commitment in the Spearman's correlational analysis. Therefore, influential as it was, race was controlled for in further analyses. Our study outcome confirms the findings from a related South African study by Bagraim (2003) who found demographics characteristics not related to professional commitment amongst actuaries. However, this contradicts other previous studies to found the opposite (e.g. Colarelli & Bishop, 1990; Kaldenberg, Becker, & Zvonkovic, 1995).

8. Focus Group Themes

8.1 Math and Science Anxieties

The qualitative part of the study captured a high level of math and science competency anxiety amongst participants. Participants indicated that even when they have high levels of career interest in seafaring careers, this interest was not matched by concomitant math and science skills. This proved to be demotivating for students and also accounted for up to 50% attrition rates. In order to ensure less attrition and increase the quality of graduates, policy interventions need to be made in the domains of math and science training. For example, maritime education and training (MET) institutes like the Australian Maritime College (AMC) provide seafarer training graduates mandatory maths training and optional maths tutoring classes throughout their study period.

8.2 Professional Calling versus Instrumentalist Career decisions

The results from the focus group discussions reinforced the findings that the more informed cadets are of what to expect from a seafaring career, the more likely they are to succeed at their studies. This is important since over half the participants in the focus group had never even seen an ocean or a ship in 'real life'. The cadet training programme was therefore viewed in a more instrumental way by these participants rather than a professional or vocational calling. The challenge therefore for the South African state is to make information about seafaring careers accessible to students as early as possible. An important theme to emerge from all focus group participants was the theme of ***instrumentalist career decision making (ICDM)***. By this, we mean that participants chose to enter the cadet programme purely because they were motivated by the promise of 'work' or a 'job' after graduating. 'work' and 'job' in this sense substitutes as a shorthand for income. Given the over 40% level of unemployment amongst South African youth, it does not seem anomalous that this is the chief motivator for cadets entering this career. We suspect that this has implications for career commitment and career longevity of seafarers from this institute.

Fei and Lu (2015) who proposed that in traditional maritime nations, seafaring was and still is a "calling" due to the long history and tradition of sailing, the pride and promise associated with it, and the lifestyle it represents. We argue that in South Africa, most determinants of career choice behaviour and motivation and commitment are mostly rooted on socio economic needs which can be in form of tangible monetary and non-monetary rewards. These rewards can be employed from the undergraduate in the form of bursaries, scholarships and paid training berths for students amongst others. In countries like South Africa which are not traditional maritime nations, a sense of calling may be weaker and the choice of seafaring or working in general is more associated with socioeconomic factors. Therefore, organizations in the maritime sector as well as universities should join forces in providing and tracking student progress and giving as much support as possible to lessen dropout as well risking losing the students to landside jobs not related to the field soon after graduation or after a short service into the career. To maintain a balance between male and female cadets more attention can be given to female cadets (74% indicated that they are likely to leave their careers at sea) as they are likely to leave work at sea for in land jobs as early as around 30 years of age.

8.3 Inequitable access to career capital (race and gender and nationality)

Recurring thick and rich discussions of lack of access to social, cultural, symbolic and economic capital resonated throughout the moderation of the focus group interviews. We have collectively coded these findings as *career capital*. Career capital has emerged in the career sociology and career psychology literature as a more complete way of making sense of why and how young people enter certain careers. It is also a useful way of understanding barriers to access. Participants' experiences of the career capital process can be captured by Figure 1 below:

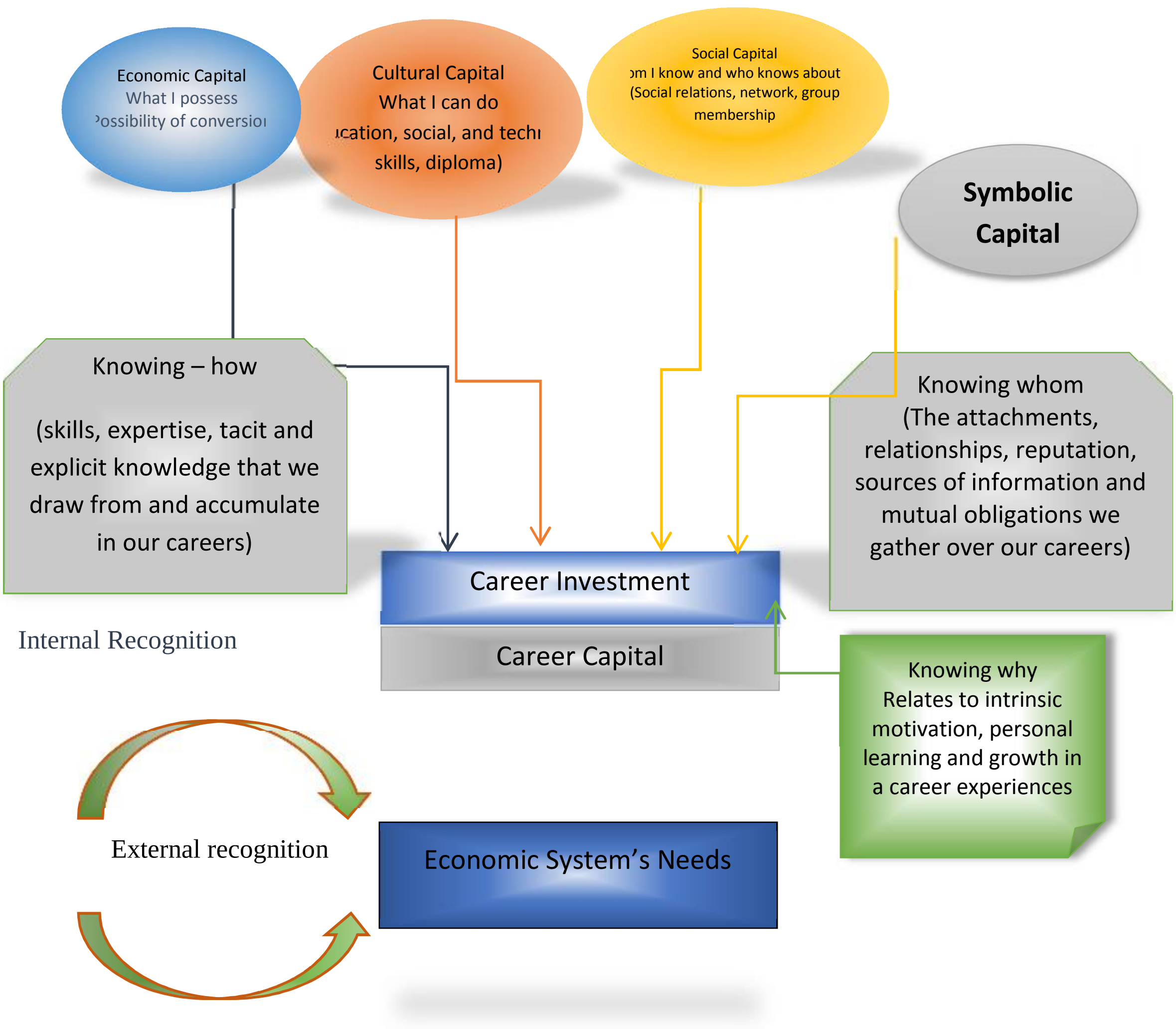

Figure 1 Career Capital (Adapted from Mgaga and Ruggunan, 2015)

9. Conclusion and future research directions

The findings in this study contribute to a growing body of research that illustrates the appropriateness of a multidimensional approach to the study of careers, including those of merchant mariners. It attempts to show that policy makers and politicians often devise policies with quantitative targets that may be more rhetoric than reality. Our exploratory study has shown that in order to achieve the envisioned 19000 seafarers, South Africa has to seriously examine how career capital is accessed and experienced by its youth in the path to becoming a seafarer.

Of course our study is limited in that it used a cross-sectional design and relied on self-reports from a small, highly select group of professionals. This study seeks to help both industry and academia understand factors contributing to prospective seafarers' experience of their training and development. We hope that this will address the challenges facing the seafaring industry as well as preparing students and organisations for a future of rapid changes in the industry.

The current findings should be adopted with caution because they are based on a small sample drawn from one institution. Therefore, further studies are required which may also include employers and people already in employ, before any recommendations can be made regarding the importance of personal characteristics in understanding professional commitment. The researchers also aim to replicate this study with seafarers in Australia and compare findings.

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Session 3C

MARITIME ENVIRONMENTAL ISSUES & ENERGY EFFICIENCY

(No. 3)

Modelling reasonable operation regimes of the main propulsion plant main diesel engine - propeller - hull on the general cargo ship

Prof. DSc. Do Duc Luu, Prof. Dr. Luong Cong Nho, Dr. Tran Ngoc Tu

Vietnam Maritime University
luudoduc@gmail.com; luongcongnho@vimaru.edu.com;tutn.dt@vimaru.edu.vn

Abstract: The article presents the modeling results of the characteristics of main propulsion plant Diesel Engine – Propeller – Hull, based on the combination of the analytical method and regressive analysis of the empirical data. The authors create the algorithms on the base of the created models to select the reasonable operating regime of the main propulsion plant (MPP) according to the different operating conditions (in still water, in sea wave, in the canal, etc.). This paper provides the numerical simulation results of the drawn combination characteristics of MPP on the 34000 DWT general cargo ship built in Vietnam with the main engine MAN 6S 46 MCC, and of the selected regime respectively the desired operated conditions. The research results would be used for the simulation of monitoring and controlling the MPP on the general cargo ship, in order to improve the education quality of the electrical and marine engineering field at Vietnam Maritime University.

Keywords: Main Engine, Propeller, Hull resistance, Main Propulsion Plant.

1. Basis of selecting reasonable exploitation regime

Choosing reasonable working regime of the combination of hull – propeller - main engine under different exploitation regimes ensures the safety of diesel main engine (DME), so that mechanical and thermal overload may not be occurred. In addition, the proposing voyage efficiency of (time, economy) for a cargo ship and sea-going cargo fleet can be achieved by choosing reasonable exploitation regime of engine's revolutions and ship's speeds in different environmental conditions, in which MPP works. Further more, the efficiency of reasonably exploiting working regime of MPP is not only suitable for ship's working purpose from the concepts of safety, high reliability and economy, but also ensures environmental norms set by International Association of Classification Societies (IACS).

The frequent regimes in MPP's exploitation of a marine vessel: working in still water, carrying cargo (Cargo Load Index, CLI) from ballast (CLI = 0) to full load (CLI = 100%); working in sea wave and wind with given CLI; working in canal; vessel in shallow water. In working process, the resistance states of ship hull and propeller are deteriorated. In this case, the reasonable exploitation regime of MPP may varies from normal exploitation regime (normal regime).

During operating the marine vessel's MPP, the captain chooses the revolution regime of the DME (from the Control Bridge) or gives a command to the engine control room (ECR), which is recommended by the Chief Engineer in order to have the desired velocity in practice. The engineer- officer staff, who chooses the exploitation revolution regime of main propulsion shaft (MPS), firstly follows the captain bidding, but need to ensure the working safety of MPP: DME is not overloaded, MPS does not fall into the area of dangerous revolutions; secondly ensures the Specific Fuel Oil Consumption (S.F.O.C) with possible minimum, attached to supervision of environmental norms in chosen DME regime.

To have necessary knowledge and skills to manage and operate the MPP in different operating regimes, the education and training electro-mechanical crew, as well as deck officer with the management level is only deployed by independent simulation software for self-studying, self-improving ability or by intergraded software's module built in the simulation system of ECR. The essence of building imitation software is to establish mathematical model and algorithm to select reasonable exploitation regime for MPP in all situations that may happen in reality. In the process of researching this complicated issue, we can choose one of mathematical models with different accuracy and coherence, which is illustrated by general cargo ship 34000 DWT, used DME of brand MAN 6S 46MCC built in 2013 (in Pha Rung Shipyard, Hai Phong city, Vietnam).

Choosing reasonable exploitation regime for MPP of marine vessel, which is set up for educating and training engineering cadets, and officer training courses, is a fundamental problem. In different levels of training programme, the principle of diesel operation follows the guide of diesel operation provided by the engine manufacturer [**1**, **2, 3**] to ensure the DME the thermo-mechanical safety, the working regime with the minimum S.F.O.C ($\mathbf{g_e}$ =min). In technical file provided by the ship builder or diessel manufacturer as well as the data of sea trial test and the certification of the diesel, there are characteristic curves that allows to exploit engine, by which we may assess the area of the MPP exploitation. For example, for the ship 34000 DWT mentioned above, following the engine document of MAN 6S 45MCC, engine factory [**6**] provides the table of test data in 4 loading regimes with power 25-50-75-100% of the normal power and the measured parameters: engine revolution ($\mathbf{n}_E$, rpm); fuel pump index (FPI, $\mathbf{h}_p$), maximum combustion pressure ($\mathbf{P}_z$, Bar), maximum compression pressure ($\mathbf{P}_c$, Bar), mean effective pressure (**MEP**, $\mathbf{P}_{me}$, Bar), the Specific Fuel Oil Consumption (S.F.O.C, $\mathbf{g}_e$, g/kWh), air intake pressure ($\mathbf{P_{scav}}$, Bar), speed of turbo-changer (n_T, rpm). In the ship sea trial test document [**7**], the data table of measured test regimes and parameters: mean revolution of propeller ($\mathbf{n}_p$, rpm), ship speed (**V**, mile/h, or $\mathbf{V}_p$, m/s), torque (**M**, kNm), relatively the 4 test regimes of consumption power (N_p%) is given. In addition, the operation guidance of DME – engine MAN 6S 46 MCC [**5**] shows the characteristics of DME working limit and characteristics of propeller limited by operating revolution as figure 1.

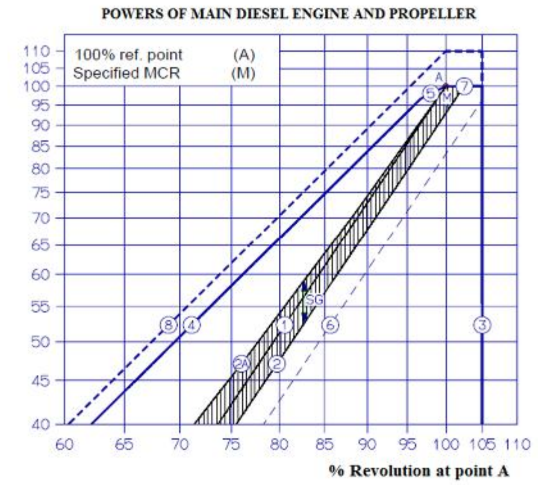

Figure 1 Power Diagram for MPP, used MAN 6S 46 MCC [5]

Line 1- Propeller curve through point A; Line 2 – Propeller curve, heavy running, recommended limit for founled hull at calm weather condition; Line 3 –Speed limit; Line 4- Torque /speed limit; Line 5 –Mean Effective pressure limit; Line 6 –Propeller curve, light running (rang 2.5 -5.0%) for clean hull and calm weather condition; Line 7 –Power limit for continuous running; Line 8 –Overload limit.

The limited power characteristics, given in the figure 1, provide us rather full information to maintain safely exploitation DME and propeller. However, characteristic line $g_e(n)$ and speed area of dangerous resonance are still not given.

It is essential for exploitation to get the information and maintain ship speed according to the propeller's revolution (through engine revolution and the transmission ratio of gear-box). Therefore, the graph of characteristic V-n combined with power characteristics ($\mathbf{N_E(n)}$, $\mathbf{N_p(n)}$) [**1**,**2**,**4**] is often used.

In essence, the problem of choosing reasonable exploitation regime is optimal control problem, the main control parameter is revolution of main engine $\Omega=\omega/\omega_n$ (relative revolution Ω by normal revolution ω_n (radian/s), n – rpm) in the reality of exploitation conditions (X- vector of parameters affecting the choice of control law), consists of choosing parameters in order to set up initial control regime for the voyage (slow change): x_1– CLI (Cargo Load Index, from 0 -100%); x_2 and x_3– surface roughness state of hull and propeller relatively (changing by the number of working months after the ship last dry dock); x_4– vessel in shallow water; x_5– vessel in canal with limited depth and width and fast changing parameters (or stochastic) in the voyage; x_6–wave and wind, $X=[x_1, x_2, ..., x_6]$. Two parameters, which are affected directly to control the engine revolution in the MPP with DME (with turbo-changer), are the fuel pump index, h_p (or relative position $\lambda=h_p/h_{pn}$) and scavenge air pressure (P_k (Bar), or $\rho = P_k/P_{kn}$) to ensure working process of DME in the revolution regime n (rpm), or relative revolution ($\Omega=n/n_n$, or $\Omega= \omega/\omega_n$), at the same time ensure appropriate economical, technical and environmental parameters. Model of control exploitation revolution is chosen as one of these following formal equations:

$t = \Omega$ **(X)**; (1)

$t = \Omega$ **(ª, °, X)**, (2)

The next model depends on rotational current velocity state μ_c(rad/s):

$t = \Omega$ **(ª, °, X, μ_c)** (3)

The system of essential models in controlling exploitation regime consists of:
- Limiting characteristic models in exploiting engine, propeller and ship hull relatively on the coordinates of power- revolution- velocity;
- Current state models of engine power, propeller's consumption power, ship speed following real exploitation condition **X**=[x_1, x_2, ..., x_6];
- Models that give the solution for reasonable operation regime.

In this article, the authors present the establishing the basic models as above and some results received for MPP of general cargo ship 34000 DWT used DME 6S46 MCC, which was built in Vietnam in 2013.

2. Mathematical models of characteristics on the coordinates N –n –V

2.1 Limited characteristics

Input database (DB) in building model is limited characteristic curves, given by engine manufacturer and shipyard. This DB is relative and contains noises, thus the data, obtained from the graph and used to input into the DB input data table, does not require high accuracy. It is important to investigate the reliability of the model according to the appropriate standard statistic, such as Fisher standards. The building method of regression models bases on the Least Square of Errors Method (LSEM) .

Mathematical basis of building regression model of experimental data in function $\mathbf{y_m}$=***f*(*a*, *x*),** contains required coefficient vector a =[a_1, a_2,…, a_n], at a time x_1, x_2,…, x_N and measuring value relatively y_1, y_2,…, y_N is paraphrased shortly as below:

Error between required regression model and measuring values at a certain measured time k: $£_k$= $\boldsymbol{f(a, x_k) - y_k}$. The coefficient vector ***a*** is found in order to minimize the sum of squares of the errors so we have function: $J = \sum_{k=1}^{N} (f(a, x_k) - y_k)^2 \rightarrow \min$

Since then, we take the partial derivative of each coefficient a_m, with m =1→ n, $n: \partial J / \partial a_m = 0$ and receive the system of ***m*** simple linear equations with m unknowns of elements in vector ***a***. Resolve this equation system we get vector with solution ***a***. Received solution of regressive equation is checked reliability (accuracy) by statistical method, Fisher function.

Limited characteristic in figure 1, although graphs' figure can be seen as straight lines, but in fact they could be high-order polynomial functions, for example, characteristic lines of propeller are often exponential function $N_p = c.n^3$. As researching results of choosing model, the authors realized that power characteristics of diesel propullsion plant - propeller have general figure and the best suitable is third-order polynomial [**2**]:

$$\boldsymbol{y = (a_1 + a_2.x + a_3.x^2)x} \qquad (4)$$

in which, coefficients $\boldsymbol{a_j}$ (j=1,2, 3) are found by input data and algorithm use LSEM
The authors create file writing in MATLAB for statistical processing and establishing regressive functions.The result of models applied to ship 34000 DWT is shown in the table 1 by input data corresponding to lines (Line 1 → 8) in the figure 1.

Table 1 Regression model of limiting characteristics for MPP used MAN 6S46MCC

Name of characteristic lines	Model's coefficient (2)			$F_{ref.}(4,n_s,0.99)$	$F_{calculate}$
	***a*₁**	***a*₂**	***a*₃**		
Line 1- Propeller curve through point A	0.0000	0.0350	0.9661	12.06; n_s=5	7.11e+03
Line 2 –Propeller curve, heavy running	0.0001	-0.1493	1.1058	12.06; n_s=5	1.51e+03
Line 2A –Total Load curve, heavy running, $N_L = N_P + N_{Gen.}$	0.0001	0.2077	0.7913	12.06; n_s=5	5.27e+03
Line 3 –Speed limit, t **= 1.05**	-	-	-	-	-
Line 4- Torque /speed limit	-0.0002	1.0707	-0.0420	6.22; n_s=10	1.02e+03
Line 5 –Mean Effective pressure limit	1.0000				
Line 6 –Propeller curve, light running (range 2.5 -5.0%) for clean hull and calm weather condition	0.0000	0.0037	0.8320	12.06; n_s=4	4.10e+03
Line 7 –Power limit for continuous running, 1.0 < t <1.05	1.1	0	0	-	-
Line 8 –Overload limit.	-0.0001	1.0979	0.0064	5.95; n_s=11	1.97e+03

Utilization characteristic when exploit MPP of vessel 34000 DWT with DME MAN 6S46MCC is the revolution's area of torsional vibration with dangerous resonance $a\mu_{BARR(1)}$=(33 – 43) (rpm), or $a\,t_{BARR}$ =[0.26, 0.33] in case of all cylinders work normally and only one misfire cylinder (the worse is cylinder number 5), the area of torsional vibration with additional dangerous resonance: $a\mu_{BARR(2)}$ > 66 (rpm), or$a\,t_{BARR(2)}$> 0,51 (by calculating table of shaft's torsional vibration, approved by Register DNV [**7**]).

Choosing operation revolution regime following the fuel-saving norm expressed by the S.F.O.C. g_e (g/kWh, SFOC). Hence, models $g_e(\Omega)$ are reference characteristics. According to document [**5**], we build model in the form of second-order polynomial with input data of 16 samples from graphs and get results of relative quantities $SFOC_{rel.} = SFOC_{abs.}/SFOC_{min}$:

$$SFOC_{rel.} = 1.1425 – 0.3982\Omega + 0.2781\Omega^2,$$

with high reliability, because: Ft = 5.98e+03 >> F(3, 11, 0.99) = 6.2.
According to received model, we have values in the table below

Table 2 Calculated parameters $g_{e\bullet rel.}$(t)

t %	50	55	60	65	70	75	80	85	90	95	100
$g_{e\bullet rel.}$	1.0129	1.0076	1.0037	1.0011	1.0000	1.0003	1.0019	1.0049	1.0094	1.0152	1.0224

In order to select the operation regime, we perform chracteristics of engine power, propeller and ship speed by rotational velocity (relative Ω) of engine [**1**, **3**].

Limited characteristic of ship speed according to revolution of engine determined through revolution of propeller (by the ratio of transmiting velocity $i_{Ep} = \omega_E/\omega_P$, which is always determined in each regime of gearbox, i_{Ep} =1 without gearbox using clutch- direct propeller). Ship limit speed [$V(\Omega_P)$] (knots) received when propeller's revolution chosen by changing band, in accordance with propeller's revolution band Ω_P, in the condition of exploiting that relative to building limited power characteristics (in figure 1).

It is seen that when the engine (propeller) revolution is less than some value Ω_{P0}, ship speed does not exist (V=0) because the propeller thrust is not dominant the hull resistance. From the value $\Omega > \Omega_{P0}$, ship speed is determined by the relationship between propeller power and hull:

$$RV = ¦_H ¦_R M_p \mu_p ;\ ¦_H = \frac{1-t}{(1-w_t)},$$

where: V – ship speed (m/s);M_p– moment of propeller (Nm); R – ship hull resistance (N); η_H – Hull hydrodynamic efficiency; η_R – Relative rotative efficiency; t – Thrust deduction; w_t – wake fraction.

Studying propeller's power characteristic $N_p(\mu_p)$ for general cargo ship, we can choose the model $N_p(\mu_p) = C(\mu_p)^3$, where: C- coefficient, which represents ship resistance-propeller, depends on: their roughness state, cargo loading and marine condition. We build the model: **C** =**C**(**X**).

The total ship resistance is summation of component resistances and each component is proportional to square of ship speed. We have relationship between ship speed and propeller revolution: $k_H^{1/3} V = (¦_H \cdot ¦_p \cdot C)^{1/3} \mu_p$, in which, hull resistance's coefficient k_H depends on density of water ° (kg/m^3), wetted surface S (m^2) and received from experiment or analytical model of hull total resistance in exploitation conditions. This coefficient also depends on **X**, so we have: $\mathbf{k_H}$=$\mathbf{k_H}$(**X**).

Then, we have first-order relation between ship speed and propeller revolution:

$$V= \sigma\omega_p;\ v = \sigma_\Omega \Omega_p, \tag{5}$$

Concerning the hysteresis of system, we build the model in the following equations:

$$V = \sigma(\Omega_p - \Omega_{p0}) = \sigma\Omega_p - \sigma_0 \tag{6}$$

$$v = \sigma_\Omega \Omega_p - \sigma_{\Omega 0};\ \text{or } v = \sigma_X \Omega_p - \sigma_{X0} \tag{7}$$

where: perfomance operating characteristics curve $\sigma = \sigma_X = \sigma(X)$ may be derived by experimental or analytical methods; V(m/s) and $v = V/V_n$ are absolute and relative ship speed, V_n - speed of ship at nominal operating condition $\mathbf{V_n = V(}\boldsymbol{X=X_n}\mathbf{)}$.

We use the limited resistance coefficient $[\sigma_n]$ to describe the ship limited speed when the propeller works on the maximum propeller characteristics with nominal operating condition $\boldsymbol{X_n}$ (curve 2, fig. 1). Likely to equation (7), we change to equation for the limited speed:

$$[v_n] = [\sigma_n]\, \Omega_p - [\sigma_{n0}] \tag{8}$$

The significant factor is that, in the most severe, the main engine can sustain upper DME limited power characteristics. The method to establish this perfomance operating characteristics curve is as follows: Propeller torque M = $°D^5 n^2 K_Q$, K_Q - Propeller torque coefficient. This coeficient can be described approximately with a line form. $K_Q = a_2 - b_2(v/n)$ therefore, we obtain the computational models of the power of main engine, which Prof. Emil Stanchev defined [2, page 13]:

$$M = A_{20} n_2 - B_{20} n V,\ \text{(Nm)} \tag{9}$$

where: A_{20}, B_{20} - coefficients depending on propeller parameters.

$$A_{20} = °D^5 a_2,\ (\text{kg.m}^2);\quad B_{20} = °D^4 b_2,\ (\text{kg.m}) \tag{10}$$

Where ρ - density of seawater, kg/m^3 (ρ =1025 kg/m^3); D – diameter of propeller (m); a_2 and b_2 can be calculated from propeller torque coefficient.

From (9), we have the limited speed equals the power of main engine with limited torque characteristics $M_0(\omega) = N_0/\omega$; $\omega = \pi n/30$:

$$[V] = (A_{20}/B_{20})\omega - M_0(\omega)/B_{20}\omega, \text{ (m/s)} \quad (11)$$

Hence:

$$[v] = k_{\Omega}^{1}\frac{A_{20}}{B_{20}}\Omega - k_{\Omega}^{2}\frac{M_0}{B_{20}\Omega}$$

The coefficients k_{Ω}^{1} and k_{Ω}^{1} can be changed to dimensionless.
The curve of limited speed based on torque characteristics of engine is a hyperbol curve.
Then, we define A_{20} and B_{20} from equation (9) base on sea trial data with LSEM.

With 34000DWT ship using DME, MAN 6S46 MCC, base on the sea trial data [7], we obtain A_{20} = 6.1374 and B_{20} = 6.0041 with the following model:

$$M = 6.1374\,\omega^2 - 6.0041\omega V, \text{ (kN.m)}; \quad (12)$$

Fisher standard: Fr = 878.67 >> F(2,4,0.99) = 18, prove that the reliability of model is 99%.

The limited speed equation (11) with limited torque of engine:

$$[V] = 1.0222\omega - 0{,}1666\, M_0(\omega)/\omega, \text{ (m/s)} \quad (13)$$

If "**Fuel Pump Index**" unchanges at the maximum value, the limited speed curve is hyperbol form.

2.2. The current operation characteristics

To establish the mathematical model of MPP in real operation condition by assuming X vector and the operation conditions are determined (or set up the concrete operation), we will establish the operating characteristics of engine power, propeller and ship speed.

$$\mathbf{N_E}(t, \mathbf{X_E}), \mathbf{N_P}(t, \mathbf{X_P}), \text{ and } V(t, \mathbf{X_H}), \quad (14)$$

Where: $\mathbf{X_E}$,$\mathbf{X_P}$ and $\mathbf{X_H}$ - the concrete operation condition vectors for engine, propeller and ship hull, corresponding to the factor condition of ***X*** vector which was mentioned above.

Models are established (14) by analytical methods or experimental method, and by combination of analytical and experimental methods.

2.2.1. Establishing the charateristics of MPP using analytical method

The advantage of analytical method is that, it is more flexible and has the sense of initiative to describe the different conditions from X operation condition to obtain the relationships (4). The only difficulty of analytical method is that, we need experimental data with a large of range fluctuation, or the reliability is low. To overcome that disadvantage, we need to take test in some favourable conditions, therefore, the analytical data can be confirmed.

Ship resistance at various operation conditions

The total resistance in the still water. The total resistance in the still water includes the following components:

$$R = R_F + R_V + R_W + R_{APP} + R_A + R_{AA}, \text{kN} \quad (15)$$

Where: R_F – frictional resistance; R_V – form resistance; R_{APP} – appendage resistance; R_A – roughness resistance; R_{AA} – Air resistance.

The discussion of selecting the formulas to determine the resistance components in (15) is represented concretely in [4].

Added resistance in waves: when ship operates in the condition of wave and wind, ship resistance increases. The increase of resistance will depends on height of wave, the direction of wave propagation in comparison with the movement of ship. According to [10], the added resistance due to wave influence is determined as follows:

$$R_{AW} = \chi_{\beta} R^{0}_{AW} \tag{16}$$

where: χ_β - is a function taking into account operation angle compared to propagation direction of wave (β), determined by using Fig. 2; R^0_{AW} - is added resistance of ship in the irregular incoming wave (that means head-on incoming wave 180° compared with movement direction). These quantities are determined by formula (17) and (18) as follows:

$$\begin{aligned} R^0_{AW} = \rho g(1-t)(L/100)^3(1/q_w^2)\{A_0 + 100(C_B - 0,5)^2 A_1 + A_2(L/B) + \\ + A_3(L/10T) + A_4(x_B/10L) + 10A_5(r_y/L) + M[A_6 + A_7(L/10T)] + 10A_8 F_r\} \end{aligned} \tag{17}$$

$$\chi_R = (1,2 - 0,1\sqrt{C_{WP}}) - (2,9\sqrt{C_{WP}} - 1,9)\mathrm{Fr}. \tag{18}$$

Coefficients in (17) and (18) are determined as follows:

$$q_w = k_s^2;\ r_y = \sqrt{\frac{J_y}{\rho\nabla}} = \sqrt{\left(\frac{L^2 C^2_{WL}}{11,4C_B} + \frac{D^2}{12}\right)};\ A_i = \sum_{m=1}^{5} B_{im}\left(q_w \frac{10h_{3\%}}{L}\right)^m \quad (i = 0,1,\ldots,8).$$

where: k_s – coefficient depending on the wave type (k_s = 1 with developed wave, k_s = 0.6 with developing wave); J_y – mass inertia moment for the axis Oy; L, B, D, T – is length, width, depth and draft in turn; ρ – density of water; t – thrust deduction; M – effective coefficient of bulbous bow (M=1 if a ship has bulbous bow; conversely, M = 0); B_{im}– coefficient, determined by Table 3.

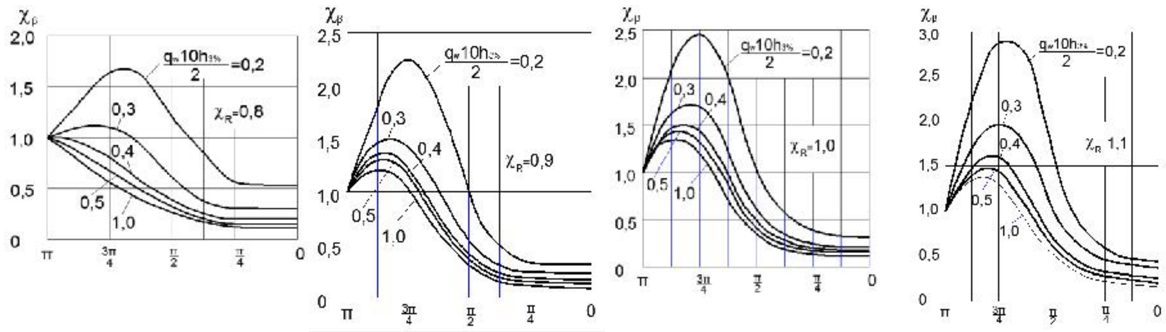

Figure 2 The curve determining the influence of angle of attack ***[10]***

Table 3 The value of B_{im} [10]

i	*m*				
	1	2	3	4	5
0	13.1320	-103.71	222.0600	-170.78	44.981
1	-1.6109	33.442	-49.2910	35.4960	-9.9726
2	1.5981	-14.900	7.8786	-0.6628	-0.0248
3	0.1151	6.5228	-7.6263	5.0745	-1.5133
4	-5.5428	48.5920	-74.5600	52.5470	-14.0310
5	-11.1200	98.9780	-152.070	105.25	-27.5260
6	-7.5139	51.670	-58.0050	28.5910	-5.1947
7	2.0858	-16.263	-17.7170	-9.6519	2.2724
8	-8.843	62.3330	-73.3620	-37.075	-6.7179

Added wind resistance being head-on a ship are determined as follows [10]:

$$R_{WAA} = C_{WAA}\frac{\rho_a}{2}V_A^2 S_A,$$

where: C_{WAA} –added wind resistance coefficient (C_{WAA} = 0,7 – for cargo ship); ρ_a – air density; V_W – wind velocity; S_A – the projection area of ship above water line to the midship section.

Added ship resistance in the shallow water. As many previous research suggests that when ship runs in the shallow water, there will be an increase in the resistance. The clear effect of flow depth on resistance will be seen apparently when $\mathrm{Fr}_h > 0,3$ ($\mathrm{Fr}_h = V/\sqrt{gh}$; where: *h*- water depth [m], *V*- ship speed [m/s]) [11].

Added ship resistance in the shallow water is determined as follows [11]:

$$\Delta R_h = \frac{1}{2}(C_{F_h} + C_{R_h})\rho V^2 S. \quad (19)$$

where: C_{F_h} , C_{R_h} - the frictional resistance coefficient and residual added resistance in the shallow water respectively.

$$C_{F_h} = C_F\left[\left(1-\frac{T}{h}\right)^{-b_f} - 1\right];\ C_{R_h} = (C_w + k_1 C_F)(\Delta C_{R_h}^2 - 1), \quad (20)$$

where: C_F – coefficient of frictional resistance in deep water; C_W – coefficient of wave resistance in deep water; k_1C_F – coefficient of viscous resistance; *C_F, C_W, k_1 – refer to [4]*

$$b_f = \left(6,63 + 0,884\frac{L}{B}\right)\frac{\lg \mathrm{Re}}{\lg \mathrm{Re} - 3,35}\frac{B}{T}.10^{-2}; \quad (21)$$

$$\Delta C_{R_h} = \left\{1 - 0,618\left(\frac{T}{h}\right)^{1,644}[2,06 - 11,6(C_B - 0,40)^3]^{0,333} \times \left\{1 + \left[0,314 + 3,59\frac{T}{h} - 5,50\left(\frac{T}{h}\right)^2\right]\ln\left(\frac{B}{6T}\right)\right\}\right\}^{-1}, \quad (22)$$

Added ship resistance in the canal. When a ship runs in a canal, there has an interaction between the ship and the canal because of the limitation of width and depth of the chanel. This impact makes the change in water resistance of a ship. As a result, additional resistance causing by the influence of width and depth is calculated [11]:

$$\Delta R_K = C_K \frac{{}^{\circ}V^2 S}{2}; \qquad (23)$$

Where: C_K – the coefficient of water resistance of a ship in the canal, determined as follows:

$$C_K = C_{F_K} + C_{R_K} \qquad (24)$$

Where: C_{F_K} , C_{R_K} - the frictional resistance coefficient and residual added resistance in the canal. They are determined as follows:

$$C_{F_K} = 0,285 C_B \left\{ \left(\frac{T}{h_K} \right) + 24,4 m_K^{5/3} \left[\left(1 + \frac{0,335}{1,26 - (v/v_{KP_1})} \right) \times \left(1 + \frac{0,322}{\lg \mathrm{Re} - 3,16} \right) - 0,54 \right] \right\} C_F \qquad (25)$$

$$C_{R_K} = (C_W + k_1 C_F) \overline{\Delta V}^2 \qquad (26)$$

These quantities in formula (25) and (26) are determined as follows:

$$V_{KP_1} = \frac{1 - 1,195\sqrt{m_K}(1 - 0,345 m_K^2)}{\sqrt{1 + 0,88 b_i}} \sqrt{g h_K}, \ \mathrm{Fr}_h = \frac{V}{\sqrt{g h_K}}; \ m_K = 2 C_M BT / [h_K (B_W + B_B)].$$

$$\overline{\Delta V} = \frac{m_K}{1 - m_K} \left[1 + (2,44 - 4,48 m_K) \left(1 - \sqrt{1 - \left(\frac{V}{V_{KP1}} \right)^3} \right) \right]; \ b_i = (B_W - B_B)/(B_W + B_B)$$

where: $b_i = (B_W - B_B)/(B_W + B_B)$ - Trapezoidal coefficient; B_W – width of canal's water surface; B_B – width of canal's bottom; h_K – canal depth; V_{KP1} – first limmited speed of ship in the canal; C_M – midship section coefficient.

Formula (25) and (26) are correct in the range as follows: $10^6 \leq \mathrm{Re} \leq 2.10^9$; $V \leq 0,95 V_{KP1}$; $0,04 \leq m_K \leq 0,30$; $b_i \leq 0,60$; $0,450 \leq C_B \leq 0,920$; $0,2 \leq T/h_K \leq 0,90$.

Ship resistance when there is a change in ship deadweight. Throughout the voyage, deadweight of ship varies incessantly because of the change of fuel, cargo weight and so on,… It leads to the variation in the draft and eventually in ship resistance. In order to assess the change in resistance of a ship due to the change draft we use the following formula [9]:

$$R_i = k_i R \qquad (27)$$

where: R_i – ship resistance in the random loading case; R– Ship resistance full loaded condition; coefficient k_i is determined according to [9, page 201].

Characteristic model of propeller

The work of combination "propeller – ship hull – main engine" causes the mechanical and hydrodynamic impact between each component.

Performance of the propulsion combination η is calculated by [12]:

$$\eta = \eta_s \eta_{trd} \eta_p \eta_R \frac{1-t}{1-w_t}, \qquad (28)$$

where: η_s – shaft performance (η_s = 0,97 ÷ 0,98 when engine room locate at the end of a ship); η_{trd} – actuator performance (η_{trd} =1 when engine have no gear box, η_{trd} =0,98 ÷ 0,99 when engine have gear box); η_p – propulsion performance; η_R – relative rotative efficiency; *t* – thrust deduction; w_t – wake fraction.

The discussion of selecting the formulas to determine the thrust deduction, wake fraction, coefficient with the effect of erratic wake on hydrodynamic moment Q of propeller and propeller performance of a ship in still water is represented concretely in [4]. In other operation condition, such as in ballast condition (or a part load), the wake fraction tends to be 5–15% larger than the wake fraction in the loaded condition. The value can be determined by equation of Moor and O'Connor [9].

Algorithm determining the relationship between velocity - revolution - engine power

Algorithm determining the relationship between velocity - revolution - engine power in the still water is presented in [4]. In other operation condition, algorithm is the same one, therefore, it is no longer necessary to discuss about it.

Essential input parameters for determining the relationship between velocity - revolution - engine power include: geometric parameters of ship hull and propeller, wave and wind level, water depth, geometric parameters of canal ship pass through.

Example. Using above theory to calculate the relationship between velocity - revolution - engine power of bulk carrier 34000DWT built in PhaRung Shipyard [7].

Input parameters: L = 179.95 m; L_{pp} = 176,75 m; B = 30 m; T_F = 9,75 m; T_A = 9,75 m; T =9,75 m; C_B = 0,8137; C_{WP} = 0,9606; C_M = 0,995; X_B = 3,849 m; A_{BT} = 14,85 m^2; h_B = 5,85 m; C_{stern} = -22; D_P = 5,6 m; Z = 4; Zp = 1; P/D = 0,73; A_E/A_O = 0,85.

Operation condition: when a ship is in the wave and wind $h_{3\%}$ = 6 m, wave propagation compared to ship movement β_w = 135^0, ship type ks =1, wind velocity V_W = 19 m/s; when a ship is in the shallow water: water depth h = 13m; when a ship is in the canal having following parameters: depth h_K = 25 m; surface width Bw = 50 m; bottom width B_B = 40 m; limited velocity in the canal V_{KP1} = 6 m/s; when a ship is in ballast condition: ship draft T_i = 5.51 m.

The calculation results are shown in fig.3.

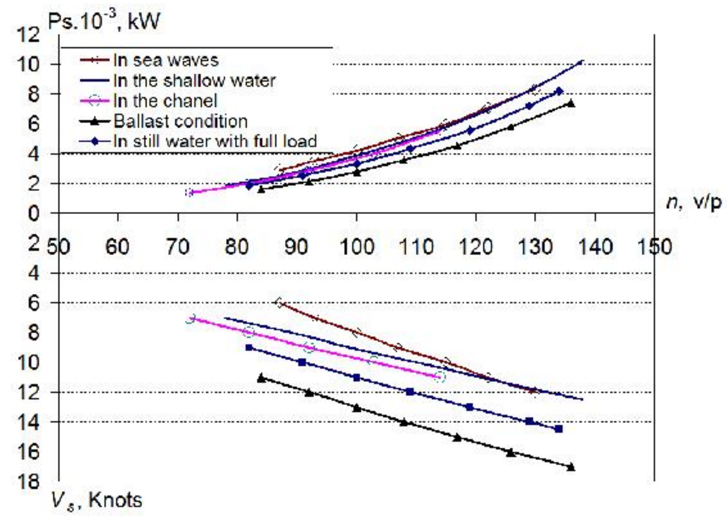

Figure 3 The relationship curves between ship velocity - revolution - engine power in different operation condition

2.2.2. Building the characteristics of MPP by experimental method

In operation condition, in some allowable regime, we measure three basic parameters: Engine power DME, propeller revolution and ship velocity.

By using measured figures (or indirect calculating), some above parameters allow us to estimate the cooperation of components in MPP. Regression model is built based on database measured in experimental condition, using LSEM.
- The propeller characteristics is built by model, formula (4);
- Engine power can be indirectly calculated or measure by available devices;
- Character V =V(n) is modelled in the form of straight line, formula (7).

2.3. Selection the reasonable revolution for operation of MPP

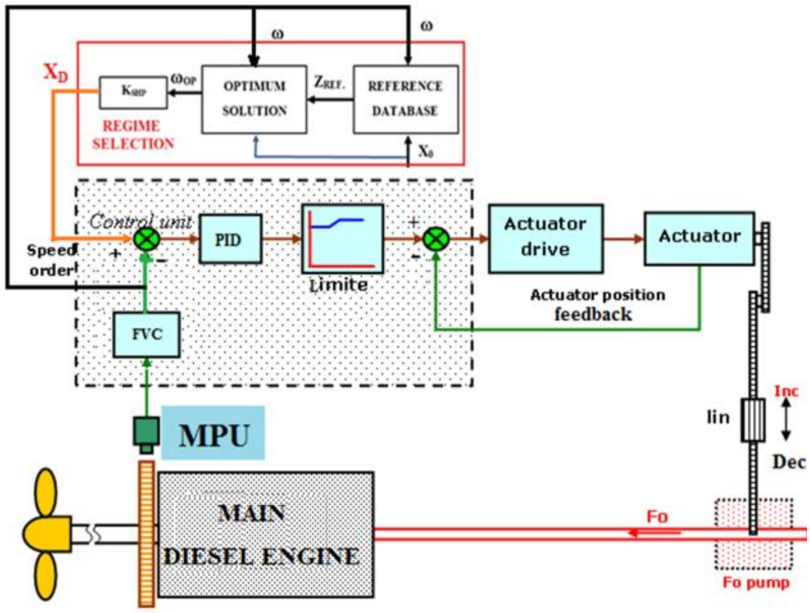

Figure 4 Principle scheme of the automatic selecting the reasonable operation mode of the MPP

Based on modelling the limited characteristics of ship diesel MPP, working characters of ship hull, propeller in the current operation condition (as well as prognose working characters of ship hull, propeller in the alleged condition) allow us to give database Z_{REF} (reference) in order to make a decision of selecting the reasonable operation regime. In the Fig.4, we suggest a principle scheme of the automatic selecting the reasonable operation mode of the MPP, using a electronic governor with the regime (revolution) selection. The Fig.4, we show the principle of controlling revolution of the DME by speed governor including MPU (Magnet Pulse Unit) and FVC (Frequency to Voltage Convector). The control signals DME in the modern diesel engine are usually fuel oil rack and scavenge air pressure (relative quantities are abbreviated by λ and ρ). Based on the decision of optimal selection signal ω_{op}, the desired signal X_D impacts on the PID – controller as a revolution error input.

Block optimum solution (BOS) in above principle diagram plays a key role in selecting the reasonable revolution condition for operation. Input data for BOS is information of current operation condition with the limited condition of X_0 and database as well as character S.F.O.C. of engine. BOS will put forward the best reasonable mode according to the optimal standard so that controlling function is established, for instance, minimum fuel consumption in the safe range of system, or possible maximum velocity in the scope for MPP working safely.

Standard database includes: The limited characters {$[N_e]$, $[N_p]$, [V]} and character SFOC g_e, that are regressive models, some of them are shown in the table №1 in the paper; The basic operation characters are built by the analytical method {$N_e(\omega, X_0)$, $N_p(\omega,X_0)$ and $V(\omega,X_0)$}, according to the above mentional bases in the point 2.2.

3. Conclusion

This paper builds the system of regression models for limited characteristic curve of DME, limited character of the ship speed when engine works above maximum constant moment characteristic curve; characteristic curve of the S.F.O.C. of DME and propeller characteristic curve in the full loaded condition. Those models have an essential reference data for maintaining the operation mode in a safe and economical way.

Based on analytical models determining ship resistance, moment and thrust of propeller in every operation mode MPP will be the prediction of propeller characteristic curve and ship hull so that we are able to select a suitable operation mode.

This article puts forward principle diagram of the automatic selecting the reasonable operation regimes; specifically it puts forth round mode of main engine and propeller according to reference data (standard characteristic model system) as well as actual operation mode of ship hull, propeller (these cases depend on working condition vector X of MPP).

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Ballast Water Management: Challenges for the Flag State and Port State Control

Samrat Ghosh[1] and Christopher Rubly[2]

1. Australian Maritime College (University of Tasmania), sghosh@utas.edu.au, Australia
2. Australian Maritime College (University of Tasmania), crubly@utas.edu.au

Abstract Merchant shipping facilitates 90 percent of global trade by volume, and in performing this vital function around 45000 vessels move more than 10 billion tons of ballast water around the globe annually. When ballast water is loaded and discharged at different ports, immense quantities of aquatic life in the form of larvae, eggs, cysts, bacteria, microbes and small invertebrates are relocated. Introduced aquatic species often become invasive in their new environment, proliferating at dramatic rates displacing native populations, causing damage to local eco-systems, human health and property, and has been recognised as a huge ecological and economic threat to the planet's environment. Overwhelming global environmental concern prompted the International Maritime Organization (IMO) to adopt the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention) during the International Conference on Ballast Water Management for Ships' in 2004, defining strict regulations for ship's ballast water and sediment controls. The BWM Convention seeks to protect the marine environment and prevent the global spread of IAS by establishing benchmark strategies and standards for managing ships' ballast water and sediments. Although the Convention remains to be ratified, it is nearing its tonnage requirement of 35% of the world's merchant shipping that will allow it to come into force in the near future. To manage the magnitude of ships that will be obliged to fulfil the requirements of the Convention, IMO has authorized Flag State Control (FSC) and Port State Control (PSC) to enforce compliance. However, regulatory bodies face a number of challenges in ensuring compliance. Based on a review of literature, this paper highlights the various facets of the BWM Convention that are inadvertently creating challenges for the PSCs and FSCs to ensure effective compliance of the Convention.

Keywords: Ballast water management, Port State Control (PSC), Flag State Control (FSC), Compliance, Invasive aquatic species (IAS), marine environmental protection

1. Introduction

Merchant shipping facilitates 90 percent of global trade by volume, and with ever expanding globalization and demand for fast turnaround times, it represents a cost effective method in the international transport of cargo (Maritime Gateway 2016). In performing this vital function around 45,000 vessels move more than 10 billion tons of ballast water around the globe annually (National Geographic 2016). The impact of this is causing significant ecological and economic damage through the transportation of marine aquatic species such as bacteria, eggs, cysts, small invertebrates, microbes and larvae in ships ballast water, which often multiply into pest proportions in the new environment, becoming invasive and displacing native species (International Maritime Organization (IMO) 2016a). Highlighting the seriousness of the problem, Briski et al. (2013) indicates invasive aquatic species (IAS) have caused 20% of global animal extinctions and contribute significantly to an additional 34% of animal extinctions.

Overwhelming global environmental concern prompted the International Maritime Organization (IMO) to adopt the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention) during the International Conference on Ballast Water Management for Ships' in 2004. The BWM Convention seeks to protect the marine environment and prevent the global spread of IAS by establishing benchmark strategies and standards for managing ships' ballast water and sediments (IMO 2016b). The BWM Convention, detailing the prerequisites and technical guidelines for managing ships' ballast water and sediments, is set to enter force 12 months after it has been ratified by 30 maritime states representing 35% of global commercial shipping tonnage. As at February 2016, the treaty had been ratified by 47 States, with less than 35% of world tonnage (IMO 2016d). Although the Convention is not in force yet, on ratification, all ships will be required to implement a ballast water and sediments management plan, carry a ballast water record book and perform ballast water management routines to a defined standard (IMO 2016b). Ballast water management standards are to be eased in over time, with ships exchanging ballast water mid-ocean as an interim measure. Eventually, with the ratification of the BWM convention, all ships would be required to be fitted with ballast water treatment systems (IMO 2016b).

To ensure compliance with the requirements of the Convention, the IMO has authorized the regulatory bodies of Port State Controls (PSC) and Flag State Controls (FSC). However, the regulatory bodies face a number of challenges in ensuring compliance. Based on a review of literature, this paper highlights the various facets of the BWM Convention that are inadvertently creating challenges for PSC and FSC to ensure effective compliance of the Convention.

2. Obligations of the Flag State and Port State Controls

The IMO is the over-arching regulatory body which together with national maritime regulators enforce the requirements of the BWM Convention on maritime nations (or States) that have ratified the convention. The national regulator is usually known as the ‘Flag State’ (also known as Flag State Control or FSC) which can be an administration or the government of the State under which ships can be registered, e.g. Australian Maritime Safety Authority (AMSA) in Australia. The FSC becomes ‘Port State Control’ (PSC) when ships of other registry call at their ports (Ghosh, Bowles, Ranmuthugala, and Brooks 2014).

Article 4 of the BWM Convention requires Flag States to adopt appropriate measures and oblige ships registered and operating under its authority to comply with the relevant standards of the Convention. To do so, the article stipulates that each Flag State shall, “with due regard to its particular conditions and capabilities, develop national policies, strategies or programmes for Ballast Water Management in its ports and waters under its jurisdiction that accord with, and promote the attainment of the objectives of this Convention”. In addition, Article 7 of the Convention stipulates that each Flag State shall require ships registered under its authority to undergo surveys to obtain certification of compliance (IMO 2004). Hence, the Flag States shall develop national legislations that contain procedures for survey of ships by qualified surveyors and include approval of Ballast Water Management Plan (BWMP), Type approval of Ballast Water Management System (BWMS), and outsourcing of tasks that fall out of the area of expertise of the Flag States to recognized organizations (Kim 2013). Flag States are also required to impose sanctions on ships under its domestic law, for any violations of the convention. Concurrently, if the Flag States are notified of a violation of the Convention by any one of its ships, they are obliged to investigate the matter, collect and analyse evidence, and implement procedures according to its legislation (Ahmed and Youssef 2014).

PSCs are required to develop and implement guidelines, plans, and facilities to enforce compliance with the BWM Convention when ships (other than those registered under its authority) visit their jurisdictional waters. Similar to Flag States, PSC must establish sanctions for any violation of the Convention that takes place within its jurisdiction. A violation in such cases may result in the ship being warned, detained, or rejected from entering the port. When a violation happens inside its jurisdiction, a PSC has the choice to take procedures according to its legislation or give information and evidence identified to the violation to the Flag State under whose authority the ship is registered. PSC may also have to carry out additional inspections of ships at the request of other PSCs or FSCs when provided with evidence of the ship’s violation of the Convention in the recent past.

However, in their efforts to ensure global compliance of the BWM Convention, PSC and FSC face a number of challenges.

3. Challenges to the Flag State and Port State Controls

3.1 Identification of exchange locations

The BWM convention specifies criteria based on geographic locations for an exchange of ballast water. This criteria requires vessels to carry out the exchange at a distance of normally 200 nautical miles from the nearest land and in water depths exceeding 200 meters. Ships' officers have to record details of such exchanges in the ballast water log book where the geographic location in terms of latitude and longitude as well as nearest distance form land need to be logged. However, PSC and FSC officers have no means to verify whether the ballast water was indeed exchanged on the logged position. The accuracy of the information is completely based on the ethics of the ships' officers who are trusted to carry out the exchange operations as per the Convention's requirements.

In addition, port states are required to determine alternate and appropriate locations for the ballast water exchange to take place. In identification of locations, the BWM convention requires port states to identify areas within its waters where there are risks of harmful uptakes, outbreaks or infestation of AIS, sewage outfalls, and poor tidal flushing (Anstey 2008). This will require PSC and FSC to carry out continued scientific and technical research towards the identification and maintenance of suitable exchange locations, which may result in the imposition of financial restraints.

3.2 Financial costs

Kim (2013) classifies the financial costs to PSC and FSC under 'preparatory' and 'compliance'. The 'preparatory' costs relate to the fulfilment of institutional needs (for example, staff required, equipment, technology, etc.) and developing national strategies (for example, stakeholder involvement, developing cooperative relationships with other States, inspection regimes, etc.). On the other hand, the 'compliance' costs may include expenses related to issuance and renewal of certificates, survey procedures, approval of ballast water management systems, training of crew, and reforms of the national regulatory framework. For example, Australia is a signatory Party to the BWM Convention subject to ratification and The Department of Agriculture is developing the Biosecurity Bill 2014 to provide a framework for Australia to manage risks associated with ballast water (AMSA 2016). The implementation costs of the bill is estimated around $0.6 million dollars (Queensland Legislation 2013).

To comply with the numerous provisions of the BWM Convention, States should reform their legislations and policies, strategies and institutional arrangements through a consistent review process to achieve the ultimate purpose of establishing a national BWM framework (Ahmed and Youssef 2014). However, such reforms are not achieved overnight and may require a number of years that requires cost considerations. For example, the Biosecurity Bill in Australia took six years to be developed and passed by the Senate (Invasive species council 2016). Hence, for many States, the concerns are not only focuses on financial investments towards 'preparatory' and 'compliance' costs but also towards building national systems towards the compliance requirements of the BWM Convention. For example, Rittel & Webber (1973) describe governmental policy and planning problems as inherently imprecise 'wicked' problems, which rely on intangible political evaluation for resolution, and that solutions are usually found through engaging with stakeholders to build consensus. For many States, it may be challenging to engage all concerned stakeholders, towards compliance with the BWM Convention. Therefore, continuous support for those States through capacity building in international or regional levels is required to the effective implementation of the BWM Convention (Kim 2013).

In building a global consensus to ratify the BWM Convention and reduce the environmental impacts of IAS through ships' ballast water, the IMO has taken the 'wicked' approach to solve the problem through extensive stakeholder engagement. Despite the extraordinary amount of time that has elapsed, this strategy has been instrumental in the move towards ratifying the BWM Convention. This may be seen through the GloBallast Partnerships joint initiative between IMO, United Nations Development Programme (UNDP) and the Global Environment Facility (GEF), which has been key to progressing global ballast water technology solutions; strengthening global understanding and information transfer in support of marine biosecurity strategies; and the formation of innovative public-private partnerships with leading marine companies through the establishment of the Global Industry Alliance (GIA) and assisting developing countries reducing the transfer of IAS (IMO 2016c). Outcomes from integrated and collaborative initiatives such as these are significant, demonstrating to the global community that despite the many complexities involved, challenges can be overcome to protect the marine environment (IMO 2016c).

However, once the reforms are in place, the challenge for Flag States would be to train their staff to understand their national regulatory framework and the aspects concerning ballast water management. Such training would involve monetary investments which may be large in cases where there is an absence of suitable training providers.

3.3 Lack of recognized training providers

The training of Port State and Flag State Control officials in the understanding and implementation of the BWM convention is of a significant interest in the effective compliance of the convention (Kim 2013). Training must cover all aspects of the Convention including requirements for and of a ballast water management plan (BWMP) approval; testing of equipment; sampling requirements; record keeping; and safety considerations for ballast water exchange. Although this list is not exhaustive, it highlights the various aspects of training required and the need for suitable and qualified training providers. However, due to the Convention not being in force and a resulting absence of a formal global recognition leading to varying national standards, there appears to be a dearth of specialised training (Anstey 2008). This is a major challenge for PSCs and FSCs who are required to keep themselves updated with changing nature of the Convention.

A web search revealed that one of the most recognized training providers, Lloyd's Register Marine (2016), provides some degree of training to shore staff who will be involved in planning how to comply with the upcoming ballast water management legislation as well as those who will be responsible for implementing the plan. The training delivered by experts in the field of BWM Convention includes the following:

- Requirements of the BWM Convention and the United States Coast Guard (USCG) legislation, including their implementation schedules.
- Options for complying with ballast water management legislation.
- Operational limitations of the various ballast water treatment technologies.
- Recognise the ship types and trades which may be suited to other alternative compliance options (such as using reception facilities).
- One approach for comparing the suitability of ballast water treatment systems for use on board a specific ship with a defined operational profile.
- Issues associated with retrofitting ballast water treatment systems.
- Approach that port state control inspectors are likely to take when reviewing compliance with the BWM Convention.

However, the training is a one-day course that does not allow it to be extensive, or provide a comprehensive understanding of all the different aspects of the Convention. For example, in April 2008, the IMO sponsored a four-day training in an introductory course on the topic of ballast water management for the Mediterranean region. While the four-day training was of value, some of the participants' stated that the requirements of the Convention was one of the most difficult to comprehend and implement (Anstey 2008).

A further search on the web for specific training provided to PSCs and FSCs in the area of BWM Convention did not reveal its prevalence. This paper acknowledges that the web search may have overlooked certain training providers, the fact cannot be ignored that there is very little in the way of BWM training being offered. The IMO Resolution A.868 (20) specifies the need for training for ships' masters and crews and goes further by directing governments to ensure that their marine training organizations include this in the contents of their syllabus. It also encourages them to include knowledge of duties regarding the control of pollution of the sea by harmful aquatic organisms and pathogens in their training requirements for certificates. It appears that, so far, this guidance has had very little impact on the provision of national BWM training requirements (Anstey 2008).

3.4 Safety Considerations

Training for PSC and FSC officials is most essential for the recognition of safety hazards that challenge them during routine inspections. For example, officials may be exposed and affected by the IAS present in the sample of ballast water collected for testing and monitoring compliance to discharge standards (Balaji and Yaakob 2014). Sampling of ballast water is primarily a matter for the authorized inspection officers during PSC inspections (Enshaei, Carney, and Mesbahi 2015). One may view the duty of collecting samples as the responsibility of the ship's staff under the supervision of PSC officials, however, the risk of exposure cannot be ruled out. PSC and FSC officials should be trained in the use of biological protocols such as the use of protective equipment which may provide the necessary protection against exposure to infectious elements when handling the samples of ballast water or when entering ballast water tanks for inspections.

3.5 Determination of sampling size

Article 9 of the BWM Convention stipulates that a ship may, in any port or offshore terminal of another Party, be inspected by officers duly authorized by that Party (i.e. PSC Inspection) in order to determine the ship's compliance with the applicable requirements. Such an inspection involves checking certificates, crew familiarization and BW sampling. Sampling of ballast water is required to monitor ship's compliance with the BWM convention. Testing the samples will provide PSC officials with key information regarding the measurement of IAS in the ballast water, effectiveness of water treatment systems in reducing/eliminating the IAS, and ship's discharge as per BWM Convention standards. For example, a ship will be banned from discharging ballast water where the ship ballast waters' sampling results show that it present harm to the environment, property, natural resources or human health. The IMO has developed publications that provide "Guidance on ballast water sampling and analysis (G2)" adopted by Res.MEPC.173 (58) in 2008. However, PSC and FSC officials face a number of challenges due to the vagueness that still exist in the standards described for sampling (Kim 2013).

The problem is that the G2 guidelines are not sufficient for practical use by PSC officers in many aspects. For example, the Guidelines stipulate that "the sampling and analysis methodologies to test for compliance with the Convention are still in development and at the present time, there are no specific sampling or analysis protocols that can be recommended for Administrations to use". Accordingly, after long discussion at the MEPC 65th session held in May 2013, "Guidance on ballast water sampling and analysis for trial use in accordance with the BWM Convention and Guidelines (G2)" was approved to provide sampling and analysis methodologies and disseminated by BWM.2/Circ.42. However, the aforementioned Guidance will be used for trial purposes only because there is still technical uncertainty with regard to BW sampling and negative opinion about BW sampling. For example, there are no clear guidelines on the volume and frequency of sample required, areas where the sampling should be collected from, etc. (Ahmed and Youssef 2014). Enshaei et al. (2015) highlight that IAS present in the ballast water tanks are known to be heterogeneously distributed throughout the tank. Hence, it is a challenge to determine the amount and location of sampling that will reveal accurate estimation of the population of IAS.

3.6 Lack of technical expertise and guidelines

Flag States require access to the appropriate technology prior to approval of the ballast water management systems (BWMS) or ballast water treatment systems (BWTS). Currently, there are reviews that have used vendor supplied information or data to evaluate the potential efficiency of these systems (Enshaei et al. 2015). Therefore, Flag States may need to improve their capacity for establishing procedures for Type Approval of BWMS and its proper application. Flag States may face difficulties to assess the required technologies (Kim 2013). Before Type Approval Certificates are issued there may also be costs incurred in order to be able to provide a detailed review of the test results and technical documents. Flag States that lack the required technical expertise or facilities may have to rely on outsourcing. In such cases, they may struggle to verify and assure the quality of the tests (Kim 2013).

Flag States also face challenges in the sampling process due to the absence of comprehensive technical guidelines (Kim 2013). To verify compliance with the BWM Convention, two kinds of sampling are required. One is Regulation D-1 (BW Exchange Standard) that requires vessels to exchange their ballast water while in the open ocean during transit; and the other is Regulation D-2 (BW Performance Standard) that defines concentration of live organisms that can be present in ballast water at the point of discharge (Enshaei et al. 2015). In absence of comprehensive technical guidelines, some States are promoting that inspection of ship's documents (such as BWMP, Ballast water record books, etc.) should be sufficient to confirm compliance, shading the need of sampling (Kim 2013). Although ship's documents may confirm compliance with D-1 (subject to accuracy of information provided), they cannot verify D-2 compliance. To determine accurate levels of IAS, complex scientific procedures are required.

3.7 Managing inspections

As mentioned in Section 2 (obligations of the Port State and Flag State Control) of this paper, PSC and FSC have to carry out inspections to ensure compliance. They may also have to carry out additional inspections of ships at the request of other PSC or FSC when provided with evidence of the ship's violation of the Convention in the recent past. However, PSCs and FSCs are required to ensure that such inspections do not result in the undue delay or detainment of the ship. In cases of undue delay, ship owners may have to be compensated (financially) by the relevant PSC or FSC (Ahmed and Youssef 2014). Considering the time restrictions and the fact that PSC not only inspect ships for complying with the Convention of BWM but numerous others, it is a possibility that PSC may struggle to conduct a comprehensive inspection within a stipulated time frame.

3.8 Varying Standards

The BWM Convention allows States to take additional or more stringent measures than the requirements stipulated in the Convention. In this regard, Article 2.3 of the BWM Convention stipulates as follows:
'Nothing in this Convention shall be interpreted as preventing a Party from taking, individually or jointly with other Parties, more stringent measures with respect to the prevention, reduction or elimination of the transfer of Harmful Aquatic Organisms and Pathogens through the control and management of ships Ballast Water and Sediments, consistent with international law'.

Therefore, it can be construed that any Administration has a right to take more stringent measures than the requirements of the BWM Convention to protect their jurisdictional water by adopting and enforcing their national legislation. Some individual maritime states view their national interests require higher standards than the IMO's Type approval standards (Bartlett 2014b). In the absence of uniform standards, the Flag States face the risks of ships registered under their authority to violate requirements of other PSC. For example, in the absence of a uniform standard, newly installed ballast water treatment systems may not pass some member port state inspection standards, leading to heavy port state fines, vessel detentions or even the prospect of a complete ballast water treatment system replacement, despite having an IMO Type approved treatment system fitted (Bartlett 2014b; IHS Maritime 2014, p. 10). Although ship owners will face the brunt of the fines and additional costs, Flag States may face flak from the ship owners that may result in ships being deregistered from the respective Flag States.

Nationalistic approaches to BWM by some States are raising concerns that vessels with IMO type approved treatment systems installed, may still be penalized due to differing type approval, port state and testing standards (Water and Wastewater International 2015; Bartlett 2014a). For example, despite the USCG treated ballast water standard being the same as the IMO D-2 standard, US regulations require ballast water treatment systems to be USCG type approved, the process of which is considerably more exhaustive than IMO type approval (DNVGL 2014). Recognizing the importance of the issue, the International Chamber of Shipping (2015) called for flag states to abstain from ratifying the BWM Convention, and submitted a proposal calling for legal changes to make IMO type approval guidelines mandatory at the IMO Marine Environment Protection Committee (MEPC) meeting in October 2014.

However it does seem that steps are underway to overcome this barrier. The USCG established the Alternate Management System under which type approvals from other flag states may be accepted as a five year interim measure until they are tested to conform to USCG type approval standards, and currently nine BWTS are approved for use in US waters (DNVGL 2014). Perhaps if the approach of an interim five-year acceptance period is applied to other areas such as port state and testing standards, these barriers too will be overcome.

3.9 Complicated BWMS Installation Schedule

Table 1 Installation schedule for the systems in accordance with the IMO resolution (In case the Convention comes into effect not later than 31 December 2016) (BIMCO 2016).

<table>
<tr><th>BWM Capacity</th><th>Keel Laid</th><th>BWMC Regulation</th><th>Compliance date from which D-2 is required</th></tr>
<tr><td>1,500 or more but less than 5,000</td><td rowspan="2">Before 2009</td><td>B-3.1.1</td><td rowspan="5">By the first renewal survey of the International Oil Pollution Prevention (IOPP) Certificate following the date of entry into force of the Ballast Water Management Convention</td></tr>
<tr><td>Less than 1,500 or more than 5,000</td><td>B-3.1.2</td></tr>
<tr><td>Less than 5,000</td><td>During 2009 to the date of entry into force of the Convention</td><td>B-3.1.3</td></tr>
<tr><td>5,000 or more</td><td>During 2009 but before 2012</td><td>B-3.1.4</td></tr>
<tr><td>5,000 or more</td><td>During 2012 to the date of entry into force of the Convention</td><td>B-3.1.5</td></tr>
<tr><td>All ships</td><td>On or after the date of entry into force of the Convention</td><td>B-3.1.3
B-3.1.5</td><td>By the completion date of the ship construction</td></tr>
</table>

All ships engaged in international voyages shall install BWMS on board by a given time in accordance with schedules stipulated in Regulation B-3 of the BWM Convention in order to achieve the goal of the Convention. In case of existing ships, it is allowed to carry out ballast water exchange for a certain period depending on the ships' construction year and capacity of ballast water. It is construed that the complicated B-3 schedule was developed because of the lack of technical development of BWMS at that time the BWM Convention was adopted and a desire for a smooth transition from Ballast water exchange to ballast water performance standard (i.e. BWMS) between 2009 and 2020 (Kim 2013). According to the estimates of BIMCO (2016), by the end of 2021, more than 50000 ships would have to be fitted with a BWMS. Table 1 (BIMCO 2016) provides the installation schedule for the BWMS in accordance to the IMO resolution, in case the Convention comes into force in 2016.

Considering the estimated number of ships and the complicated B-3 schedule, it will be a challenge for the Flag and Port State Controls to understand the schedule correctly and ensure its effective implementation (Kim 2013).

4. Conclusion

This paper does not claim to provide an exhaustive list but does highlight a number of challenges faced by FSC and PSC towards ensuring compliance. In seeking to protect the marine environment from the threat of IAS through the compliance of the BWM Convention, a global consensus is required to resolve issues such as nationalistic approaches to port state control and treatment system type approval. The issues may be overcome through extensive stakeholder engagement, while maintaining benchmarks that protect the marine environment. The need for qualified and national training providers is essentially required for all States to comprehend various facets of the Convention. To ensure its effective compliance, FSC and PSC have a mammoth task towards managing their resources such as increased workload, technical expertise, and monetary investments. Although, the Convention is nearing its tonnage requirement (35% of the gross tonnage of the world's merchant shipping) for coming into force, lack of specific guidelines towards its requirements are still creating gaps towards enforcement and must be addressed by IMO. Future research should address the challenges faced by other stakeholders such as seafarers on ships, BWMS manufacturers, ship owners, and ports.

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Whirling vibration characteristics due to lubricating oil pressure in diesel generator shafting system

Ass, Prof, CE. Pham Huu Tan, Dr. CE. Nguyen Tri Minh – VMU, Vietnam
MSc. Vuong Quang Dao – PhD. candidate at MMU, Korea

Email. phamhuutan@vimaru.edu.vn

Abstract: Diesel generator is the essential component on ships and offshore structures. Not only supply the electric power for the auxiliary systems but also in the case of special purpose vessels, the diesel generator is widely used as the primary power source because of the flexibility, efficiency and effective cost in its initial setup. To ensure the stability and prevent from leading to failure, the vibration characteristics of shafting system should be controlled especially the whirling vibration.

In this paper, the influence of shaft bearings lubricating oil pressure to the vibration characteristics of diesel generator shafting system is concerned. When the lubricating oil pressure increases, the oil film stiffness increases. In the case of oil film stiffness variation, the vibration resonance changes. Through analysis results, critical bearing stiffness with the referred lubricating oil film pressures can be identified in order to control the vibration resonance. The resonance of diesel generator structural vibration combined with hull foundation should be avoided from synchronized speed. Therefore, it is necessary to analyze and control the shaft whirling vibration.

One of methods to reduce shaft whirling vibration of diesel generators is to select suitable pressure for lubricating oil film in bearings. Analyzing and experimental results showed that the adjustment of suitable lubricating oil film pressure could improve the vibration characteristics especially the whirling vibration of diesel generator shafting system.

Keywords: shaft whirling vibration, oil film stiffness, diesel generator, lubricating oil film pressure.

1. Introduction

Dynamic characteristics of diesel generators are variable. The unbalance masses (i.e. piston - connecting rod groups, misalignment-shafting system…) and excitation forces (i.e. gas pressure in cylinders, rotating movement of propeller in water…) can lead to the structure vibration especially shaft whirling vibration. Whirling vibrations is excitation vibration. When excitation vibrations coincide with the natural frequency of engine structure, the resonance occurs resulting violent vibration. The excessive whirling vibration adversely influences particular shafting system elements and system integrity in whole. **Figure 1** shows a destroyed shaft line at high speed due to whirling vibration.

Figure 1 Destroyed shaft line at high speed due to whirling vibration

The problems caused by whirling vibration are as the following:

- Complete shafting system destruction;
- Shorten shaft and other elements fatigue life;
- Fatigue cracks at crankshaft and journal bearing;
- Excessive noise, hull and superstructure vibrations.

In order to reduce the structure vibration, most diesel generators are mounted on a flexible bed, while the engine and generator are coupled by employing a flexible coupling. Shaft whirling vibration is closely related to the oil film pressure in shaft bearings. When the lubricating oil pressure increases, the oil film stiffness increases. In the case of oil film stiffness variation, the vibration resonance changes.

This paper presents whirling vibration characteristics due to lubricating oil pressure variation in the diesel generator shafting system. The influence of shaft bearings lubricating oil pressure to the vibration characteristics of diesel generator shafting system is concerned.

2. Theory for whirling calculation

2.1 Vibration of diesel generators by the moving parts and the expanding gas forces

Structural vibration is generally caused by the dynamic properties of the structure and excitation forces. Mathematically the relationship between the exciting forces, structure properties and the vibration response is normally presented by the general equation of motion [1]:

$$\boldsymbol{M}\ddot{x}(t) + \boldsymbol{C}\dot{x}(t) + \boldsymbol{K}x(t) \qquad (1)$$

Where ***x(t)*** = solution of the equation (deflection at the system nodes); ***M*** = mass matrix; ***C*** = damping matrix; ***K***= stiffness matrix; ***F(t)*** = excitation force vector.

Mass of moving parts of diesel generator can be calculated by equation as [2]:

$$m = \frac{(m_p+0.3m_c)}{\pi r^2} + 0.7m_c \qquad (2)$$

Where: $\boldsymbol{m}$ = total mass of a piston-connecting rod mechanism, $\boldsymbol{m_p}$ = mass of the piston, $\boldsymbol{m_c}$ = mass of the connecting rod, $\boldsymbol{r}$ = rotating radius of crankpin.

The matrices ***M*** and ***K*** represent the dynamic characteristics of the structure. Modifying these characteristics or excitation forces can result reducing the vibration response.

The matrix ***M*** is not only the total masses, but represents also the masses distribution over the whole structure. The same applies to the stiffness matrix ***K***. From the vibration point of view, it may be very important where the mass or stiffness is located.

C denotes the damping, which in practice is not only a uniform number. In real structures the damping normally varies depending on the frequency and mode shape, as well as on the location. In complex structures like engines, several different damping types can be found.

Figure 2 shows a schematic diagram for researching the dynamic properties of the structure and the excitation forces [2]. The crank shaft is driven by the expanding gas in the cylinder. The expanding gas creates on the piston top a pressure force ***F***, which is transmitted to the crankshaft through the connecting rod. The transmitted gas pressure acting on crankshaft can be divided into two components: *centripetal force* resulting shaft axial vibration and *tangent force* resulting torque, which tents to rotate the crankshaft.

Acceleration of the piston. The pressure force ***F*** exists on the top of piston and makes piston moving downward. If we consider the origin of the x - axis as the uppermost position of the piston, the displacement of the piston corresponding to an angular displacement of crank of $\theta = \omega$. The displacement of the piston from its topmost position can be expressed as [2]:

$$x_p = r + l - r\cos\omega \ - l\sqrt{1 - s \quad {}^2\phi} \tag{3a}$$

Also:

$$l\sin\phi = r\sin\theta = r\sin\omega \tag{3b}$$

$$\cos\phi = \left(1 - \frac{r^2}{l^2}s \quad {}^2\omega\ \right)^{\frac{1}{2}} \tag{3c}$$

So that:

$$x_p = r + l - r\cos\omega \ - l\sqrt{1 - \frac{r^2}{l^2}s \quad {}^2\omega} \tag{4}$$

In general, r/l < ¼, **Eq. (4)** can be approximated as:

$$x_p = r(1 - \cos\omega\ ) + \frac{r^2}{2l}s \quad {}^2\omega \tag{5}$$

Or, equivalently:

$$x_p = r\left(1 + \frac{r}{2l}\right) - r(\cos\omega \ + \frac{r}{4l}\cos 2\omega\ ) \tag{6}$$

Eq. (6) can be differentiated with respect to time to obtain expression for the velocity and acceleration of the piston:

$$\dot{x}_p = r\,\omega(\sin\omega \ + \frac{r}{2l}\sin 2\omega\ ) \tag{7}$$

$$\ddot{x}_p = r\,\omega^2(\cos\omega \ + \frac{r}{l}\cos 2\omega\ ) \tag{8}$$

Where: $\boldsymbol{x_p}$ = vertical displacement of the piston in the $\boldsymbol{x}$ direction from its topmost position, $\boldsymbol{\omega}$ = angular velocity of the crankshaft, $\boldsymbol{l}$ = length of connecting rod.

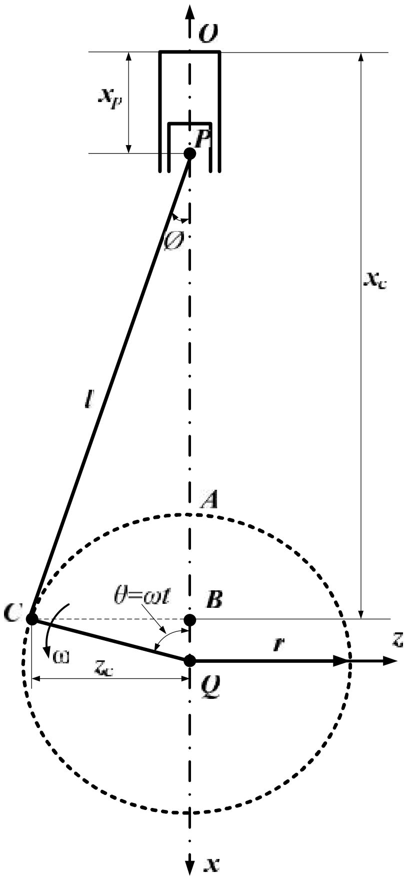

Figure 2 Schematic diagram of a cylinder of diesel generator

Acceleration of the Crankpin. With respect to the xz – coordinate shown in **Fig. 2**, the vertical and horizontal displacements of the crankpin are given by [2]:

$$x_c = OA + AB = l + r(1 - \cos\omega t) \tag{9}$$

$$z_c = CB = r\sin\omega t \tag{10}$$

Where: $\boldsymbol{x_c}$ = vertical displacement of crankpin in the $\boldsymbol{x}$ direction, $\boldsymbol{z_c}$ = horizontal displacement of crankpin in the $\boldsymbol{z}$ direction.

Differentiations of **Eqs. (8)** and **(9)** with respect to time give the velocity and acceleration of the crankpin:

$$\dot{x}_c = r\omega\sin\omega t \tag{11}$$

$$\dot{z}_c = r\omega \cos \omega t \tag{12}$$

$$\ddot{x}_c = r\omega^2 \cos \omega t \tag{13}$$

$$\ddot{z}_c = -r\omega^2 \sin \omega t \tag{14}$$

Inertia Force. Although the mass of the connecting rod is distributed throughout its length. It is generally idealized as a massless link with two masses concentrated at its ends, the piston end and the crankpin end. The vertical component of the inertia force (***F_x***) for one cylinder is given by [2]:

$$F_x = m_p\ddot{x}_p + m_c\ddot{x}_c \tag{15a}$$

or:

$$F_x = (m_p + m_c)r\omega^2 \cos \omega \ + m_p \frac{r^2\omega^2}{l} \cos 2\omega \tag{15b}$$

Similarly, the horizontal component of inertia force for a cylinder can be obtained:

$$F_z = m_p\ddot{z}_p + m_c\ddot{z}_c \tag{16a}$$

Where $\ddot{z}_p = 0$ and $\ddot{z}_c$ is given by **Eq. (14)**. Thus:

$$F_z = -m_c r\omega^2 \sin \omega \tag{16b}$$

The unbalanced and inertia force on a single cylinder are given by **Eqs. (15b)** and **(16b)**. The mass ***m_p*** is always positive, but ***m_c*** can be made zero by counterbalancing on the crank. Therefore, it is possible to reduce the horizontal inertia force ***F_y*** to zero, but the vertical unbalanced force always exists. Thus, a single cylinder engine is inherently unbalanced.

In a multi-cylinder engine, it is positive to balance some or all of the inertia forces and torque by proper arrangement of the cranks. The lengths of all the cranks and connecting rods are taken to be ***r*** and ***l***. For force balance, the total inertia force in the ***x*** and ***y*** directions must be zero, so that:

$$(F_x)_{total} = \sum_{i=1}^{N}(F_x)_i = 0 \tag{17}$$

$$(F_z)_{total} = \sum_{i=1}^{N}(F_y)_i = 0 \tag{18}$$

Where $(F_x)_i$ and (F_z) are the vertical and horizontal component of inertia forces

Thus, if the moving parts of the cylinders are equivalence and the power of cylinders are balance, the vibration due to the expanding gas forces and inertial forces of cylinders are suppressed, so the engines will not vibrate.

2.2 Stiffness and damping calculation for journal bearing

Lubricating oil is supplied into bearings of shafting system to lubricate its working surfaces and then reduce the friction. It plays a key role in determining the dynamic characteristics of diesel generators shafting system.

The schematics of a journal are shown in **Fig. 3**. Letter ***O*** is the center of journal whereas ***O'*** is the center of bearing. The radial clearance, ***c***, between the bearing bore of radius ***r_1*** and of the journal radius, ***r***, equals ***r_1* - *r***.

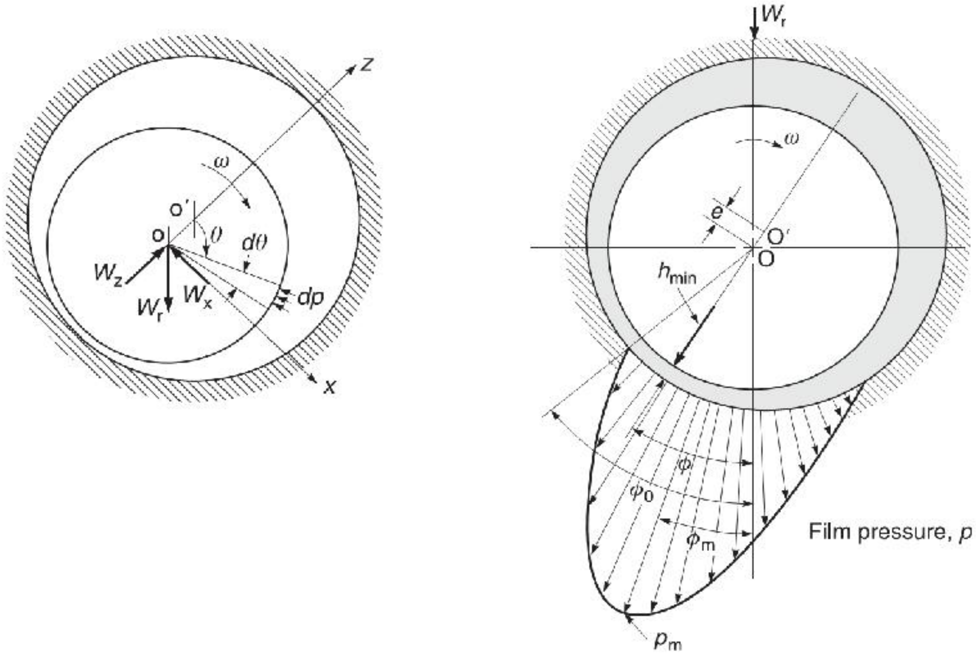

Figure 3 Schematics of plain journal bearing geometry

When the shaft speed is fast enough to create hydrodynamic pressure larger than the applied load, the journal can separate and move around the bearing until it reaches an equilibrium. The eccentricity ***e*** is the distance between the centers of shaft and bearing. When the journal touches the bearing and when the load equals zero. The ratio of eccentricity to clearance is presented by eccentricity ratio ***ε***:

$$\varepsilon = \frac{e}{c} \qquad (0 \le \varepsilon \le 1) \tag{19}$$

The oil film thickness at any position can be calculated approximately by [3]:

$$h \sim c(1 + \varepsilon \cos\theta) \tag{20}$$

The minimum thickness is given as*:*

$$h_{min} = c - e = c(1 - \varepsilon) \tag{21}$$

Journal bearings are short bearing in this case. Following Reynolds equation [4], the pressure of oil film can be calculated by the equation:

$$P = \frac{3\mu\omega\varepsilon}{c^2}\left(\frac{b^2}{4} - y^2\right)\frac{\sin\theta}{(1+\varepsilon\cos\theta)^3} \tag{22}$$

Maximum pressure of oil film at angular position ‾$_m$ and ***y = 0*** can calculate by [5]:

$$p_m = \frac{3\mu\omega\varepsilon L^2 \sin\theta_m}{4c^2(1+\varepsilon\cos\theta_m)^3} \tag{23}$$

with:

$$\theta_m = cos^{-1}\left(1 - \frac{\sqrt{1+24\varepsilon^2}}{4\varepsilon}\right) \tag{24}$$

The load capacity is solved by integration of the pressure wave around the bearing:

$$W_x = 2\int_0^{\pi}\int_0^{L/2} pr\sin\theta \, dy \, d\theta \tag{25}$$

$$W_z = 2\int_0^{\pi}\int_0^{L/2} pr\cos\theta \, dy \, d\theta \tag{26}$$

By using the Sommerfeld substitution we can obtain:

$$W_x = \frac{\mu}{4}\left(\frac{L}{c}\right)^2 \frac{\pi}{(1-\varepsilon^2)^{3/2}} \tag{27}$$

$$W_z = \frac{\mu}{4}\left(\frac{L}{c}\right)^2 \frac{4\varepsilon^2}{1-\varepsilon^2} \tag{28}$$

$$W_r = \sqrt{{W_x}^2 + {W_z}^2} = \frac{\mu}{4}\left(\frac{L}{c}\right)^2 \frac{\varepsilon\sqrt{16\varepsilon^2+\pi^2(1-\varepsilon^2)}}{\left(1-\varepsilon^2\right)^2} \tag{29}$$

The Sommerfeld number ***S*** is given by equation:

$$S = \frac{\mu}{P}\left(\frac{r}{c}\right)^2 = \left(\frac{L}{c}\right)^2 \frac{\left(1-\varepsilon^2\right)^2}{\pi\ \sqrt{1\ \ \varepsilon^2+\pi^2(1-\varepsilon^2)}} \tag{30}$$

And average pressure is calculated by equation [6]:

$$P_{average} = \frac{W_r}{2rL} \tag{31}$$

The bearing stiffness can be obtained by equation:

$$K_f = \frac{dW_r}{dh} \tag{32}$$

Where: $\boldsymbol{r}$ = journal radius (m); $\boldsymbol{r_1}$ = bearing bore radius (m); $\boldsymbol{L}$ = bearing length (m); $\boldsymbol{c}$ = radius clearance (m); $\boldsymbol{e}$ = eccentricity (m); $\boldsymbol{\varepsilon}$ = eccentricity ratio; $\boldsymbol{h}$ = oil film thickness (m); $\boldsymbol{h_{min}}$= minimum oil film thickness (m); $\boldsymbol{\theta}$ = angular position (rad); $\boldsymbol{h_v}$ = oil film thickness at angular position $\boldsymbol{\theta_v}$ (m); $\boldsymbol{\theta}_m$ = maximum pressure position (rad); $\boldsymbol{P}$ = oil film pressure (Pa); $\boldsymbol{P_m}$ = maximum oil film pressure (Pa); $\boldsymbol{W_x}$, $\boldsymbol{W_y}$, $\boldsymbol{W_r}$ = load capacity (N); $\boldsymbol{P_{average}}$ = average oil film pressure (Pa); $\boldsymbol{K_f}$ = bearing stiffness (N/m); « = lubricant absolute viscosity (Pa-s).

2.3 Whirling vibration in diesel generator shaft system

Whirling vibration due to shaft static and dynamic unbalance is a forced vibration caused by internal centrifugal force. It is well known that a diesel generator shafting system will never be perfectly balanced. Due to material inhomogeneity the center of gravity does not coincide with the rotation axis. Due to the center of journal and bearing does not coincide to make eccentricity. Eccentricity depends on oil film pressure of journal bearing. When the shaft rotates, the eccentric masses produce exciting centrifugal force. Unbalance excites forward synchronous whirling.

Alignment-related vibration of shaft system of diesel generator is possible if the shafts are not properly coupled due to assembly or manufacture errors. It is the case when shaft system loses the rotation axis continuity and smoothness. Alignment-related errors excite first order synchronous whirling vibration.

Excitations having alignment errors nature normally are not taken into account in whirling vibration calculation. Such errors must be prevented by adherence to the technological specifications and standards of shaft manufacture and alignment processes. The schematic of a diesel generator arrangement is shown in **Fig. 4**.

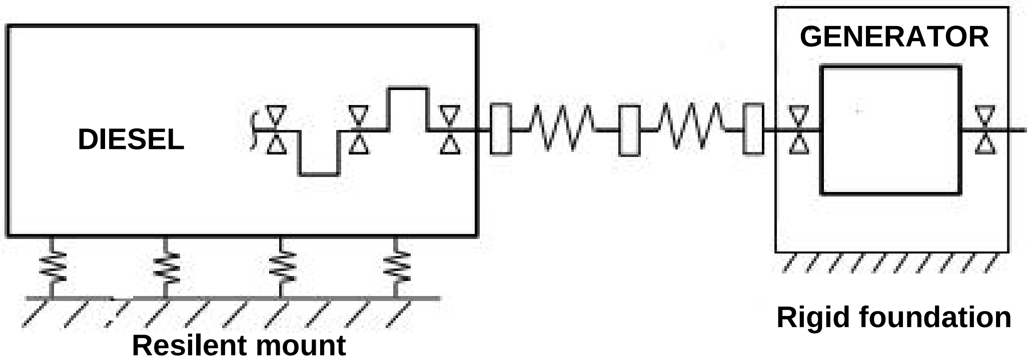

Figure 4 Schematic of a diesel generator arrangement

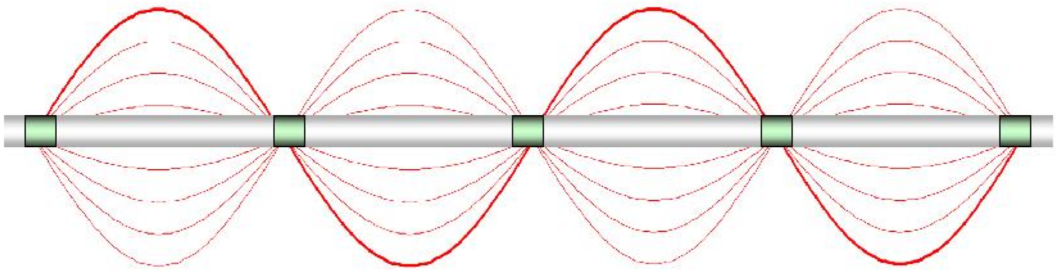

Figure 5 Schematic of whirling vibration of rotating shaft and bearing

At the same time there are no obstacles for rotating shaft to vibrate as above-mentioned beam in two orthogonally related planes if correspondent alternating forces are applied. As a result, the shaft rotation axis will move in the space along the beam vibration orbit. **Fig. 5** shows the schematic of whirling vibration of rotating shaft and bearing (in the blue color).

Thus, whirling is a poly-harmonic motion of the rotating shaft caused by two plane excitation forces. Every time when ‘whirling vibration’ term is used with regard to the shaft system of diesel generator we should bear in mind shaft lateral vibrations in two planes simultaneously. The difference between two plane lateral vibration and whirling vibration consists in shaft section proper rotation only.

Sometimes, people concerned with “vibration analysis” of machinery lose sight of a very simple truth: vibration is merely a response to other conditions in a machine, it is not (and should not be) the fundamental concern for the machinery engineer. Instead vibration should be thought of as nothing more than a ratio of the forces acting on the machine to its stiffness. Mathematically, this is summarized as:

$$V(r) = \frac{F}{D \cdot S} \qquad (33)$$

A change in unbalance by eccentricity is a force changing in diesel generator shaft system. In this case, force increases, stiffness stays the same, and vibration increases as a result.

In order to reduce the vibration, along with reducing the exciting sources, adjusting the dynamic stiffness to control the vibration response is the very valuable method. One of methods to adjust the dynamic stiffness to control shaft whirling vibration of diesel generators is to select suitable pressure for lubricating oil film in bearings.

2.4 Results and Discussion

This study concerns about **6Ч12/14** diesel generator: nominal power = 50 kW; number of cylinder = 6; cylinder bore = 0.12 m; piston stroke = 0.14 m; maximum expansion gas pressure p_z = 7.5 MPa; revolution n = 1500 r.p.m.; shaft diameter d = 0.14 m; length of bearing L = 0.075m; bearing clerance c = 0.1mm, lubricating oil viscosity μ = 0.0185 Pa-s.

According to the local structure vibration measuring results, at synchronized speed (1500 r.p.m.) the vibration is most heavy at 2nd order (50Hz - Mode 1). The relationship between bearing stiffness and reasonance frequency is shown in **Fig. 6** obtained by theorical calculation base on masses spring system. According to this figure, the resonance of shafting system intersects the frequency of 2nd order vibration at synchronized speed when bearing stiffness is about 240 MN/m. That is critical dynamic stiffness of the shaft bearing. The final goal in this study is identifying the oil film pressure corresponding to critical dynamic stiffness in shaft bearing, on purpose to avoid the 2nd order resonance structural vibration of the generator combined with hull foundation from synchronized speed.

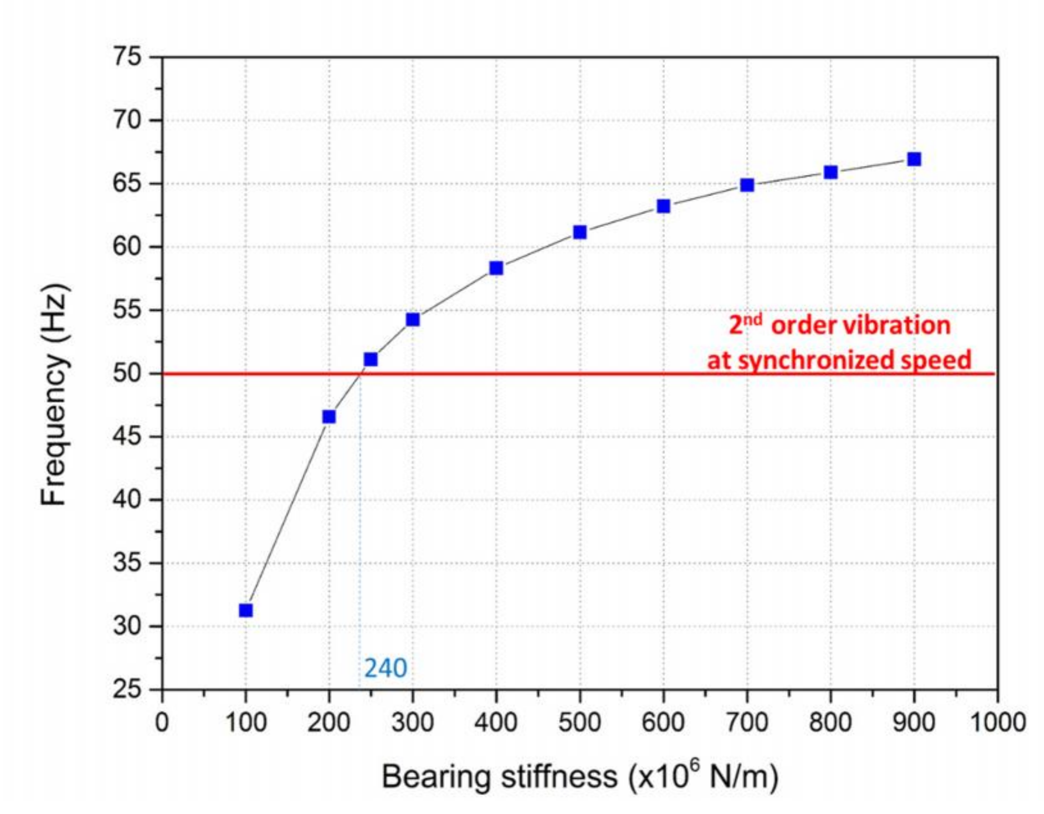

Figure 6 The relationship between bearing stiffness frequency

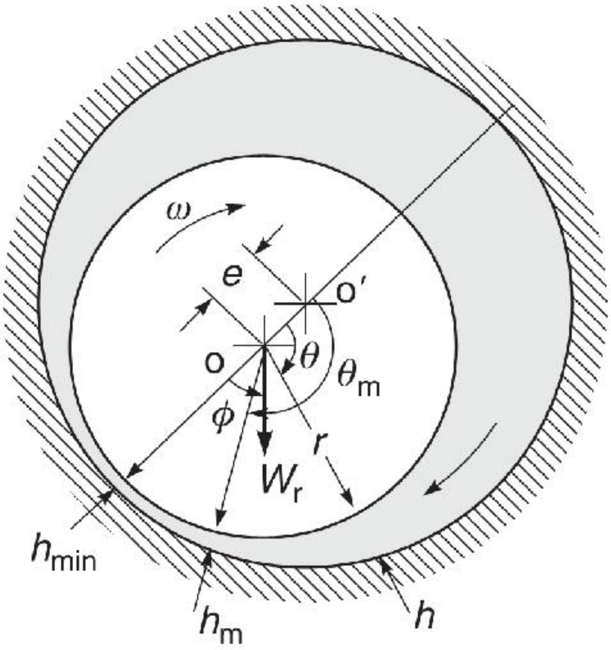

Figure 6 Schematics of shaft bearing geometry

The attitude angle :

$$□ = t^{-1}\left(\frac{\pi\sqrt{1-\varepsilon^2}}{4\varepsilon}\right) \quad (34)$$

The oil film thickness :

$$h \sim c(1 + \varepsilon \cos\theta) \quad (35)$$

At the lowest bottom position $(\theta_v = 180 - \phi)$:

$$h_v = c(1 - \varepsilon\, c\ \ \theta_v) \quad (36)$$

The load W_r can be obtained:

$$W_r = \mu \left(\frac{r}{c}\right)^2 \left(\frac{L}{d}\right)^2 \frac{\varepsilon\sqrt{1\ \ \varepsilon^2+\pi^2(1-\varepsilon^2)}}{(1-\varepsilon^2)^2} \quad (37)$$

The bearing stiffness:

$$k_f = \frac{dW_r}{dh} = \frac{W_{r(\varepsilon)} - W_{r(\varepsilon - 0.0\ )}}{h_{v(\varepsilon)} - h_{v(\varepsilon - 0.0\ )}} \quad (38)$$

And average pressure is calculated by:

$$P_a = \frac{W_r}{2r} = \frac{W_r}{d} \quad (39)$$

All of the other parameters can be calculated and are shown on **Table 1.**

According to the calculating results, the critical dynamic stiffness 240×10^6 N/m occurs when the eccentricity ratio $\boldsymbol{\varepsilon}$ = 0.456 and the average pressure $\boldsymbol{P_{average}}$ = 0.5 MPa. The critical pressure of lubricating oil film is identified. This critical oil film pressure should be avoided on purpose to reduce the 2nd order resonance of structural vibration of generator combined with hull foundation from synchronize speed.

Table 1 Calculation sheet of lubrication oil film parameters with various oil pressures

Parameters		Sym.	Unit	Value				
Eccentricity ratio		**ε**	-	0.3	0.4	**0.456**	0.5	0.6
Average Pressure		$\mathbf{P_{average}}$	*MPa*	0.24	0.38	**0.50**	0.61	1.04
Stiffness		$\mathbf{K_f}$	*×10^6 N/m*	167	200	**240**	288	498
Load		$\mathbf{W_r}$	*N*	2509	4006	**5206**	6440	10921
Sommerfeld number		**S**	-	0.95	0.59	**0.46**	0.37	0.22
Attitude angle		**Ø**	*degree*	68	61	**57**	54	46
Minimum oil film thickness		$\boldsymbol{h_{min}}$	*mm*	0.07	0.06	**0.05**	0.05	0.04
Lowest position	***Location***	$\boldsymbol{\theta_v}$	*degree*	112	119	**123**	126	134
	Oil film thickness	$\mathbf{h_v}$	*mm*	0.09	0.08	**0.08**	0.07	0.06
Location of maximum pressure		$\boldsymbol{\theta_m}$	*degree*	119	112	**110**	109	107
Maximum pressure		$\boldsymbol{P_m}$	*MPa*	0.51	0.74	**0.87**	0.98	1.26

3. Conclusion

Whirling vibration may result damage on shafting system in some case and the structural vibration of diesel generator acts as the excitation force causing whirling vibration. In **6Ч12/14** diesel generator, the engine is mounted on the flexible supports and the generator is mounted on rigid foundation. The whirling vibration can be evident when the generator 2nd order resonance structural vibration combined with hull foundation accords with synchronized speed and rotor dynamics misalignment.

In order to reduce shaft whirling vibration of diesel generators, it is necessary to select suitable pressure for lubricating oil film in shaft bearing, prevent it from the critical stiffness. In the case of **6Ч12/14** diesel generator, the critical pressure of lubricating oil film is identified, about 0.5 MPa. By avoiding operation system in this critical oil film pressure condition, the structure vibration is reduced especially 2nd order of whirling vibration at synchronized speed.

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A Collaborative Approach to Protecting the Ocean Environment

Professor Paul Szwed[1], Director Carleen Lyden-Kluss[2], Associate Professor Matthew Rooks[3]

1. Massachusetts Maritime Academy, pszwed@maritime.edu,
100 Academy Drive, Buzzards Bay, Massachusetts, 02532 USA
2. North American Marine Environmental Protection Association (executivedirector@namepa.net)
3. Graduate School of Maritime Science, Kobe University (koberooks@gmail.com)

Abstract Oceans, often thought of as our last global commons, serve many important roles from providing us food and resources to connecting nations for trade. Despite this role of importance, our seas are becoming increasingly stressed. Addressing such issues of the common requires a collaborative international approach, as evidenced by the United Nations sustainable development goal 14 to "conserve and sustainably use the oceans, seas and marine resources" [1]. Further, the IAMU recognizes the importance of this aspect of their mission as evidenced by the Tasmanian Statement [2] and also by the theme of their 2016 annual general assembly calling for submissions about "strengthening cooperation for protection of the ocean environment" [3]. Using the collaborative value creation (CVC) framework [4, 5], this paper describes how IAMU might form a partnership with various INTERMEPA (the International Marine Environmental Protection Association) member associations to jointly advance their mutual shared mission to "save our seas" [6]. Using the CVC framework, this paper will describe a pathway for partner selection, partnership implementation, design and operations, and institutionalization. Building upon the foundation of success experienced by NAMEPA (the North American MEPA), this paper will also explore the opportunity to utilize IAMU member network connections to fulfil a critical objective listed under the Tasmanian Statement and create a new MEPA chapter in Japan (NIPPONMEPA) as a case study using the CVC framework. Proposed activities will likely include identified effective practices and may include new innovations such as joint events conducted virtually using the MIX methodology [7].

Keywords: Cooperation, Partnership, Protection of Maritime Environment, Oceans, Sustainability.

1. Introduction

Oceans, often thought of as our last global commons, serve many important roles from providing us food and resources to connecting nations for trade. Despite this role of importance, our seas are becoming increasingly stressed. Addressing such issues of the common requires a collaborative international approach, as evidenced by the United Nations sustainable development goal 14 to "conserve and sustainably use the oceans, seas and marine resources" [1]. Further, the IAMU recognizes the importance of this aspect of their mission as evidenced by the Tasmanian Statement [2] and also by the theme of their 2016 annual general assembly calling for submissions about "strengthening cooperation for protection of the ocean environment" [3]. This article will examine how two non-profit organizations can form a partnership using a "top-down" collaborative value creation framework and "bottom-up" chapter-first approach to address the continuing challenge of protecting or marine environment – to "save our seas".

1.1 International Marine Environmental Protection Association

[8] The International Marine Environmental Protection Association (MEPA) movement began in 1983 with the formation of Hellenic MEPA (HELMEPA) in Greece by shipowner George P. Livanos. Since that initial chapter began more than three decades ago, six more MEPA's have been created (in Cyprus, Turkey, Australia, Uruguay, North America and the Ukraine). Each share the voluntary commitment to "**Save our Seas**". In 2006, INTERMEPA (International MEPA) was created as an umbrella organizations and to demonstrate that the marine environment is independent of "politics of any nation or nations" and to foster the voluntary cooperation of its members in order to:

- Encourage the effective compliance of the members of every MEPA with the national and international laws and regulations adopted for the protection of the marine environment from pollution;
- Conduct a uniform public awareness campaign with top priority to offer young schoolchildren in every MEPA’s country a specially designed education on the marine environmental and the ways to prevent its pollution;
- Create and promote safety mindedness and security spirit within the industrial sectors in each country that are voluntarily enlisting as members in every MEPA;
- Enhance quality standards and professional competence throughout each MEPA's membership and especially the members from within the maritime community, with the means of a concerted training effort to educate and inform all, from the owner to the youngest employee of every participating company;
- Cooperate with international organizations, such as the United Nations Environment Program (UNEP), the International Maritime Organization (IMO), and the European Union, as well as national agencies, i.e. coast guards, port authorities, tourist boards and any other entity whose aims coincide with those of INTERMEPA;
- Promote relationships and/or partnerships with educational institutions (schools, colleges, universities, maritime academies, and other MET institutions) to further spread the MEPA voluntary commitment within today’s youth who are the world’s future scientists, engineers, managers, and politicians;
- Publicly recognize individuals, associations, organizations, companies and any other that demonstrate outstanding achievements in the field of the protection of the marine environment from pollution; and
- Promote and spread the MEPA philosophy in other countries.

Typically, to establishing a MEPA, whoever has the initiative to establish a MEPA should first submit to the Secretariat and through it to the Steering Committee:

- Written proposal by one existing MEPA member of INTERMEPA;
- Draft declaration similar to INTERMEPA’s with a list of the particulars of the founders;
- Statement providing that it is a non-profit, private initiative; and
- Written support of at least two of IMO, UNEP, WWF, ICS, and prospective volunteer membership mainly from within the ranks of shipping and the wider business community of the home country.

By joining, the new member has access to information material, technical assistance and other support from the existing members. As can be seen by this foundation process is “top-down” in that it is driven by an often high-level organizing organization within the maritime industry (as opposed to a “bottom-up” or more organic “grassroots” formation from an individual or employees). This will become an important distinction later in the article as a “bottom-up” approach will later be explored.

1.2 International Association of Maritime Universities

[9] The International Association of Maritime Universities (IAMU) was founded by seven universities representing the five continents of the world (representative universities) in November of 1999, with a shared recognition of significance of maritime education and training (MET) in the rapid globalization of the international shipping arena. Since then, IAMU has significantly expanded its membership, and now boasts 58 universities/academies/faculties of the world’s maritime education and training institutions, and the Nippon Foundation as its members, totaling 59 altogether.

The original representative universities at the time of foundation in 1999 are:

- Arab Academy for Science and Technology and Maritime Transport (representing Africa);
- Australian Maritime College (representing Oceania);
- Cardiff University (representing western Europe) [now replaced by Polytechnical University of Catalonia, Faculty of Nautical studies, Barcelona];

- Istanbul Technical University, Maritime Faculty (representing Mediterranean, Black Sea, as well as central and eastern Europe);
- Kobe University of Mercantile Marine (representing Asia) [now transformed to Kobe University, Faculty of Maritime Sciences];
- Maine Maritime Academy (representing the Americas including the Caribbean Sea); and
- World Maritime University (of general representation).

The IAMU is the global network of leading maritime universities providing maritime education and training (MET) of seafarers for the global shipping industry. All members of IAMU share the understanding that:

- Globalization has been progressing rapidly in the international shipping arena;
- Safety, security and environmental protection [emphasis added] are crucial issues for the maritime sector; and
- Passing on maritime skills and knowledge to the following generations needs to be achieved on a global scale.

All members of IAMU also recognize the significance of MET and note that:

- The shipping industry is a service industry, in which human resources are the critical element;
- It is only feasible to secure and to preserve highly qualified human resources in the maritime industries through effective education and training; and
- Effective education and training in the maritime sector derives from scientific and academic rigor and development of a clear link between practical skills, management techniques and a focus on quality.

Based on this shared understanding, it has been mutually agreed that members shall:

- Cooperate with each other in a range of scientific and academic studies, developments, and practical applications associated with MET;
- Endeavor to achieve measurable and worthwhile outcomes for MET through IAMU activities;
- Publicize the results of their activities as extensively as possible both within and outside IAMU, and shall endeavor to accumulate scientific results for the benefit of the international maritime community; and
- Thereby contribute to the enhancement of maritime safety, security and environmental protection [emphasis added].

The Association was created in 1999 by a group of maritime universities from across the world as a non-profit organization. It is interesting to note that, like INTERMEPA, IAMU is a non-profit collection of affiliated organizations who share similar interests and missions.

The balance of this article will examine the collaborative value creation (CVC) framework as it applies to partnerships among non-profit organizations. It will then examine the international MEPA's and the IAMU as two such non-profit organizations with aligned missions who might benefit from enhanced partnership.

2. Collaborative Value Creation

The socio-economic and environmental problems facing the world are too difficult for individual organizations to address adequately [4]. Since we are "all in this together," we can no longer "go it alone;" collaboration between and among organizations is an imperative [10]. Businesses have long collaborated or co-created value with other businesses and their customers [11, 12, 13] and have worked closely with governments or non-profits [14, 15, 16] in cross-sector partnering. We are now seeing non-profit organizations collaborate and co-create value with each other [17, 18]. Using a collaborative value creation framework (CVC) [4, 5], this article explores opportunities among non-profit organizations to collaborate and co-create value.

The CVC framework is comprised of four components: 1) the *value creation spectrum*, 2) *collaboration stages*, 3) *partnership processes*, and 4) *collaboration outcomes*. While this CVC framework was originally established to explore the nature of collaborations between business and non-profit partners, it will be used in this study examine the collaboration between two non-profit organizations.

2.1 Value Creation Spectrum

According to Austin and Seitanidi, the creators of the CVC framework, greater value is realized as collaboration moves across the value creation spectrum (from sole creation toward co-creation) [4]. In essence, as organizations deepen their partnering efforts, more value may and often will be created at all levels. In an effort to deepen the understanding of this value creation spectrum, the various dimensions indicated by sources of value will be examined.

There are four proposed sources of value in organizational collaboration:

- *Resource complementarity* – While much of the resource dependency literature focuses on partnering to access resources other than those already possessed, there is support for the notion that greater value co-creation can exist when partners exhibit fit and complementarity also [19, 20].
- *Nature of resource* – Similarly, partners can share generic resources that all organizations possess (e.g., money/time, reputation/brand). However, when partners share unique, organization-specific resources (e.g., knowledge, membership, networks), there will be a greater potential for value co-creation.
- *Resource directionality and use* – Resources can flow unilaterally or reciprocally. However, it is suggested that as complementary and distinctive resources are co-mingled, new services or activities can be created that neither of the organizations could have created on their own.
- *Linked interests* – While cross-sector alliances may have difficulty in that they do not share objectives or even value functions, in a single-sector, value co-creation may be enhanced when both partners perceive self-interests to be linked (by the value created for each other or the social good).

With the above sources of value in mind, four types of value can be derived in varying degrees: 1) associational value (based on the benefit achieved from the relationship itself), 2) transferred resource value (based upon the exchange of resources), 3) interaction value (resulting from derived intangibles like trust, reputation, joint capabilities), and 4) synergistic value (such that what is produced collaboratively is “more than the sum of its parts”).

2.2 Collaboration Stages

Partnerships are dynamic and as they evolve, so too does the nature of value creation. To describe the various stages of collaboration, Austin [21, 22] created a collaboration continuum consisting of three-stages: 1) *philanthropic* (typically where a corporate donor unilaterally transferred resources to a non-profit recipient), 2) *transactional* (where partners reciprocally exchanged resources), and 3) *integrative* (where organizations integrate missions, strategies, etc. for the purpose of co-creating value). A fourth stage is also envisioned that goes beyond integrative collaboration – *transformational* collaboration (where organizations co-create transformative change at the societal level) [5]. This last highest level stage of convergence, marked by increased interdependency and intensity of relationship, is emergent with some signs of practice, but not fully realized.

It is important to consider collaboration as dynamic within the stages of development. The continuum does not represent sequential progression of discrete points. A partnership may be partially in one stage and partially in another. A partnership need not pass through every stage. Likewise, partnerships may move in either direction along the continuum at different points in time.

The nature of the relationship between partners changes in intensity and form of interaction across the four stages. The following figure illustrates a few key dimensions about the nature of the relationship and how it might change across the four stages within the collaboration continuum. A more complete listing of these dimensions can be found in the original work of Austin [21, 22, 4].

	Philanthropic>Transactional>Integrative>Transformational
Level of Engagement	Low---High
Interaction Level	Modest--Intense
Amount of Resources	Small--Large
Type of Resources	Funding------------------------------------Core Competencies
Strategic Value	Minor--Major

Figure 1 Nature of Relationship Across Collaboration Continuum

Taken together, the above concepts can be formed into a comprehensive CVC spectrum [4].

	Sole-Creation--->Co-Creation
SOURCES OF VALUE	
Resource Complementarity	Low-->High
Resource Nature	Generic------------------------------------->Distinctive Competency
Resource Directionality	Unilateral--->Conjoined
Linked Interests	Weak/Narrow--->Strong/Broad
TYPES OF VALUE	
Associational Value	Modest--->High
Transferred Resource Value	Depreciable--->Renewable
Interaction Value	Minimal--->Maximal
Synergistic Value	Least--->Most
Innovation	Seldom--->Frequent
STAGES	Philanthropic-->Transactional-->Integrative--->Transformational

Figure 2 CVC Spectrum

2.3 Partnership Process

Next, once the importance of a partnership has been understood according to the CVC, an organization must embark upon partnership processes that involve: 1) *formation*, 2) *selection*, 3) *design*, 4) *operations*, and finally 5) *institutionalization*. Partnership formation, as defined by Selsky and Parker [23], is often defined by initial conditions, contexts, and opportunities. In other words, formation is the determinant(s) by which CVC opportunities can be identified and evaluated for action. An important element of formation is fit within the partnership – can the partnering organizations achieve congruence with respect to perception, interests, and strategic direction. In order to evaluate organization fit as part of the formation, the CVC recommends the following process.

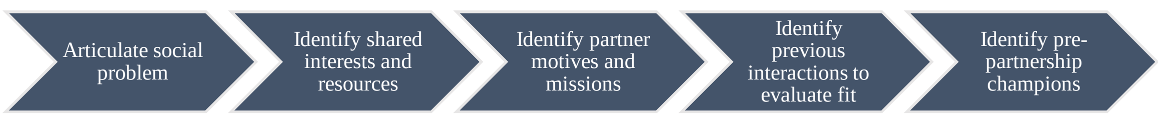

Figure 3 Partnership Formation Process

Partner selection is part of and an extension to the formation process. As might be expected, poor partnership selection is a common reason for partnership failure [24]. The process of assessing potential partners is further facilitated by developing partnership-specific criteria (e.g., target industry, scope of operations, time scales of operation). Seitanidi and Crane [25] created a partnership selection process for co-creation of value that included: 1) assessing potential, 2) developing partnership criteria, and 3) risk assessment.

Once formation and selection takes place, the partnership must be implemented, which serves as the CVC engine. There are many parameters that influence design and operations (e.g., setting objectives, specifying structure, forming rules, drafting MOUs, establishing leadership positions). These forms of formal control are typically identified early on and have significant influence on the partnership that ultimately develops. The CVC framework suggests a set of partnership design and operations processes that involve iterative experimentation and adaptation (at the organizational and collective levels) leading to operationalization (which includes the stabilization of shared processes and structures [25]). Another useful framework for considering partnership processes involves educational institutions efforts to collaborate [26], including pilot studies to get to know partners, a limited cooperation phase, and followed by an extended cooperation phase. Partnering processes are deemed complete when convergence, fusion, or abandonment occur.

2.4 Collaboration Outcomes

Collaboration outcomes are the metric by which the partnership is judged. Understanding of collaboration outcomes is an evolving area of practice and research, particularly when the focus is on benefits to society [27, 28]. Traditionally, partnerships between businesses focused on internal value creation, but more recently there has been a strong shift to focus on external value creation, particularly when it comes to partnerships among non-profit organizations. Example include collective impact [29], social value measurement [30], and social impact beyond financial returns [31]. For non-profit partnerships, collaboration outcomes “should encompass the social value generated by the collaboration [5]. This form of external value creation can be evaluated across different levels [32, 33], but the focus here will be at the macro- (vice meso- or micro-) level. At the macro-level, the loci of focus is on the generation of social, environmental, or economic value for the broader community or society beyond the partnering organizations.

3. Case Study

Most of CVC framework comes from the perspective of a “top-down” approach. For the purposes of later argument, lets now consider the potential for partnership between INTERMEPA and IAMU (two non-profit organizations) using the CVC framework:

1. Is there potential value in such a partnership? Yes. Through resource complementarity and shared interests (namely protection of the marine environment), associational and interaction value are highly likely. Additionally, assuming a depth and breadth of the partnership, synergistic value may also be realized.
2. How might the partnership develop? Any partnership is only as strong as the commitment of member organizations and individual efforts. Given the strong overlapping missions in the area of environmental protection and education, it can be foreseen that a high level of development could be realized at the integrative, or even eventually transformational, level.
3. What might the processes of such a partnership look like? The first three conditions illustrated in figure 3 of partnership formation exist. There is no known history of efforts (unsuccessful or otherwise) to previously form a partnership. The next formation step would be the identification of champions within each organization to shepherd the formation. Taken together, this selection of potential partners would set up the foundation necessary design and implementation of the partnership (through MOU of other means).

4. Which outcomes might this partnership adopt? Any partnership should have realistic measurement objectives to inform strategy and operations. Any objectives would be a significant topic for the design of the partnership, but could include aspects of education, outreach, and advocacy, as well as direct impact on the ideal to “save our seas”.

While a “top-down” approach to developing a partnership among non-profit organizations would likely be effective (and should be pursued), we will present a case study to illustrate how a “bottom-up” approach may be equally effective. In fact, the “bottom-up” approach has the added advantage that it “provides an opportunity for community empowerment that conventional approaches have failed to provide” [34]. This type of approach at the local and regional (as opposed to national and international) level allows for stakeholder involvement at the community level. Given the interests of the authors, this case study leverages the depth of experience in founding and running a Marine Environmental Protection Association (MEPA) in North America (second author) and the creativity of launching and growing a local NAMEPA chapter at a North American maritime education and training (MET) university (first author) against the interest to form a similar MEPA-styled chapter at MET university in Japan (third author), considering “the rise of Japanese NGOs… resulting from ‘bottom-up’ motivation to address socio-economic, technological, and environmental concerns in an increasingly borderless world” [35]. The history of the Japanese environmental movement has illustrated that while “weakly consolidated at the national level” two-decades ago, recent events have brought heightened attention to environmental issues that would allow for a strong “bottom-up” approach [36].

This final section will draw upon the experience in successfully forming and growing the NAMEPA and translating lessons learned there toward establishment of a new chapter in Japan that might form the foundation for a NIPPONMEPA.

When the now Executive Director of NAMEPA was in Greece in 2006, Ms. Carleen Lyden-Klus was asked why no MEPA existed in North America. Upon return, after interviewing key stakeholders (e.g., ship owners, class societies, Coast Guard officials), a consensus for support was built. A sponsor in the form of the other co-founder (and until recently Chairman of NAMEPA), Mr. Clay Maitland, was identified and invited to underwrite the effort and work set forth to develop a concept statement and apply to INTERMEPA using the process previously described. In 2007, a “road trip” of seminars was conducted to engage stakeholders (e.g., maritime concerns, regulatory agencies, and environmental conservancy groups) and develop common vision built upon mutual interests to preserve the marine environment.

A portfolio of educational materials and programs were developed to education the public, with a focus on K-12 students, as future stewards of the environment. That outreach extended into the maritime academies where local chapters have been formed to further extend the reach of the mission. This structure of leveraging alliances is crucial given the small size of the non-profit NAMEPA organization (currently two full-time and 11 part-time employees in addition to the Executive Director). Memoranda of Understanding (MOUs) were developed with the US Coast Guard, Transport Canada, US National Oceanic and Atmospheric Administration, INTERTANKO, Chamber of Shipping of America, the US Power Squadron, and more.

To establish a local MEPA chapter (where a national or regional MEPA does not exist), the following “bottom-up” steps are suggested:

- Review NAMEPA chapter guide (available in hardcopy and digital forms).
- Review the by-law structure of NAMEPA, and consistent with national non-profit (or NGO) laws and regulations. When operating a student chapter under the auspices of a MET college or university, such as Kobe University, separate by-laws may not be necessary and local rules may dictate.
- Recruit a cadre of environmentally-minded students (preferably those who will be around for at least a couple of years to accomplish formation work and activities).
- Review the mission of MEPAs and identify which aspect will best serve the interests of the chapter and the community. Each MEPA and chapter are unique and based upon the strengths

of membership. NAMEPA has a strong communications theme reflective of the Director's expertise. HELMEPA is active in seafarer training to address a need in Greece.

- Develop your platform and mission.
- Identify officers and a Board of Directors (making sure to invite key stakeholders from the maritime industry and environmental advocacy groups).
- Seek support from the maritime industry and its members (e.g., Japanese ship owners and shipping companies, Class NK, Japanese Ministry of Transport, and former Secretary-General of the IMO, Hon. Koji Sekimizu).
- Identify an anchor sponsor (e.g., like NIPPON Foundation support for IAMU).
- File for MEPA status through INTERMEPA process.
- Host a kick-off education event and invite campus community, maritime industry leaders, and local community (e.g., TEDx Talks, themed Pecha Kucha night, etc.). Consider a blend of student/faculty and industry speakers. Invite selected speaker from an environmental advocacy group.
- Continue to recruit new members. One great way to increase membership (as well as informing the broader public is to host a beach clean-up activity [37].
- Train members on how to deliver educational programs into local schools and public community groups.
- Continue to build using techniques appropriate for the institution and national culture. Be creative in how best to advance your mission and vision using a platform designed by your member.

Additionally, having recently established and re-energized a local NAMEPA chapter at Massachusetts Maritime Academy, it will be possible for Kobe University to use the MIX methodology [7] to conduct shared virtual events and chapter-to-chapter communication, learning, and growth. It is anticipated that by leveraging existing networks, building upon a history of success, and engaging students, an innovative and thriving NIPPONMEPA will result.

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Floating Power Platforms for Offshore Cold-ironing

Dr. Shantha Jayasinghe[1], Mr. Gamini Lokuketagoda[1], Dr. Hossein Enshaei[1], Professor Dev Ranmuthugala[1], Dr. Daniel Liang[2]

1. Australian Maritime College, University of Tasmania, Launceston, Tasmania, 7250 Australia
2. DNV GL - Energy, Singapore
Email: shanthaj@utas.edu.au

Abstract The colloquial term 'cold-ironing' refers to connecting a ship to shore power when it is at berth, as its main and auxiliary engines, made of steel/iron, are shut down, literally becoming cold. In the current environment where strict emission regulations govern virtually every ship operation, shore power has become an essential service sought by ships at berth in emission controlled ports. At present, these ships in port can receive shore power only when they are at berth, usually during the transfer of cargo or passengers. However, there are many more ships anchored in and around the ports awaiting access to berths. Efficient supply of shore power to these anchored ships is a challenge and thus they rely on their on-board power generation systems to supply essential loads. As the waiting time can vary from a few hours to weeks, emissions from these ships are significant, especially as they are clustered together in close proximity to land. Therefore, if an efficient and effective way of powering anchored ships with clean or low emission power is available, it can significantly contribute towards reducing emission around busy ports as well as the operating cost of anchored ships.

In an attempt to address this problem, authors propose a floating power platform for 'offshore cold-ironing'. The proposed system consists of a fuel cell, a battery bank, and a small LNG engine driven generator set installed on a floating platform such as a barge and moored in close proximity to the anchored ships to supply them with their required electrical power. Nowadays, with the advancements of the fuel cell technology, installation of a suitable fuel cell stack on a floating platform such as a barge has become feasible. Nevertheless, fuel cells response slowly and thus fast dynamic loads such as dynamic positioning load in adverse sea conditions can easily push the fuel cell beyond its safe operating range, possibly creating power system instabilities that can result in blackouts. In addition, the floating platform itself needs dynamic positioning or some form of control to maintain its position relative to supplied ships, further influencing the dynamic load.

The battery bank can support the fuel cell to cope with such loads. However, in extreme situations, even the battery bank will discharge rapidly and the fuel cell may struggle to charge it. Therefore, when the state of charge of the battery bank drops below a defined lower threshold, the LNG engine-driven generator set starts and provides boost power to charge the batteries. As the generator is used only when the battery charge is low, and the emission from the LNG is relatively low in comparison to other fossil fuels used on-board, the proposed system can be considered as a low emission technology solution. The feasibility of the proposed concept of floating power platform, from the power system control perspective, is investigated in this paper through modelling and simulation, with the results clearly showing the efficacy of the proposed hybrid power system to supply the dynamic loads encountered on anchored ships.

Keywords: Battery, cold ironing, fuel cell, LNG engine, power management, shore power.

1. Introduction

Shipping is considered essential for the growth of the global economy as it accounts for more than 90% of the goods transported locally and internationally [1]. Therefore, current economic and population growth across the world requires a complementary growth in the shipping industry, with greater demand for the number and size of ships plying the major economic routes. Unfortunately, this results in a greater use of fossil fuels, in turn increasing the global share of greenhouse gas (GHG) emissions from ships and thus contributing significantly to climate change and other environmental issues [2, 3]. In an attempt to reduce these emissions, many countries and regions have imposed strict emission regulations and defined emission control areas (ECAs) around their coasts [4, 5]. Ships that visit ports in these areas or sail through these regions are required to take measures to comply with emission regulations [6]. Cold-ironing is one such measure where ships at berth shut down their relatively high emission engines and receive power from shore connections [7, 8]. Even though the generation of shore power may use similar fossil fuel, (e.g. diesel fuel), it is possible to do so within a more controlled environment and thus can yield to a net reduction in emissions [9]. Thus, the use of shore power is increasing in popularity in comparison to running on-board engines.

At present, ships can receive shore power only when they are at berth for cargo operations or passenger transfer. Ships at anchor, waiting for their turn, are unable to access shore power. Currently, there is no efficient and effective way to supply them with shore power and thus on-board main and/or auxiliary engines have to supply essential loads. As the waiting time can vary from a few hours to weeks, emissions from these ships could be significant. Therefore, an innovative solution is required for the efficient and effective supply of clean or low emission power for anchored ships, especially around busy ports such as in Singapore.

As proposed in [10] an offshore floating renewable power station is a promising solution for supplying anchored ships with clean power. The 'offshore cold-ironing' platforms presented in this paper is a continuation of this idea. An overview of the proposed system consisting of a fuel cell stack, a battery bank, and a small LNG engine-driven generator is shown in Figure 1. A schematic diagram of the corresponding power conversion system is given in Figure 2. The coupled LNG engine and generator set does not run continuously. It is used only to give a power boost when the battery is discharged below a certain level, and will shut down once fully charged. This ensures low emission due to the sparing use of the engine and the relatively low emissions of the LNG in comparison to other commonly used marine fuels. Therefore, the proposed system can be categorised as a low emission technology solution. The combined system can be installed in a platform such as a barge and moored closer to the anchored ships to supply the required electrical power. As reported in [11], installing a fuel cell power system in a floating platform, e.g. barge, is feasible.

A typical ship power system provides service and propulsion loads [12]. Although service loads may experience fluctuations, their magnitudes and rate of change usually fall within operational envelop of fuel cells. However, difficulties arise with propulsion loads that are linked to dynamic positioning, especially at rough sea conditions. Similarly, the moored platform may not hold to its position during a rough sea and therefore a suitable control mechanism is required for position fixing. Therefore, load dynamics caused by propulsion motors and thrusters can easily push the fuel cell away from the stable operating region causing blackouts. In such situations, the battery bank can support the fuel cell to keep it within its operating envelop. When the combined fuel cell and battery system is unable to supply the load, the LNG engine is started automatically to supply a power boost. These combined operations bring complexities into the proposed floating power system and thus its performance heavily depends on the effectiveness of the control and power management technologies used within the system.

Various control and power management schemes are proposed in relevant literature for similar hybrid power systems. These techniques can be broadly classified as traditional PID based controls [13-16], model reference based controls [17-19], and learning based controls [20, 21]. Out of these three categories, the traditional PID based controls are the simplest and thus the most widely used. Nevertheless, model reference based control schemes render fast transient response while learning based controls are generally immune to parameter changes. As the focus of this paper is to investigate the feasibility of the proposed system, simple PI controllers and a straightforward power management strategy which is based on the battery state of charge measurement were adopted. In this study, the proposed system, its control scheme and the power management were modelled in the MATLAB/Simulink environment, with simulations carried out to test their performance under dynamic loading conditions. Simulation results show that the proposed floating hybrid power system is capable of supplying dynamic loads without triggering blackouts.

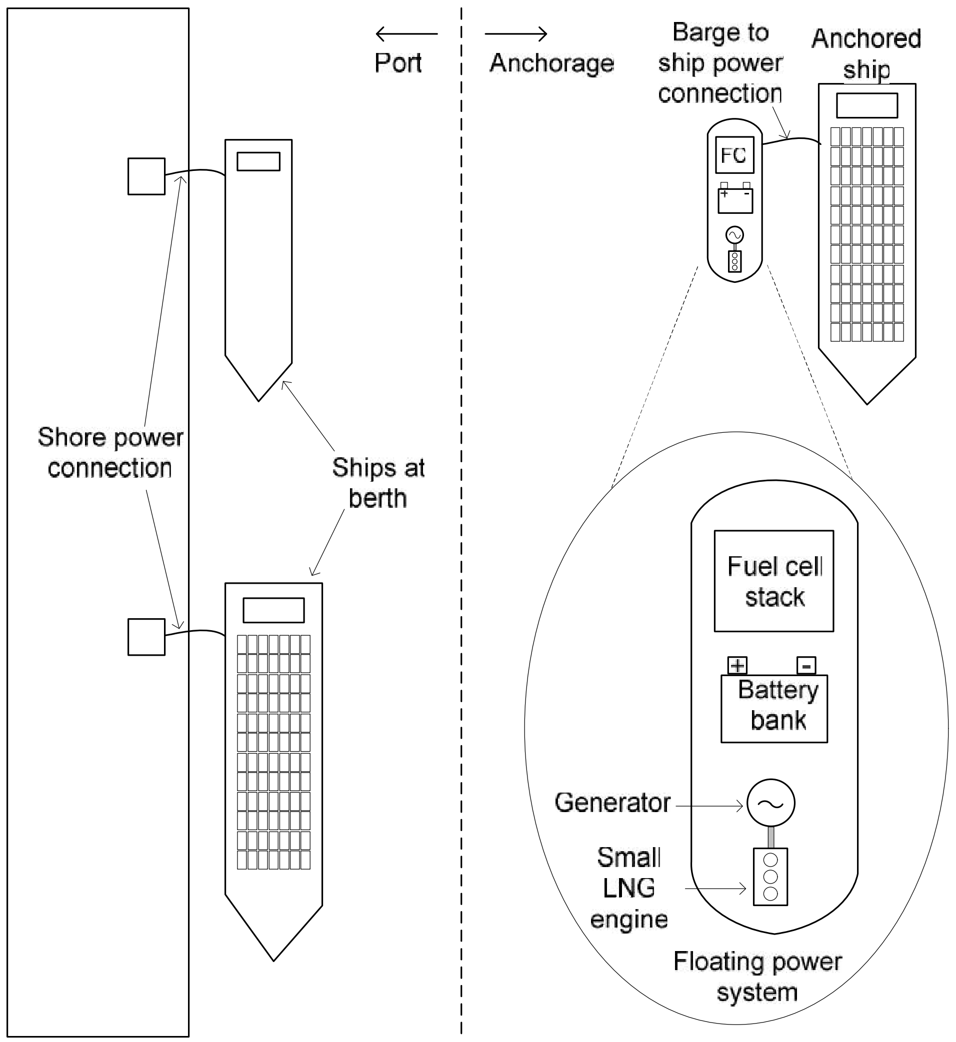

Figure 1 An overview of the proposed system

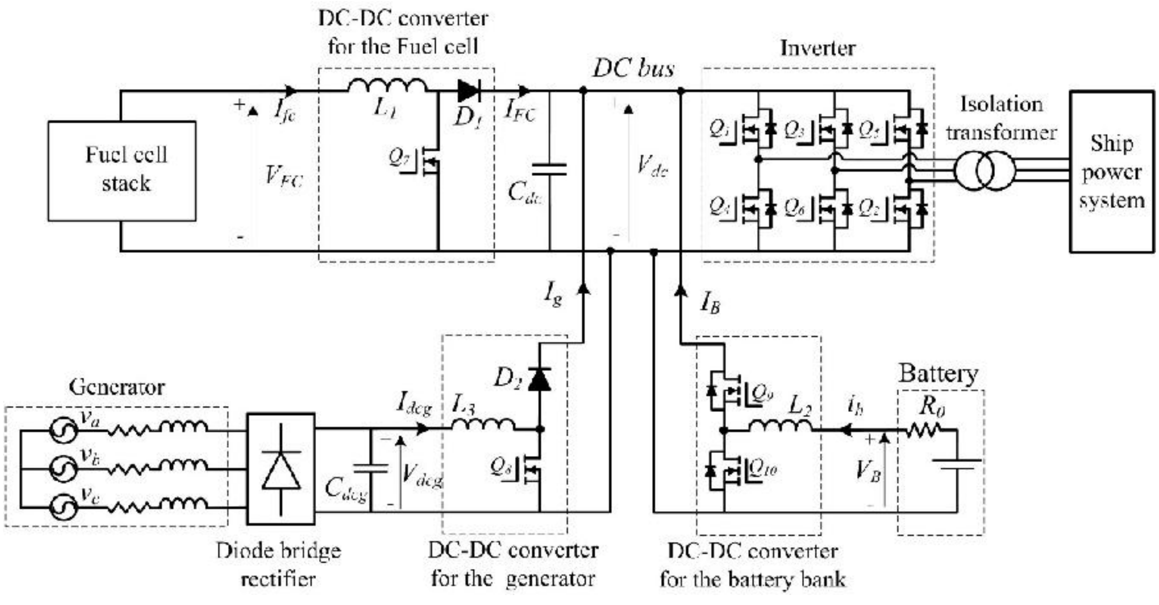

Figure 2 Schematic diagram of the proposed 'offshore cold-ironing' system

2. System Modeling

2.1 Fuel Cell Model

A schematic diagram of the fuel cell model used in this study is shown in Figure 3. In this model, the open circuit voltage (E_{oc}), exchange current (i_0) and the Tafel slope (A) are calculated using equations (1), (2) and (3) respectively [22, 23].

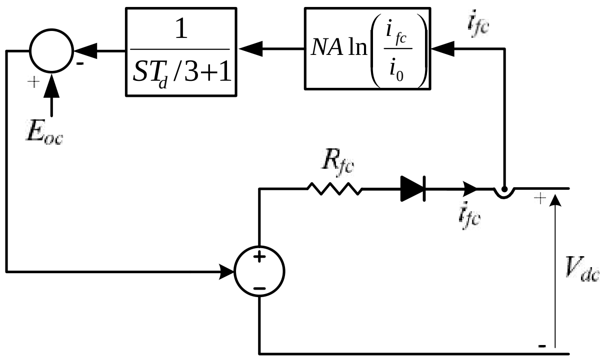

Figure 3 Fuel cell model

$$E_{oc} = K_c E_n \quad (1)$$

$$i_o = \frac{zFk\left(P_{H_2} + P_{O_2}\right)}{Rh} e^{\frac{-\Delta G}{RT}} \quad (2)$$

$$A = \frac{RT}{z\sim F} \quad (3)$$

where N is the number of cells in the fuel cell stack, R is the universal gas constant (8.3145 J/mol K), F is Faraday's constant (96485 C/mol), z is the number of moving electrons, E_n is the nernst voltage which is the thermodynamics voltage of the cells that depends on the temperatures and partial pressures of reactants and products inside the stack (V), α is the charge transfer coefficient which depends on the type of electrodes and catalysts used, P_{H2} is the partial pressure of hydrogen inside the stack (atm), P_{O2} is the partial pressure of oxygen inside the stack (atm), k is the Boltzmann's constant (1.38×10^{-23} J/K), h is the Planck's constant (6.626×10^{-34} Js), ΔG is the size of the activation barrier which depends on the type of electrode and catalyst used, T is the temperature of operation (K), K_c is the voltage constant at nominal condition of operation, R_{fc} is the internal resistance of the fuel cell stack, S is the Laplace variable and T_d is the response time (s).

2.2 Engine and Generator Models

The engine is represented as a first order delay with the time constant $^{2}{}_{en}$ as shown in Figure 4. The governor of the engine controls the fuel supply to the engine and thus controls the engine torque, T_{ENG}, to regulate the engine speed under varying load conditions. The corresponding closed loop speed controller of the small LNG engine and the generator set is represented as in Figure 4, where T_e is the electrical load and J_{gen} is the equivalent inertia of the rotating parts.

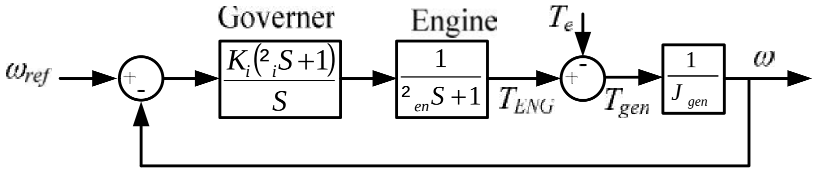

Figure 4 Engine model and closed loop speed controller of the small LNG engine and generator set

3. Control and Power Management

3.1 Fuel Cell Power Controller

The interfacing dc-dc converter, shown in Figure 2, is used to control the fuel cell power by controlling the current passes through it. The corresponding controller block diagram is shown in Figures 5, where P_{fc}^* represents the power reference for the fuel cell stack and V_{FC} represents the fuel cell voltage. The power reference can be adjusted to suite system requirements. Nevertheless, due to the slow dynamics of the fuel cell it cannot respond to fast changes. Therefore, generally, the fuel cell power reference is changed slowly. Hence, in this study, it is set to a constant value which in turn ensures smooth operation of the fuel cell stack. This value is then divided by the fuel cell voltage to generate the current reference, I_{FC}^*. As shown in Figure 5, the actual current passing through the dc-dc converter, I_{FC}, is then compared with the reference and the error is passed through a PI controller to generate the duty cycle, D_{fc}. The duty cycle, which varies between 0 and 1, compared with a triangular carrier signal in the pulse width modulation (PWM) unit to generate gate pulse for the transistor *Q7*.

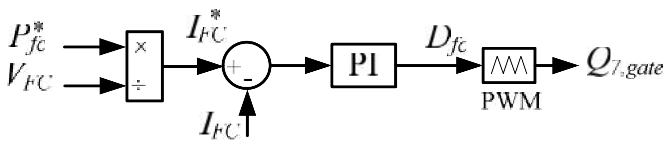

Figure 5 Fuel cell power controller (P_{fc}^*- power reference, V_{FC} - fuel cell voltage, I_{FC}^* - current reference for the interfacing dc-dc converter of the fuel cell stack, I_{FC} - output current of the dc-dc converter, D_{fc}- duty cycle of the dc-dc converter)

3.2 Battery Power Controller

Due to the slow dynamics of the fuel cell, sudden load changes cause deviations in the dc-link voltage. The battery power controller, shown in Figure 6, senses these deviations by comparing the actual dc-link voltage, V_{dc}, against the set value, V_{dc}^*. The error is passed to a PI controller to generate the duty cycle, D_{Bat}, for the corresponding dc-dc converter. As described above, the PWM unit generate gate pulses for Transistors Q_9 and Q_{10} based on the duty cycle. This controller attempts to restore the dc-link voltage. As a result of this voltage restoration effort, battery power varies. This controller is simple and easy to implement as it automatically takes care of both charging and discharging of the battery bank.

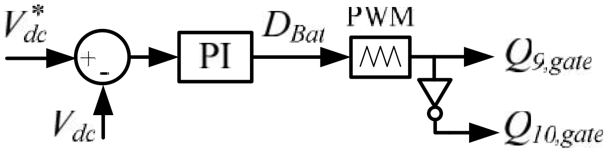

Figure 6 Battery power controller (V_{dc}^*- dc-link voltage reference, V_{dc} - measured dc-link voltage, D_{fc}- duty cycle of the interfacing dc-dc converter of the battery bank)

3.3 Generator Power Controller and Power Management Strategy

A battery state of charge based simple power management strategy is used in this study where the LNG engine automatically starts when the state of charge of the battery bank falls below a certain threshold to provides boost power. For the sake of simulation, the generator power reference P_{gen}^{*}, was set to a constant value in this study. Whenever the sum of the generator power and fuel cell power exceeds the load demand, the surplus gets stored in the battery bank and thus it gets charged. As shown by the hysteresis block in Figure 7 the generator runs until the state of charge of the battery reaches the upper threshold before cutting out. The corresponding controller is shown in Figure 7.

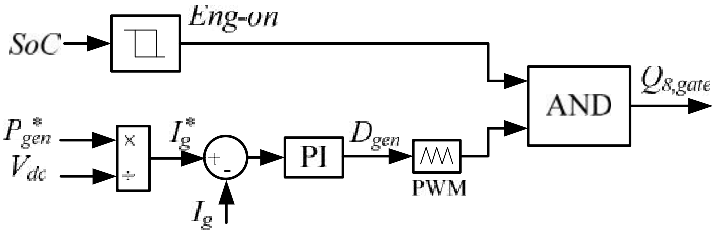

Figure 7 Engine power controller (*SoC* - state of charge of the battery bank, P_{gen}^{*}- power reference, V_{dc} - measured dc-link voltage, I_g^{*} - current reference for the interfacing dc-dc converter of the generator, I_g - output current of the interfacing dc-dc converter, D_{gen}- duty cycle of the dc-dc converter)

4. Simulation Results

The proposed hybrid power system was modelled and simulated using the MATLAB/Simulink software to test its performance at dynamic loading conditions. System parameters of the simulation setup are given in Table I. Load power variations used in this study are shown in Figure 8(a) by the trace marked 'Load power'[24]. As mentioned above, fuel cell power reference was set to a constant value. As evident in Figure 8(a) by the traced marked 'Fuel cell power' the controller is able to maintain the fuel cell power at the set value. The battery bank absorbs the fluctuations present in the load power as shown in Figure 8(b) by the trace marked 'Battery power'. The negative battery power shown during the 0-30s period indicates that the fuel cell power is larger than the load demand and thus the battery gets charged. The plot of corresponding state of charge variation in Figure 8(b) shows an increase during this period. After that, the load power exceeds the fuel cell power and thus the battery bank is discharged causing its state of charge to drop.

In order to show the performance of the engine power controller, the lower and upper thresholds of the battery state of charge was set to 64% and 65% respectively. Practical values of theses thresholds can be significantly different to these values, depending on the application environment. The points at which the battery state of charge meets these thresholds are marked by vertical dashed lines in Figure 8. When the Battery state of charge drops below 64%, the generator starts and delivers power to the common dc-bus. As mentioned above, the engine power is set to a constant value in this study and thus the corresponding generator power remains constant as shown in Figure 8(a) by the trace marked 'Generator power'.

Whenever the sum of the generator and fuel cell power exceeds the load power, the battery bank is charged. This is evident in the variations of the battery state of charge shown in Figure 8(b). When the battery state of charge reaches 65%, the engine cuts out, thus the generator power drops to zero as shown in Figure 8(a). These results verify the ability of the proposed hybrid power system to supply dynamic loads while ensuring smooth operation of the fuel cell stack through appropriate control and power management.

Table 1 System parameters of the simulation setup

Rated power of the fuel cell stack	350kW
No load voltage of the fuel cell stack	900V
DC-Link voltage reference	600V
Nominal voltage of the battery bank	480V
Maximum capacity of the battery bank	400Ah
Rated power of the generator	100kW
Output line voltage ($V_{LL\text{-}rms}$)	440V
Output frequency	60Hz

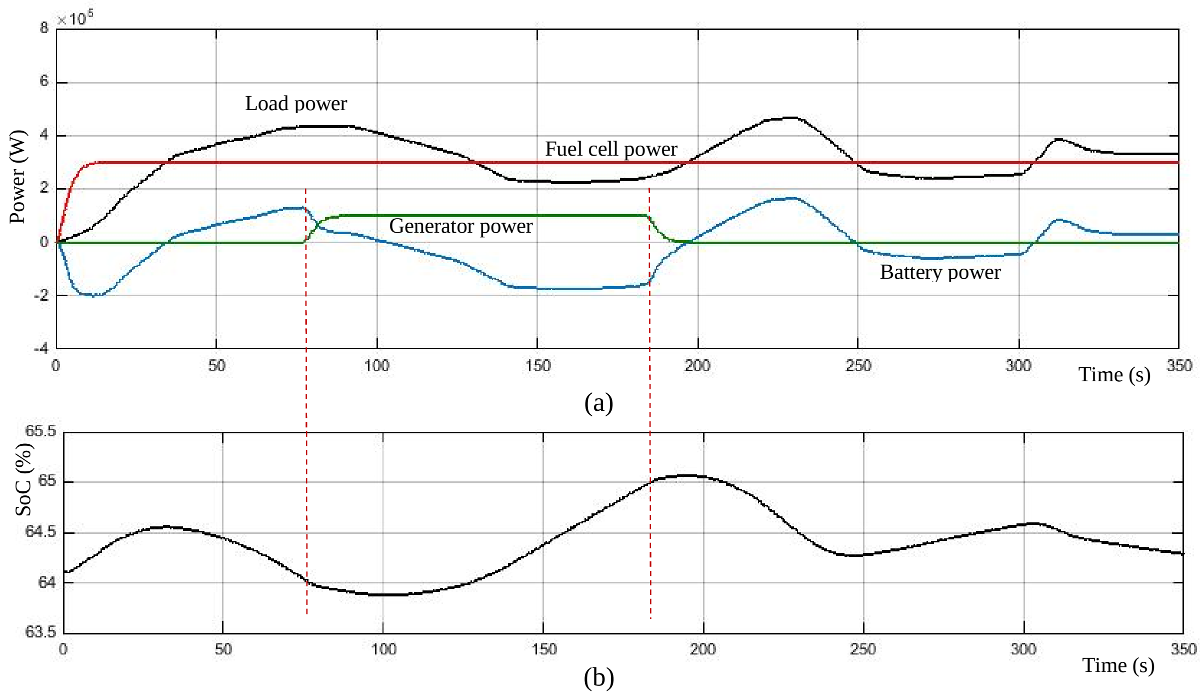

Figure 8 (a) Load power, fuel cell power, battery power and generator power, (b) State of charge (SoC) of the battery bank.

5. Conclusion

This paper proposes a hybrid power system for offshore cold-ironing of anchored ships, which consist of a fuel cell stack, battery bank and a small LNG engine-driven generator set. In this study, a simple PI controller based control system and a battery state of charge based power management strategy were used to verify the operation of the proposed hybrid power system under dynamic loading conditions. Simulation results show that the fuel cell and battery combination is able to supply dynamic power demands, while the small LNG engine-driven generator provides boost power to charge the battery bank when its charge falls below a set threshold. Based on the results, it can be concluded that the proposed hybrid power system is capable of supplying dynamic loads that can occur in a ship's power system while at anchor, ensuring smooth operation of the fuel cell stack. It is thus a viable option to provide efficient, effective and low emission power to a large fleet of vessels anchored in and around congested ports across the world. Assessing the performance of the proposed system against actual power demands recorded from anchored ships would be a possible step to take the proposed concept to the next level.

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The determining torsional vibration damping coefficients algorithm for computing marine shafting's vibrations

Ass. Prof. Nguyen Manh Thuong

Vietnam Maritime University, Email: thuongmt29@gmail.com

Abstract The most difficulty in the computations of ship shafting torsional vibrations is to determine such torsional vibration damping coefficients as those in main engines and shafting structures, or those of hydraulic resistances on propellers. The difficulties are due to the complex nature of the hydro dynamical process, that it is difficult to come up with an analytical method to determine these quantities. Even direct measurements of such quantities are difficult to make in the practice.

Currently in Vietnam, these data usually are given by the manufacturers that doesn't make sure about the accuracy, or they are calculated based on the semi-empirical formulae those are old and may be not appropriate for the modern types of engines and equipment. Therefore, the aim of the author is to determine these quantities from the results of torsional vibration measurements during the new built ship tests. Based on the analysis of results obtained for shafting's types with different features (for example, characteristic types of engines, propellers, shaft materials ...) and combined with the theoretical analysis we would generalize calculations of the above quantities. It allows to obtain the new calculating formulae for these quantities more certain and convenient for basic design calculation of ship shafting.

The paper presents a theoretical basis and algorithms of determining the torsional vibration damping coefficients of the engine structure, shaft material and hydrodynamic damping coefficient to propellers from results of vibration measurements. By programming with the help of Symbolic Math Toolbox package in Matlab software we will establish an analytical equation for amplitudes of elastic torque $M(k\mu)$ caused by torsional vibrations in an arbitrary shaft section (where perform measurements conveniently). In this equation it contains *m* unknown variables, supposed to be unknown damping coefficients for each given shafting with given size and mass parameters and a finite number of masses. Therefore, to identify these *m* unknown variables, we must have at least *m* values of torque amplitude corresponding to *m* values of $k\mu$ measured in a position of shafting to make a system of *m* equations. However, the system of equations is not linear so to facilitate the calculations we need to have more than *m* values of the measured amplitudes. The program would indicate how many values of the measured amplitudes should have, and after having the measurement results, it will determine the unknown damping coefficients.

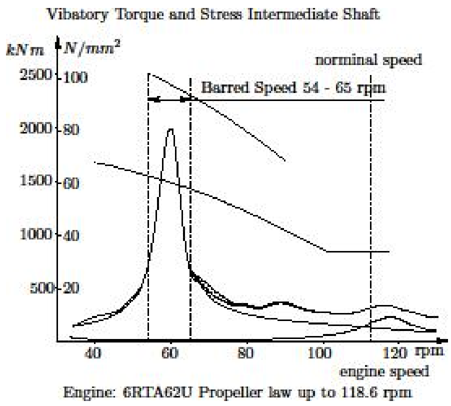
To illustrate, the article presents the example calculation for ships series B 170-V designed by Polish Architecture Institute and built in Ha Long shipyard. The data on the shafting and the results of vibration measurements obtained from the documents submitted by Ha Long shipyard and the Designer to GL registry for approval. The obtained results of calculation will explain the reason for deviation between real vibrations and computed vibrations or show the appropriateness of assumptions about the damping coefficients used in computations of torsional vibrations. Based on this profile, we can be able to improve the vibration calculation model.

***Keywords**:* torsional vibrations, damping coefficient, relative and absolute damping coefficients, elastic torque.

1. Introduction

As we know, the kinds of resistances acting on the shafting's vibrations in general are not constant, but non-linearly depend on amplitudes and velocities of vibrations. For example, the resistance in the shaft's material (relative resistance) or hydraulic resistances on propellers (absolute resistance) is the exponential functions of torsional deformation amplitudes or torsional vibration amplitudes of propellers (for example, the resistant work to propellers per a vibration cycle is proportional to square of the vibration amplitude [1]). Therefore here we should solve systems of nonlinear differential equations. It is the reason why such complicated resistant models are used to calculate only resonant vibrations, assuming that forms of forced vibrations are similar to forms of free vibrations [1, 3].

But currently, many Design Agencies and Registries have accept assumptions, supposing these damping coefficients are constants and resistant torques proportional to the speed of deformations. The damping coefficients of the water on propellers accord to the Archer formula [2].



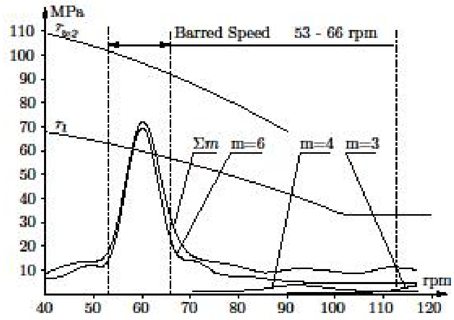


Figure 1a Stress amplitude/ rotation speed at intermediate shaft calculated by the Polish designers [2]

Figure 1b Stress amplitude/ rotation speed at intermediate shaft measured [2]

Figures 1a and 1b show calculated by the Polish design agency and measured torques of elastic deformations at intermediate shaft of B-170-V ship and figure 2 shows the calculation results of the authors of this paper. As seen on the pictures, the frequency curves of calculations and of actual measurement are rather identical. Differences in quantities are interpreted as errors caused by using simplifying assumptions about resistances.

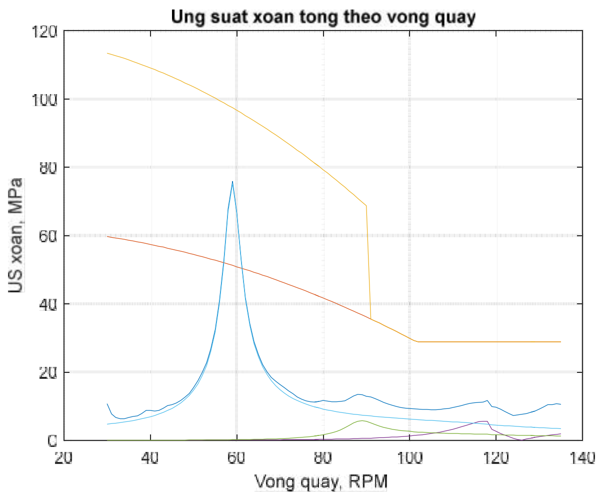


Figure 2 Stress amplitude/ rotation speed at intermediate shaft calculated by the author

In spite of the fact that there are differences between computations and measurements, we may see that, computation results with the above simplifying approximate assumptions meet the purposes of torsional vibration calculation for basic design stage and the requirements of the Registry for torsional vibration calculations. But essential problem posed now is how to determine these damping coefficients. How do we design without data given by manufacturers? What is to be based on to confirm results of design vibration calculations be reliable?

We may infer that, the determination of the above damping coefficients still is the problem to be solved even for the world developed shipbuilding industry because the foreign registry offices still require testing torsional vibration measurements for new designed ships.

This paper will present algorithms determining damping coefficients having had the torsional measurement results when testing new build for the use in the future to study these types of resistances.

Indeed, after determining the damping coefficients for many different ship shaftings, we will have more experience and understanding of the factors causing resistances that may help us to establish semi-empirical formulas to determine the coefficients of resistances in engines and in the shaft material or resistances to propellers by water ... to serve torsional vibration calculations in design stage.

2. Establish algorithms determining the damping coefficients

Let's consider an actual shafting as a torsional vibration system of *n* discrete masses, linking together by elastic elements without weights as shown in Figure 3 [1, 2]. The vibration driving forces are forces from cylinders acting on engine crank shafts and of water on propeller. The main forms of resistance included are those in the structure of piston-cylinder/connecting rod/crank shaft, and those in shaft material and of water on propellers. Designating angle of torsion deformation of *i-th mass as* φ_i, forcing torque on that mass as M_i, inertial mass moment of the *i-th* mass as I_i, absolute damping coefficient- a_i, relative damping coefficient between two masses *i* and *i+1* as $b_{i,i+1}$ and stiffness between them- $K_{i,i+1}$, we have dynamical equation of *i_th mass as* [3]:

$$-b_{i-1,i}\dot{\varphi}_{i-1} - K_{i-1}\varphi_{i-1} + I_i\ddot{\varphi}_i + (a_i + b_{i-1,i} + b_{i,i+1})\dot{\varphi}_i + (K_{i-1,i} + K_{i,i+1})\varphi_i - b_{i,i+1}\dot{\varphi}_{i+1} - K_{i,i+1}\varphi_{i,i+1} = M_i$$

where: $i = 1,\dots,n$. (1)

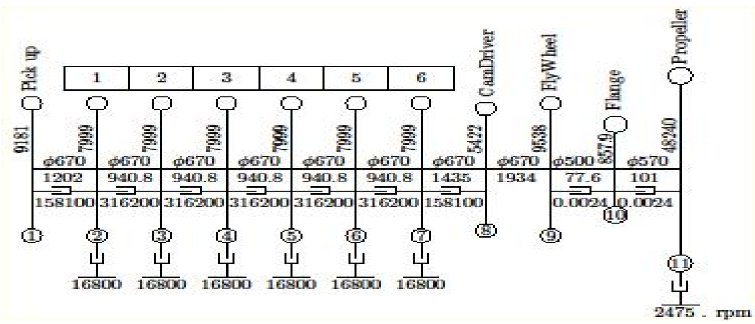


Figure 3 Torsional vibration model of B_170 V, main engine - 6 RTA 62 U

For stable vibrations, torsional angle of *i-th* mass is equal sum of harmonic vibrations:

$$\varphi_i = \sum_1^m (S_{i,k}\sin k\mu t + C_{i,k}\cos k\mu t), \quad (2)$$

and the exciting moments, being cyclic, can be presented by Fourier's series:

$$M_i = \sum_1^m M_{i,k}\sin(k\mu t + \varphi_i) = \sum_1^m (M^s{}_{i,k}\sin k\mu t + M^c{}_{i,k}\cos k\mu t). \quad (3)$$

Replacing (2) and (3) into (1) we will get an equation system for each harmonic order *k*, after equating coefficient of *sin* and *cos* we will get a system of *2×n* algebraic equations as [3]:

$$F_k A_k = M_k, \quad (4)$$

where:

$M_k = [M^s_{1,k}, M^s_{2,k} \dots, M^s_{n,k}, M^c_{1,k}, M^c_{2,k} \dots, M^c_{n,k}]^T$ - column vector of exciting torque amplitudes at harmonic order k;

$A_k = [S_{1,k}, S_{2,k}, \dots, S_{n,k}, C_{1,k}, C_{2,k}, \dots, C_{n,k}]^T$ - column vector of torsion angle amplitudes according to harmonic order k;

$F_k = [f_{i,j}]$ – square matrix $2 \times n$, its elements $f_{i,j}$ are functions of $k\omega$, stiffness of shafts $K_{i,i+1}$, inertial moment I_i and of damping coefficients a_i, $b_{i,i+1}$ [4].

In calculations forced vibrations, the elements $f_{i,j}$ of F_k are determined if damping coefficients are given and torsional vibration amplitudes of masses due to harmonic k are computed by:

$$A_k = F_k^{-1} M_k . \tag{5}$$

Then elastic torsion torque amplitude at order k in shaft between masses *i-th* and *(i+1)_th* is calculated by:

$$E^k_{i,i+1} = K_{i,i+1} \sqrt{(S_{i,k} - S_{i+1,k})^2 + (C_{i,k} - C_{i+1,k})^2} = K_{i,i+1} \Delta^{\cdot\cdot}_{i,i+1} . \tag{6}$$

If supposing we measure the elastic torsional torque in a shaft $E_{i,i+1}$ (see Figure 4), then according to (6) we can determine the amplitude of the relative torsion deformation $\Delta^{\cdot\cdot}_{i,i+1}$ between two masses i and $i+1$:

$$\Delta^{\cdot\cdot}_{i,i+1} = E^k_{i,i+1} / K_{i,i+1} . \tag{7}$$

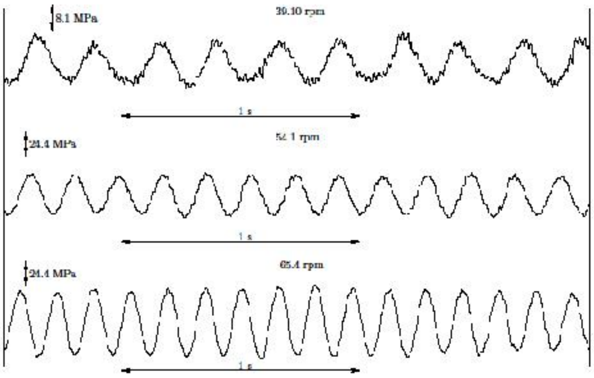


Figure 4 Stress/time at the intermediate shaft at different rotation speeds [2]

On the other side $\Delta^{\cdot\cdot}_{i,i+1}$ can be calculated by equation (5) as following. Having:

$$\left\{ \left[\Phi_{i+1,1\dots 2n} \right] - \left[\Phi_{i,1\dots 2n} \right] \right\} \times M_k = \left(S_{i+1,k} - S_{i,k} \right) . \det(F_k)$$

$$\left\{ \left[\Phi_{n+i+1,1\dots 2n} \right] - \left[\Phi_{n+i,1\dots 2n} \right] \right\} \times M_k = \left(C_{i+1,k} - C_{i,k} \right) . \det(F_k)$$

Therefore:

$$\Delta^{\cdot\cdot\,2}_{i,i+1} \det^2(F_k) = \left\{ \left(\left[\Phi_{i+1,1\dots 2n} \right] - \left[\Phi_{i,1\dots 2n} \right] \right)^2 + \left(\left[\Phi_{i+1,1\dots 2n} \right] - \left[\Phi_{i,1\dots 2n} \right] \right)^2 \right\} . M_k^2 , \tag{8}$$

where: $\left[\Phi_{i+1,1...2n}\right]$; $\left[\Phi_{i,1...2n}\right]$; $\left[\Phi_{n+i+1,1...2n}\right]$; $\left[\Phi_{n+i,1...2n}\right]$ are lines *i, i+1* and *n+i+1, n+i* of matrix $[\Phi]$ with elements determined as: $\Phi_{i,j} = D_{j,i}$ - where $D_{j,i}$ - algebraic complement of the element (*j,i*) of F_k.
$\ddot{\Delta}_{i,i+1}$ can be calculated according to (7) if the elastic deformation torque is measured.

Thus, suppose there are *m* values of damping coefficients a_j and $b_{j,\,j+1}$ are unknown and should be defined. Then equation (8) will contain *m* unknown variables (they are damping coefficients in F_k). In principle, in order to determine the *m* these variables, we should get *m* values of elastic torsional torque in shaft between masses *i, i+1* (see F. 4) in order to make *m* algebraic equations to determine *m* unknown values of a_j and $b_{j,j+1}$. However, the system of equations obtained is the type of multi-hidden variable and high order, so that to be able to solve it, we should make more than *m* equations to obtain a system of linear equations with the new hidden variables, those are combination of productions of unknown as:: $x_i = a_1^{m1}.a_2^{m2}...b_1^{n1}.b_2^{n2}...$

To illustrate, here we consider the ships of series B 170 V. Its torsional vibration model is as shown in F.3 having the following characteristic parameters.

- The number of concentrated masses: n=11;
- The inertial moments of concentrated masses (kgm^2):
  I_i = [9181.0 7999.0 7999.0 7999.0 7999.0 7999.0 7999.0 5422.0 9538.3 857.9 48240.1];
- The stiffness of shafts (MNm/rad)
  K_i=[1201.92 940.82 940.82 940.82 940.82 940.82 1434.93 934.24 77.16 101.04];
- Diameters of shafts (mm):
  D_i =[670 670 670 670 670 670 670 670 500 570];

Designating unknown damping coefficients a_i and $b_{i,i+1}$, with symbles *s, z, f, y, r* and place them into equation (1), we get matrix F_K(22,22) for each value of *kw* (k- harmonic order, w- rotation speed of propeller), having form:

F_k =

[1201920-9.18*kw^2, -1201920, 0,… -kw*r, kw*r,… 0]
[-1201920,2142740-7.99*kw^2, -940820, 0,0,0,0,0,0,0,0, kw*r, -kw*z, kw*s,… 0]
[0, -940820,1881640-7.99*kw^2,-940820, … kw*s,-f*kw, kw*s, …0]
……
[-kw*r, kw*z, -kw*s,.. ,-1201920, 2142740-7.99*kw^2,-940820,… 0]
……………………
[0, 0, ... ,-77160, 178200-0.85*kw^2, -101040]
[0, … 0,.. ,kw*y, ... 0, -101040, 101040-4.82*kw^2]

To determine the determinant det(F_k) and the algebraic complements $D_{i,j}$ can be done with using the Symbolic Math Toolbox package of Matlab software by the command "det(F_k)" if the matrix size is small enough (depending on the number of non-zero elements), the result is a formula in symbolic form on the screen, for example:

ans=
287104808668908863951708990 1.315*kw^{14}*r^3*s^4*z+
221806357247935442301960410 9325.3*kw^{16}*r^2*s^3*z + … +128838153688249620904 18376

Finally, with each value of *kw*, after having computed all the algebraic complements $D_{i,j}$ of elements in the interesting lines, replacing them into equation (8), supposing we get an equation as:

$$C_1 f^{15} r^2 z + ... + C_i z^7 s^4 .... + C_{p-2} s + C_{p-1} y + C_p r = C_0 . \quad (9)$$

There are p constants C_i in the left side of the equation (9), according to k and rotation speed w of the propeller shaft. Here, to determine r, f, z…, we should obtain p values of torsion torque amplitudes according to p value of kw in order to make p equations (9) and a system of p linear equations with p hidden: $x_1=r$, $x_2=f$, $x_3=z$, …, $x_i=f^m r^n \ldots z$,… Resolving this system we would identify the hidden r, f, s…

If the computing is performed correctly and with inputs being the elastic torque values obtained by calculations as described above (assuming the damping coefficients are constant), then the result must match, it means, for example:

if: $x_1=r$, $x_2=f$, $x_3=z$, $x_i=f^m r^n z$,
then: $x_i=x_2^m x_1^n x_3$.

Being sure it correct, take values of elastic torsional torques measured practically to put into (9) to calculate. If $x_i \neq x_2^m x_1^n x_3$, for example, depending on differences we may assess the suitability of the used assumptions about resistances.

However, in the example case, unfortunately we can not directly use the command *det(F_k)*. It would cause errors “Out of Memory” or the text is too long, we would get a report on screens, for example:

ans=
287104808668908863951708990 1.315*kw^14*r^3*s^4*z+……………………………………………… … +.22180635724793544230196041093 25.3*kw^16*r^2*s^3*z + 128838153688249620904183 76... Output truncated. Text exceeds maximum line length of 25.000 characters for Command Window display.

To overcome this problem, we should divide the calculation procedure into some steps:

- Step 1: replace the original terms of the first matrix by new symbols (to get more compact form), for example:

I1=-I1*kw^2+K1; r=kw*r; I2=-Ic*kw^2+K1+Kx; z=kw*z; s=kw*s; I3=-Ic*kw^2+2*Kx; I4=-Ic*kw^2+2*Kx; I5=-Ic*kw^2+K3+Kx; I6=-I3*kw^2+K3+K4=I6; I7=-I4*kw^2+K4+K5; I8=-I5*kw^2+K5+K6; I9= -Ic*kw^2+K6,

to obtain matrix F_k looking as:

```
Fk=
[   I1, -K1,    0,  0,0,0,0,0,0,0,0,-r,  r,0,0,0,0,0,0,0,0,0];
[-K1,    I2,-Kx,  0,0,0,0,0,0,0,0, r,-z, s,0,0,0,0,0,0,0,0];
…………..
[r,-r,0,0,0,0,0,0,0,0,0,I1,-K1,0,0,0,0,0,0,0,0,0];
……………
[0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,-K5,  I8,-K6];
[0,0,0,0,0,0,0,0,0,0,y,0,0,0,0,0,0,0,0,0,   0,-K6,   I9];
```

- Step 2: use the comand “det” for a smaller size, for example: D10=det(F_k(1:10,1:10)). The obtained results looks like that:

```
D10 =
- I3*I4^3*K1^2 - I1*I4^3*Kx^2 + I1*I2*I3*I4^3 + I4^2*K1^2*Kx^2 -
I1*I2*I4^2*Kx^2 + 2*I3*I4*K1^2*Kx^2 + 2*I1*I4*Kx^4 - 2*I1*I2*I3*I4*Kx^2 -
K1^2*Kx^4 + I1*I2*Kx^4
```

- Step 3: transform F_k to F_k^1 by Gause method so that F_k^1(1:10,1:10) be a triangle matrix;

- Step 4: replace elements of $F_k^1(11:22,11:22)$ with an other symbols to get a new matrix of 12×12:

B_k=

```
[  b1_1, b1_2, b1_3, b1_4, b1_5, b1_6, b1_7, b1_8,  b1_9,        0,          0,  b1_12]
[  b2_1, b2_2, b2_3, b2_4, b2_5, b2_6, b2_7, b2_8,  b2_9,        0,          0,      0]
[  b3_1, b3_2, b3_3, b3_4, b3_5, b3_6, b3_7, b3_8,  b3_9,        0,          0,      0]
[  b4_1, b4_2, b4_3, b4_4, b4_5, b4_6, b4_7, b4_8,  b4_9,        0,          0,      0]
[  b5_1, b5_5, b5_3, b5_4, b5_5, b5_6, b5_7, b5_8,  b5_9,        0,          0,      0]
[  b6_1, b6_2, b6_3, b6_4, b6_5, b6_6, b6_7, b6_8,  b6_9,        0,          0,      0]
[  b7_1, b7_2, b7_3, b7_4, b7_5, b7_6, b7_7, b7_8,  b7_9,        0,          0,      0]
[  b8_1, b8_2, b8_3, b8_4, b8_5, b8_6, b8_7, b8_8,  b8_9,        0,          0,      0]
[  b9_1, b9_2, b9_3, b9_4, b9_5, b9_6, b9_7, b9_8,  b9_9,    b9_10,          0,      0]
[     0,    0,    0,    0,    0,    0,    0,    0, b10_9,   b10_10,     b10_11,      0]
[     0,    …     0,    0,    0,    …    ….                 b11_10,     b11_11, b11_12]
[b12_1,     0,    0,    0,    0,   0,   0,   0,    0,       0,          b12_11, b12_12]
```

- Step 5: repeat step 1), for example: $\det(B_k(1:6,1:6))$, and then do the same as in step 2)…

The purpose of this algorithm is to divide the final formula of $\det(F_k)$ into shorter terms so that they can be displayed on the screen.

3. Conclusion

Thus, the above presented algorithms allow determining the damping coefficients if having measured torsion elastic torque amplitudes at any shaft section. Numbers of measurement results should obtain will depend on number of masses.

Now the paper's author has just got the formula for $\det(F_k)$ in a form of string of characters written with syntax errors for Matlab, which is to be corrected and the final results haven't obtained yet because of that it takes long time, but hopping reach it in the near future. Once, when we obtain this formula already in an analytic form, we may use it for other shaftings having the same or less numbers of concentrated masses.

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Session 4

RESEARCH IN MET

Ship Automatic Track keeping At Low Speed

MSc. Thanh-Dat Le[1], Prof. Nam-kyun Im[2], PhD. Van-Luong Tran[3]

1. Vietnam Maritime University, lethanhdat@vimaru.edu.vn
2. Mokpo National Maritime University, namkyun.im@mmu.ac.kr
3. Vietnam Maritime University, tranvanluong@vimaru.edu.vn

Abstract: There are lots of ship's situations when operating from port to port such as with full speed sailing, reducing speed inside traffic scheme, stopping at a certain area and berthing operation with designed heading angle. However, the previous studies on ship automatic track -keeping controllers have not been designed properly as they considered that the ship speed is stable and in constant value. It seems improperly situation in practical maneuverings, especially when the ship entering to ports.

In this paper, the authors focus on studying on the activities of the ship inside traffic scheme until ship is stopped at certain area before berthing. We considered ship operation at low speed and reducing speed situation under disturbance effect. However, in low speed and disturbance's influence, ship's Track-keeping is not easy. Extra auxiliary devices such as tug-boats, ship's bow and side thrusters, etc. are also needed. Without these assistances, other methods should be needed in order to help the ship that called "Boosting effect". "Boosting effect" study will be introduced in this paper and numerical simulations for this effect were carried out to perform the ship auto track-keeping inside traffic scheme at low speed under disturbance influence. The results of simulations showed good performance and this designed control can be adapted in near future.

Keywords: Simulation; Track-keeping; Nonlinear expression; Wind effect; Boosting Effect.

1. Introduction

In the field of maritime safety system, various reports have been given on the research of ship automatic Track-keeping control and ship automatic berthing control over a long time but they are distinct from each other. Until the late 1970s, marine control studies were focused on the design of different autopilots. While the classical proportional-integral-derivative (PID) autopilots perform reasonably well in a specified performance envelope, their overall operational effectiveness is limited; this is due to the fact that classical PID autopilots require manual adjustments to compensate for changes in environment (wind and sea state) and in the dynamics of the ship. With the advent of accurate marine positioning system installed on board, Track-keeping control for ships has been studied extensively during the 1980s.

Hasegawa, K. (1987) introduced an adaptive track keeping subsystem for automatic collision avoidance system using fuzzy control which is described quite similar to human behaviors and easily linkable to an expert system. Kallstrom (1999) suggested PID automatic track keeping algorithm for high speed craft. Hwang, C. (2002) suggested a H∞-autopilots using PID-type controllers for collision avoidance. His autopilots subsystem considered the worst case disturbances. Velagic, J. (2005) developed a standard fuzzy ship autopilot to an adaptive fuzzy autopilot for track keeping. Furthermore, Xue, Y.(2011) also introduced simulation result of PID heading control for automatic collision avoidance for ships navigating in waterway. However, they have considered in common just nearly constant speed, which could not be assured of in berthing circumstance. To be confirmed berthing in advance, a ship is required to reduce its own speed and to stop at a certain area with designed heading angle.

The automatic berthing control of ships has been a relatively new development beginning in earnest in the 1990s. In a marine context, the berthing maneuver is a complicated procedure in which both human experience and intensive control operations are involved. Ship berthing needs for handling multiple input and output parameters with the inclusion of data from environmental disturbances. Due to the slow speed of the berthing ship the controllability of the ship is significantly reduced, whereas the disturbances from wind and current can become relatively large; intensive rudder/propeller adjustments and large lateral movement of the ship can intensify the non-linear aspects of the ship dynamics, making the behavior of the ship rather unpredictable; ship motion at low advance speed is difficult to represent using differential equations, there by negating most control methods which are dependent upon the mathematical model of the dynamics of the ship; the shallow water and bank effects will add further adverse influence upon the ship handling.

Hasegawa, K. and Im, N (2002) introduced comparison method in which wind forces and moment were compared with rudder and thrusters forces and moment respectively when ship maneuvers in port. More recently, Tran, V (2012) used nonlinear mathematical expression and equilibrium equation to calculated critical wind velocity in automatic berthing. These researches was successful as the effects of the wind to ship maneuvering were clearly verified. Although considering low speed situation and disturbances, those previous researches on automatic berthing control have been carried out in very short circumstances with few steps to finish the operation. And even they suggested auxiliary devices, it still did not make a perfectly benefit for whole auto-berthing system for ship from port to port.

Usually, the ship that manned carries out three stages to be berthed at a quay;

- Stage 1, the ship departs from previous port, takes manoeuvring through open sea, then approaches the entrance of port of arrival. She often operates at normal speed or full speed. Previous researches on auto-Track-keeping are in this stage;
- Stage 2, she navigates inside traffic scheme route leading to a certain area with reducing speed. She stops at that area with desired heading angle;
- Stage 3, with the assistant of other devices, the ship takes berthing to the wharf with no difficulties. Previous researches on auto-berthing are only in this stage.

In order to connect the automatic track keeping in with berthing procedure, this research recommended automatic Track-keeping for ship at low speed. That means only 2nd stage which stated above is the environment to carried out this research. It can be understood that Track-keeping operation of ship starts from the first approach of ship in port domain until the ship stops at anchorage area, just before berthing procedure is operated.

Ship's Track-keeping at low speed and reducing speed under disturbance's affection faces difficulties to keep heading angle. This difficulty comes when rudder is not enough effective. We suggest the engine operation "Boosting effect" to be a solution for ship under this situation, without extra auxiliary devices. The clarified definition of "Boosting effect" is showed further in this paper.

2. Ship mathematical model

Ship Motion Equation

There are lots of mathematical models such as MMG, HSVA four quadrant, DEN-Mark 1 and others for ship's maneuvering motion. In case of MMG mathematical model among the above methods it was originally proposed by MMG (Mathematical Models of Maneuvering Motion Group) which was established by the second section of the Japan Towing Tank Committee in March 1976. MMG models divided the hydrodynamic forces and moments acting on a ship in maneuvering motion into the modules such as hull, propeller, rudder and other considerable external hydrodynamic forces and moments.

$$
\begin{aligned}
(m+m_x)\dot{u} - (m+m_y)vr &= X_H + X_P + X_R + X_W \\
(m+m_y)\dot{v} + (m+m_x)ur &= Y_H + Y_P + Y_R + Y_W \\
(I_{zz}+J_{zz})\dot{r} &= N_H + N_R + N_W
\end{aligned}
\tag{1}
$$

The ship's motion equations (1) are applying MMG model for 3-DOF ship dynamic (surge, sway and yaw motion) in coordinate system (Fig. 1). Where, O-$x_0y_0z_0$ is the earth- fixed coordinate and G-xyz is the body-fixed coordinate which is origin at the center of gravity,

In addition, because MMG mathematical model is presented as modular type, a recent researched model for module can be simply considered by changing older model used in the mathematical model, such as additions of the extra disturbance's forces and moments

m : mass of ship
m_x, m_y : added mass in surge and sway direction
u, v, r : surge and sway velocity and yaw rate
J_{zz}, I_{zz} : added mass moment, mass moment of inertia
X_H, Y_H, N_H : hydrodynamic forces acting on ship's hull
X_P, Y_P : hydrodynamic forces acting on ship's propeller
X_R, Y_R, N_R : forces and moment due to rudder
X_W, Y_W, N_W : forces and moment due to wind
$\dot{u}$, $\dot{v}$: acceleration in surge and sway direction
$\dot{r}$: acceleration of yaw motion.
δ : rudder angle
ψ : ship's heading

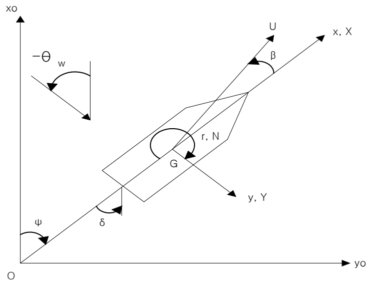

Figure 1 Coordinate system for ship dynamic

Model ship

The Mokpo National Maritime University's training ship SAE NURI was adopted as the model ship. The ship's principle particular is shown in Table 1 as follow;

Table 1 Principle particular of the ship

Type	Training ship
LoA	103[m]
Lpp	94[m]
Breadth	15.6[m]
Draft	5.4[m]
Thruster (Bow)	49000N
Transverse projected area	183.3[m2]
Lateral projected area	1053.7[m2]

Disturbance Model

Isherwood, R.M (1972) has analyzed the results of wind resistance experiments carried out at different laboratories with models covering a wide range of merchant ships. He gives empirical formulas for determining the two horizontal components of wind force and the wind-induced yawing moment on any merchant ship form for a wind from any direction. According to his model, the coefficient of wind effects can be defined as follows;

$$C_X = A_0 + A_1\frac{2A_L}{L_{OA}^2} + A_2\frac{2A_T}{B^2} + A_3\frac{L_{OA}}{B} + A_4\frac{S}{L_{OA}} + A_5\frac{C}{L_{OA}} + A_6M$$

$$C_Y = B_0 + B_1\frac{2A_L}{L_{OA}^2} + B_2\frac{2A_T}{B^2} + B_3\frac{L_{OA}}{B} + B_4\frac{S}{L_{OA}} + B_5\frac{C}{L_{OA}} + B_6\frac{A_{SS}}{A_L} \quad (2)$$

$$C_N = C_0 + C_1\frac{2A_L}{L_{OA}^2} + C_2\frac{2A_T}{B^2} + C_3\frac{L_{OA}}{B} + C_4\frac{S}{L_{OA}} + C_5\frac{C}{L_{OA}}$$

where, C_X : coefficient of fore and aft component of wind force
C_Y : coefficient of lateral component of wind force
C_N : coefficient of wind-induced yawing moment
A_0~A_6, B_0~B_6, C_0~C_5 : Isherwood's coefficient for model

Then, wind force and moment would be calculated by following algorithm with the relative wind speed to ship (V_R);

$$X_W = C_X \frac{1}{2} \rho V_R^2 A_T$$
$$Y_W = C_Y \frac{1}{2} \rho V_R^2 A_L \qquad (3)$$
$$N_W = C_N \frac{1}{2} \rho V_R^2 A_L L_{OA}$$

when, X_W : Fore and aft component of wind force
Y_W : Lateral component of wind force
N_W : Yawing moment
V_R : relative wind speed to ship

There are lots of disturbance models such as current, wave,.. to take into account, but this wind model was applied as the main disturbance model because in the area which simulation has been taken, wind is the most adverse effect to every ship (described in Chapter 3). More works needed to be done in future that considering extra disturbance models.

3. Automatic track-keeping concept

PID control

Nowadays, due to the development of high technology, various navigation aids installed on board such as a gyrocompass, AIS, GPS, Doppler log…can provide an accurate measurement of the ship state (heading, position, speed and yaw rate). As in the case of Sperry's work (1922), PID controller designs were predicated on visual observation of the way experienced helmsman would steer the ship. He acknowledged that helmsman would anticipate ship motions before applying rudder corrections but more importantly he postulated that they possessed the ability to judge angular velocity, yaw rate, there by effecting derivative control.

In this simulation-based research, a PID controller is designed under assumption that the ship state can be taken on board that ship. When K_p, K_d and K_i are proportional gain, derivative gain and integral gain, respectively. Eq. 4 shows the input and output data δ are designed rudder angle for each loop, and e is error between target heading ψ_T and current heading angle ψ_P.

$$\delta = K_p.e(t) + K_d \frac{de(t)}{dt} + K_i \int_0^t e(\tau)d\tau \qquad (4)$$
$$e = (\psi_T - \psi_P)$$

Ship's Track Design

Previous researches related to ship's automatic Track-keeping control system have been considered at ship's high-speed (above 10 knots) and their scopes of application are not inside the port's domain. In spites of the fact that previous researches related to ship's automatic berthing control have been considered at ship's low speed, their scope of application are too small inside port domain, also in very short time. These above disadvantages are not solved, then they cannot cooperate which each other to adapt with whole ship's automatic berthing system.

This simulation based research using a traffic scheme in South Korea as the environent to operate Track-keeping. Ship's track was joined by 10 waypoints and the ship must keep-track on and stop by anchorage point as waypoint No. 10 (Fig. 2);

Figure 2 Designed Track for Simulation

Fig. 2 shows the traffic scheme in Mokpo-si, Jeollanam-do, South Korea, in front of Mokpo National Maritime University's quay. This area is the place that was taken as the environment in simulation. The breadth of traffic scheme at the most narrow segment is about 7 times of ship's length.

By using PID control for track keeping, the designed rudder angle is calculated by $\delta = K_p e(t) + K_i \int_0^t e(\tau)d\tau + K_d \frac{de(t)}{dt}$ (with K_p=-1, K_i=-0.015 and K_d=-0.8 are gains for P, I, and D control respectively). Wind with direction from North to South and its varied strength from 0 knots, was chosen to apply to the disturbance model.

Track-keeping Algorithm

The ship moves on a segment between way-point P_i and P_{i+1} . The Fig. 3 shows current ship's position described by (x_t, y_t) and is calculated from inside ship's motion equations at time t of the loop system. The current way-point's position is (x_d, y_d). After that, the ship's bearing to current way-point (B_d) can be obtained as in Eq. 5. Then the ship's target heading (ψ_d) will be decided for proper quadrant of (B_d). At the end of simulation, if the ship reaches the anchorage place, she should head toward the berthing quay.

$$B_d = \text{arctg}\,\frac{y_d - y(t)}{x_d - x(t)} \tag{5}$$

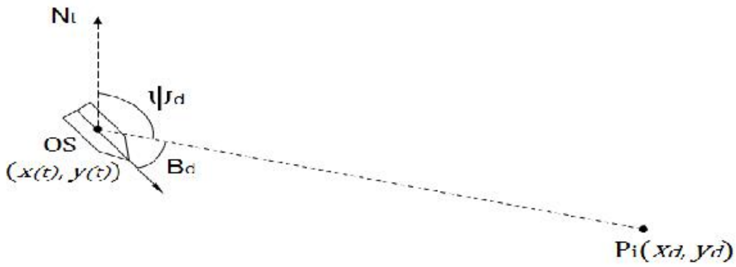

Figure 3 Ship's target heading to way-point

When the ship reached a certain remain distance (d_0) to current waypoint (P_i), she will change her heading toward the next waypoint (P_{i+1}). That means, when $d \le d_0$ ship's direction changes from $\overrightarrow{P_{i-1}P_i}$ to $\overrightarrow{P_iP_{i+1}}$.

As to confirm that this research suggested Track-keeping control for ship's berthing, ship's speed at the starting point of simulation is equal to 10 knots, propeller index is 2.75 round per second. After the ship reaches way-points one by one, the propeller's revolution will be reduced for safe approaching to berthing place (eg. If current waypoint is waypoint P_i then rpm $n_k = n_{k-1} - 0.25$).

From waypoint No.1 to waypoint No. 4, the ship's speed will be about 10 knots as same as the beginning of simulation. From way-point No.5 to waypoint No. 8 the ship's speed will be reduced to about 2 knots as real Track-keeping of T/S SAE NURI conducted by human. Then ship's speed will be continuously reduced its own speed until approximately 0 knots for safe approaching to anchorage place at waypoint No. 10. In case of the speed is too high even the engine stopped (i.e. n=0) and the ship has a risk of passing out the anchorage point, the astern thruster force should be made to reduce that inertial motion.

Hence, if ship's berthing procedure is to conduct, it will be carried out by automatic berthing controller or by assistant of tug boats, etc. as usual.

Boosting Effect method

The environment to carry out this reseach can be explained by following figure;

- At stage 1, ships in open sea usually use full speed or normal speed to manoeuvre.
- At stage 2, ships in port domain usually reduce their speed for safely manoeuvring. They have to stop at a certain area with desired heading angle.
- At stage 3, ships take berthing to wharf with the assistants of tug-boats, side-thrusters, port mooring equipments…

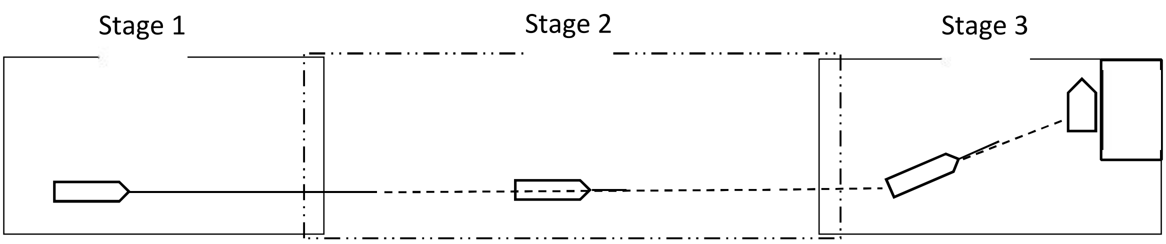

Figure 4 Operation of ship until berthing

Previous researches have been carried out in stage 1 or stage 3. That is the reason we suggested the stage 2 to be our environment of research to adapt with auto-berthing system for ship from port to port. Usually, keeping heading angle at low speed is difficult. Previous researches related to ship's auto-berthing suggested tugboats, side-thrusters, … in this situation for short moment. Meanwhile, previous researches that related to ship's auto-track keeping have not been mentioned this situation. Ship movement in low speed also occurred difficult to keep her own heading angle. In that case, rudder is not as effective as in high speed situation. It can be explained that at low speed situation, ship's turn rate is not change even its rudder reached the limit effective angle (i.e. 35º-40º both sides).

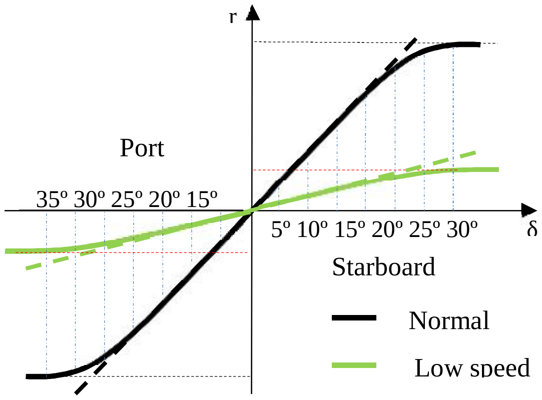

Figure 5 Diagram of turning characteristic is used to correct rudder's effect

The diagram in Fig. 5 shows how ship's turning characteristic depends on ship's speed. As normal as ship's high speed, ship's turn rate increases as fast as rudder angle increases for each side of turn. But at low speed, ship's turn rate is not effective as slow changing of turn rate or even unchanging. Due to the effect of disturbances, this problem will lead the ship off the designed track as soon as possible. According to Fig. 5, ship's turn-rate at normal speed (above 10 knots) changes to high value as fast as rudder angle is increased. While at low speed, it changes slowly and only can reach low value. That shows rudder effect is small at low speed.

To solve these problems, "boosting effect" was suggested as the advance solutions. "Boosting effect" has been used often in ship's berthing procedure. The ship's engine was ordered to "boost" for short time by the Pilot or ship's Captain to aid the turning when ship's speed is too low. "Boosting effect" has a character as a pulse signal, when applied, it won't increase ship's speed as much as normal speed but also increase ship's turn rate. Therefore, "boosting effect" is applied when ship's turn rate (yaw rate - r) has not changed big enough to aid the ship's turning while maximum effective rudder angle was also used for such moment. When this happened, ship's thruster is being boosted until yaw rate reaches a value for good enough ship's turning.

The diagram below describes how the system responses for each time of facing this problem;

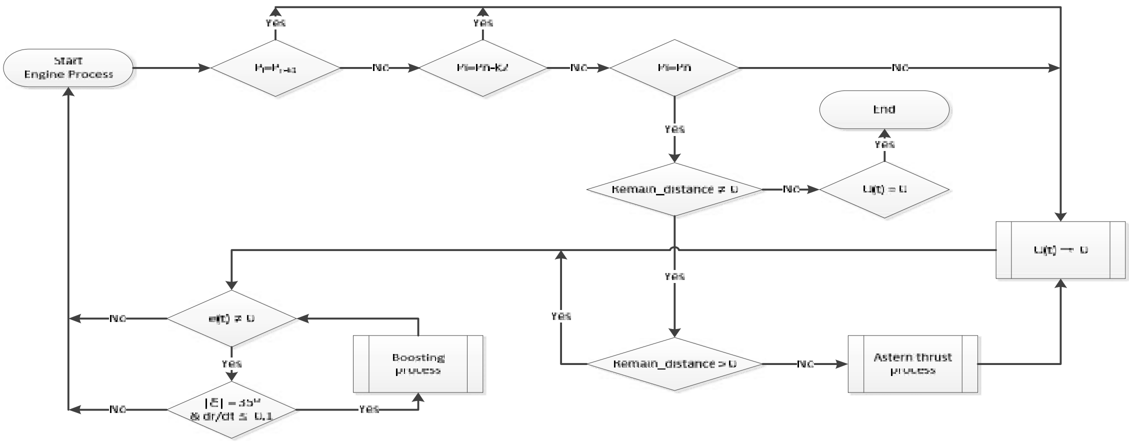

Figure 6 Block diagram of heading angle control

The diagram in Fig. 8 shows exact process of using engine for heading control. Speed of ship is reduced base on current waypoint P_i, some waypoints P_{n-k1}, $P_{n-k2,..}$ are marks for ship to keep her rpm at certain values. Engine is boosted only when the ship has problem on keeping heading angle, even the rudder reaches maximum effective angle 35º. Otherwise, astern force is used only to remove forward inertial force in order to stop the ship at certain area safely.
The engine control is stopped when ship stay near stopping point with no speed. The desired heading angle will continuously be kept until the stop of ship.

4. Simulation results

For a start of simulation, when no wind model was applied, the ship's trajectory under no wind's influence left small off-track errors. The ship kept close to the track inside traffic scheme and stayed firm in way-point No. 10 anchorage point. This would prove that without disturbance, this control is reliable for Track-keeping inside port domain with reduced speed. With the increased wind speed's affection from 0 to 5 knots, more errors have been seen in Fig. 7 below.

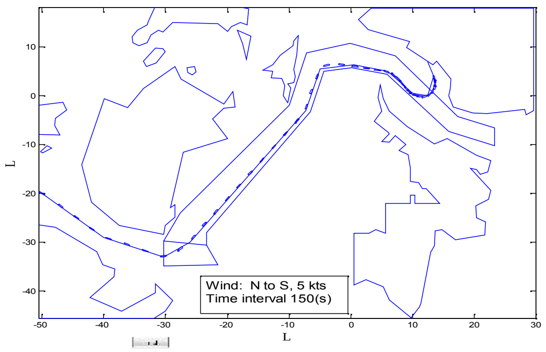

Figure 7 Ship's trajectory with the assistant of "Boosting effect" under the affection of wind (from N to S, 5 kts)

More errors have been found when the ship at the very end of keeping track from way-point No. 9 to No. 10 when ship's speed was very low under 1.2 knots. However, the ship could keep stable as former situation. The ship reached the final point, kept staying at last waypoint. For outcome history data, the control seems to be reliable when keeping ship's track under small disturbance's influence.

When wind's speed was 10 knots high, it seems that the control finally completed the Track-keeping procedure with great effort. Fig. 8 shows the ship's Track-keeping trajectory with the assistant of "Boosting effect". In this circumstance, the last schedule of Track-keeping this trajectory is the most error trajectory among the last shown 3 results, under the wind's conditions of 0 kts upped to 10 kts. The ship drifted out of track from way-point No.6 to No.10.

In fact that this problem lead us to reconsider to improve the effort of the control. However, we should pay attention to the disturbance's affection to review this controller's effort. Wind speed in this circumstance was about 10 knots high meanwhile the ship's speed was very low at the end of the operation as about 1.0 knots when she had just passed waypoint No.9 and even equal to 0 knots when she reached way-point No. 10.

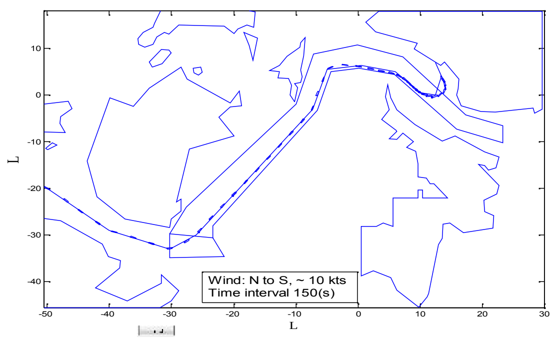

Figure 8 Ship's trajectory with the assistant of "Boosting effect" under the affection of wind (from N to S, 10 knots)

Fig. 9 shows how the ship's Track-keeping without the assistant of "Boosting effect" under the same characteristic with the last condition shown above;

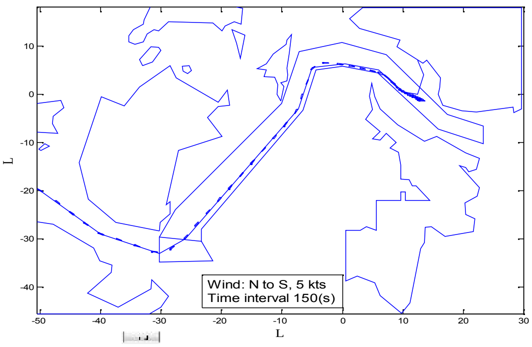

Figure 9 Ship's trajectory without the assistant of "Boosting effect" under the affection of wind (from N to S, 10 knots)

According to Fig. 9, ship's Track-keeping under wind effect without using "Boosting effect" left so many errors. The ship did not only drift out of designed track from waypoint No. 6 to waypoint No. 8 but also could not reach the anchorage point.

To find out more details of the assistant of "Boosting effect", the comparison between the controllers of each situation with or without "Boosting effect" under wind's influence has been made by following figures;

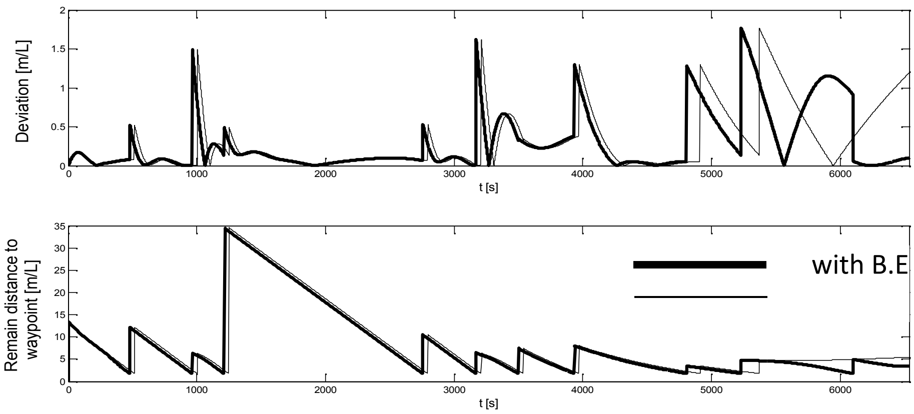

Figure 10 Comparison between controllers with "B.E" and without B.E" by time history of parameters: Deviation, Remain distance to waypoint

Time history parameter "Remain distance to waypoint" in Fig. 10 shows how the ship passed each way-point. It was shown as the distance to previous way-point had been reduced to minimum value and distance to current way-point has been raised up to maximum value. The last distance should be the distance from the ship to the wharf. In this case, the controller without "Boosting effect" did not move the ship to way-point No.9, even drifted far off the track. Whilst the controller with "Boosting effect" has done it also brought the ship to way-point No.10.

While time history of parameter "Deviation" shows how the ship kept close to the designed track. The maximum deviation off-track of the ship using controller with "Boosting effect" is *160* meters, about 1.7 ship's length, according to the segment between waypoint No. 9 and waypoint No. 10. This deviation value was accepted because of this segment was inside anchorage place, and there are no obstacles of water level or passing ships. The others deviation value was also accepted because the traffic scheme's breadth was 6 to 7 times of ship's length and the ship's motion was inside the half safe of traffic scheme's route. The thicker line stands for engine process with "Boosting effect", the rest stands for engine process without "Boosting effect".

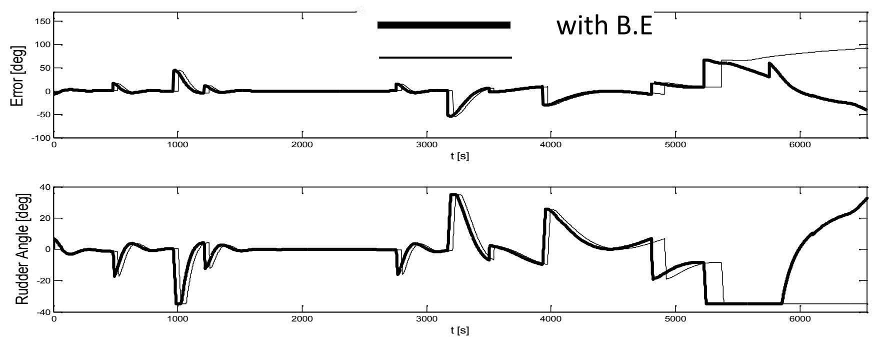

Figure 11 Comparison between controllers with "B.E" and without B.E" by time history of parameters: Error, Used Rudder Angle

According to Fig. 11, the controllers with "Boosting effect" totally helped the ship to reduce the heading error. At the end of simulation, controllers with "Boosting effect" was turned to port because of strong wind effect. This could be acceptable because the ship would conduct berthing procedure after finish Track-keeping. The controllers' simulation result was accepted in using rudder angle. Rudder angle was used without breaking the limitation (|δ| ≤ 35º).

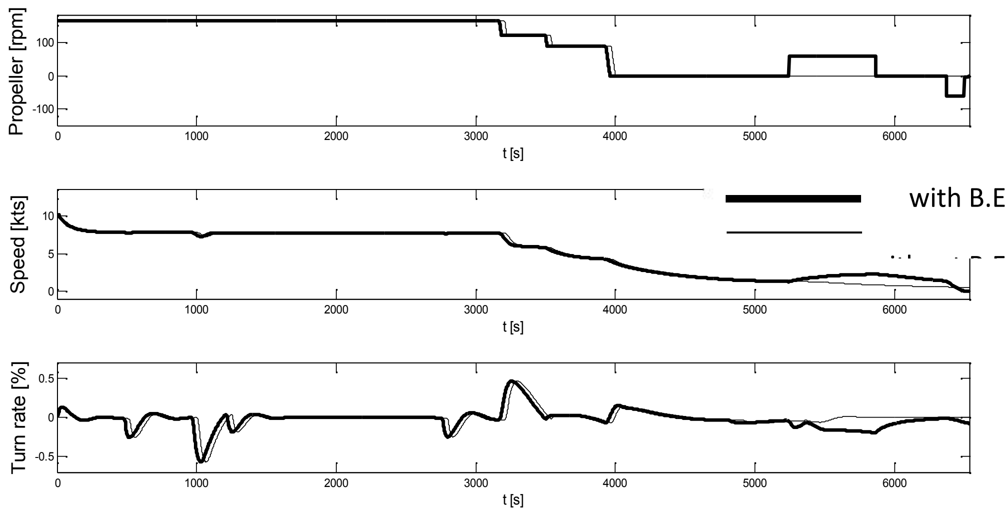

Figure 12 Comparison between controllers with "B.E" and without B.E" by time history of parameters: Change of turn rate, Propeller index and ship's speed

Fig. 12 shows how ship's engine control the ship's speed. Because of no "Boosting effect" was used, propeller history (*rpm*) of the controller without "Boosting effect" was reduced step-by-step to reduce ship's speed. At the end of simulation, ship's speed is equal to 0.5 knots that could not help the ship to return its track.

Otherwise, controller with "Boosting effect" using propeller index for both increasing and decreasing ship's speed. The speed was increased a little bit by "Boosting" of ship's engine when ship's turn rate was not being changed big enough. At that time, propeller index was increased up. When the ship's speed was too high to slow down, propeller was also used to astern thrust the ship. At the end of simulation, ship's speed was equal to 0.005 knots. This is safe enough as the ship stopped near the last waypoint. The criteria was met.

5. Conclusion

After reviewing the simulation results, this study proved that:

- The ship can use this controller for specific purpose of automatic Track-keeping at the specified moment as when finished ocean navigating and before berthing to a quay; in the specified place as Track-keeping insides traffic scheme that is leading to the wharf; and with difficulties are low speed, reducing speed and disturbance effect.
- Heading angle at low speed was controlled with the assistant of "Boosting effect" which is unfamiliar with other previous researches. "Boosting effect" was proved as a vital characteristic of this controller to aid the ship at low speed, under the strong wind and without any help of extra auxiliary devices.

Acknowledgement

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Advanced Navigation System (ANS) in the Mediterranean Sea "Regional Project for Management Control System"

Captain: Mohamed Abdel Fattah Omar [1]
Captain: Zouheir Abdel Fattah Badawy [2]

1. *Marine lecturers in maritime college, Arab Academy for Science, Technology and Maritime Transport (AASTMT), Email:* c_m_omar@yahoo.com
2. *Marine lecturers in maritime college, Arab Academy for Science, Technology and Maritime Transport (AASTMT), Email:* zouheirbadawy2014@gmail.com

Abstract- Mediterranean Sea is a major oil and gas transportation route accommodating a large number of ships crossing the sea annually; it is an area in which the oil and gas industry is highly active with several important producers located in the region. Despite increased environmental awareness and international conventions on pollution, marine pollution continues to be an environmental issue; the oil well explosion was a tragic accident that preventable with different systems and procedures in place. Going forward, the safety of workers and the environment must be of paramount importance, and a guiding principal for all in the regulation, exploration, and production of oil and gas. New systems and procedures must now be described, implemented and regulated, however, in a way that is reliable and transparent. This will allow the nation's offshore oil and natural gas industry to return to work in a way that will preserve thousands of critical jobs, in a region just beginning to recover from unprecedented hardship.

Advancements in information technology have significant impacts on the shipping industry. Many of the modern navigational technologies and data are amenable to computerization. A key hydrographic survey within the Traffic Separation Scheme (TSS) of the Straits of Malacca and Singapore, as part of the Marine Electronic Highway (MEH) Demonstration Project, a regional project of the Global Environment Facility (GEF)/World Bank, which International Maritime Organization (IMO) is executing. The demonstration project aims to link shore-based marine information and communication infrastructure with the corresponding navigational and communication facilities aboard transiting ships, while being also capable of incorporating marine environmental management systems. The deployment of information systems in more mature applications such as in a Marine Electronic Highway could lead to the integration of maritime safety technologies with marine environment management and protection systems resulting in improved performance, new capabilities and innovative applications. MEH provides a host of potential opportunities and benefits not only for the shipping industry, but also to a variety of users. Its application may be extended to environmental management programs, search-and-rescue operations, anti-piracy program, environmental impact assessment, and fisheries/aquaculture management, among others. The use of such experience to execute a similar project as Malacca Strait MEH in the Mediterranean Sea can be considered an important need for such strategic place.

Key words: Marine Electronic Highway -The Traffic Separation Scheme – The oil industry – The Geographic Information System – The Space borne Synthetic Aperture Radar.

1. Introduction

The Mediterranean region has so far been a relatively small producer of offshore oil and gas as compared to the world production. In 2011, total offshore oil and gas production in the Mediterranean region was estimated at 87 million toe (Tone of Oil Equivalent) with 19 million toe crude oil, 68 million toe natural gas. However, Mediterranean oil reserves represent 9,400 million toe, equivalent to 4.6% of world oil reserves. Offshore structures and waste streams can affect marine species and the entire food web through intrusive noise and the possible introduction of non-indigenous species. Explosions and drilling can also cause seafloor and geological disturbances. This impact increases as offshore exploration activities go deeper, a trend that is observed worldwide and in the Mediterranean Sea. (WWF, 2015)

Overall vessel activity within the Mediterranean has been rising steadily over the past 10 years and is projected to increase by a further 18 per cent over the next 10 years. Transits through the Mediterranean are expected to rise by 23 per cent. Increases in vessel activity will be coupled with the deployment of ever larger vessels. The development of new pipelines by passing the Bosporus and the expansion of current pipeline capacity is likely to result in a significant increase in the density of tanker deployment in the eastern Mediterranean The Mediterranean is both a major load and discharge centre for crude oil. Approximately 18 per cent of global seaborne crude oil shipments take place within or through the Mediterranean. North African ports in Libya, Algeria, Tunisia and Persian Gulf oil shipped via Egypt account for over 90 per cent of all crude oil loaded in the Mediterranean. Italy accounts for nearly half of all crude oil discharged in the Mediterranean. Exports of crude oil from Black Sea ports averaging at over 100 million tons a year are expected to continue to rise, resulting in continued seaborne transits via the Bosporus and increased use of eastern Mediterranean ports linked to new pipelines intended to bypass the Bosporus. (SAFEMED, 2008)

The Mediterranean Sea is a high risk of marine pollution, and came up with possible ways of which the marine pollution can be prevented with measures in place to check and minimize the occurrence of the spill in this special area. The most important challenge of IMO nowadays is to develop a framework which accommodates and builds on existing systems already furthering the concept of Navigation system by integration and display of maritime information onboard and ashore by electronic means to enhance berth-to-berth navigation and related services, safety and security at sea and protection of the marine environment. The most important projects in focused and related with the Navigation system are World Bank-funded Marine Electronic Highway (MEH) project in the Malacca Straits. During the last years the possibilities and value of satellite based detection of oil spills could be impressively demonstrated, as well as in operational near real time processing and transmission of the satellite based results to the users on board vessels. (Bak, 2013) Pollution can be caused by a collision or by accidental or deliberate dumping. Pollution from vessels is often not discovered until it is found on the coastline many hours after the vessel has departed the area. This provides a problem for Law Enforcement and so it is clear that if pollution incidents are to be handled effectively the important criteria are early detection and the ability to contain the pollutant before it spreads uncontrollably. In addition, if early detection can be implemented then it may be possible to identify and arrest the polluter before he leaves the area. Safety of Navigation and efficiency of Vessel traffic services (VTS) are essential to minimize the risk of collisions that could pollute the marine environment. (VTMIS, 2016)

2. The development of Vessel Traffic Services

Traditionally, the master of a ship has been responsible for a ship's course and speed, assisted by a pilot where necessary. Ships approaching a port would announce their arrival using flag signals. With the development of radio in the late 19th century, radio contact became more important. But the development of radar during World War Two made it possible to accurately monitor and track shipping traffic. The world's first harbor surveillance radar was inaugurated in Liverpool, England, in July 1948 and in March 1950; a radar surveillance system was established at Long Beach, California - the first such system in the United States. The ability of the coastal authority to keep track of shipping traffic by radar, combined with the facility to transmit messages concerning navigation to those ships by radio, therefore constituted the first formal VTS systems. The value of VTS in navigation safety was first recognized by IMO in resolution A.158 (ES.IV) Recommendation on Port Advisory Systems adopted in 1968, but as technology advanced and the equipment to track and monitor shipping traffic became more sophisticated, it was clear guidelines were needed on standardizing procedures in setting up VTS. In particular, it became apparent that there was a need to clarify when a VTS might be established and to allay fears in some quarters that a VTS might impinge on the ship's master's responsibility for navigating the vessel. As a result, in 1985, IMO adopted resolution A.578 (14) Guidelines for Vessel Traffic Services, which said that VTS was particularly appropriate in the approaches and access channels of a port and in areas having high traffic density, movements of noxious or dangerous cargoes, navigational difficulties, narrow channels, or environmental sensitivity. The Guidelines also made clear that decisions concerning effective navigation and maneuvering of the vessel remained with the ship's

master. The Guidelines also highlighted the importance of pilotage in a VTS and reporting procedures for ships passing through an area where a VTS operates. (IMO, 2016a)
Vessels Traffic Management Systems (VTMS) are making valuable contribution to safer navigation, more efficient traffic flow, and protection of the environment. Incidents and emergency situations can be dealt with quickly. The VTMS traffic image is compiled and collected by means of advanced sensors such as radar, Direction Finding (DF), Closed-Circuit Television (CCTV), Automatic Identification System (AIS) and Very High Frequency radio (VHF) or other co-operative systems and services. A modern VTMS integrates all of the information into a single operator working environment for ease of use and in order to allow for effective traffic organization and communication. The Mini-VTS-Systems as shown in figure 1 or complex VTMS with several radars, integration with VHF, AIS, GNSS, CCTV, DF, Operator Positions, and Power Supplies etc. For the smaller harbors the Mini-VTS should be more than sufficient, with options for add-ons if any rise in demand occurs. For large ports covering larger areas with several operators and integration with other ports or Authorities, a more complex system is recommended. The VTS also has many impacts especially in the Mediterranean Sea due to many challenges in this area. (ARLO, 2016)

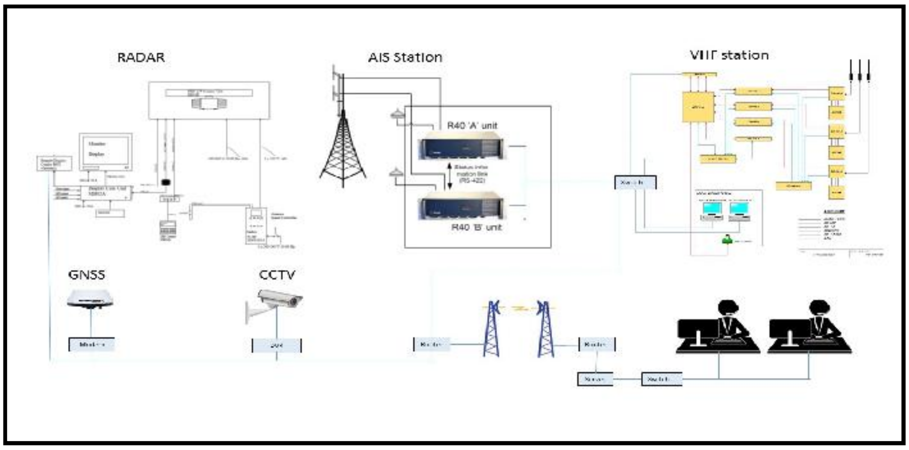

Figure 1 The Mini-VTS-Systems
Source: (ARLO, 2016)

3. Environmental Challenges in the Mediterranean Sea

The Mediterranean Sea is one of the most important areas in the world in terms of maritime transport; it is the world's largest inland sea covering an area of 2,499,350 sq km. The Mediterranean Sea also is a body of water that is almost completely surrounded by land. It lies between three continents: Europe to the north, Asia to the east and Africa to the south. It stretches over 2,500 miles (4000 km) from Gibraltar to Israel. It is connected to the Atlantic through a 14 km wide strait, where Europe and Africa meet. The Suez Canal links it to the Red Sea and the Bosporus to the Black Sea. The environmental challenges in this area depend on the shipping and trades there. (Worldatlas, 2016)

3.1 Shipping in Mediterranean Sea

The Mediterranean Sea is one of the crowded area in terms of shipping activities as shows in figure 2, with about 30% of international marine trade taking place among the ports of Mediterranean and nearby seas. Every year nearly 20.000 tons of petroleum leaks to Mediterranean from the surrounded 60 oil refining plants as a result of consciously or unconsciously accidents.

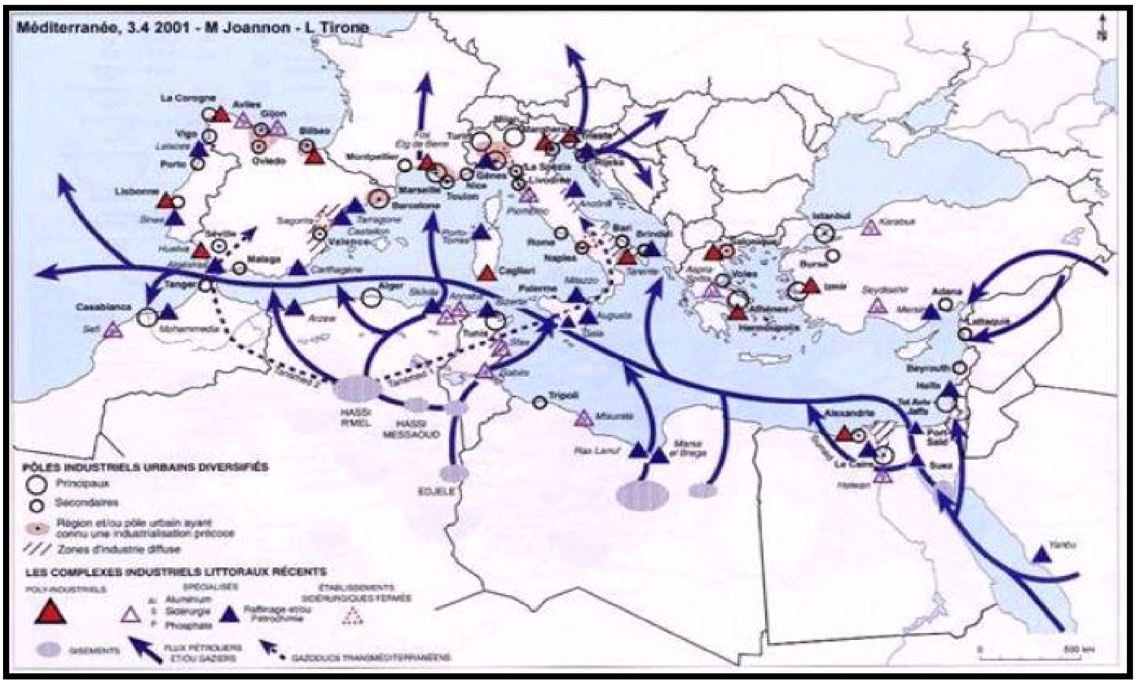

Figure 2 Shipping Routes in the Mediterranean Sea
Source: (IRIT, 2005)

In the last few years there has been growing acknowledgement that the seas which surround Europe offer significant opportunities for - and potential risks to - territorial development. The sea provides resources on and in its waters and on and under the sea bed that can be harnessed as the basis for territorial development; it enables the flow of goods, services and people, connecting different parts of Europe to each other and the wider global community; and it provides an important environmental asset that needs careful management not least because the health of the sea is critical to efforts to combat climate change. However, different stakeholders have different priorities in terms of what uses and priorities should be privileged in different parts of the maritime environment and few have an overview of the range of issues that require consideration in making such judgments in an informed way. (Sciencedirect, 2016)

3.2 Crude Oil and Gas Trades within the Mediterranean

Crude oil and Liquefied Natural Gas (LNG) trades are concentrated around a relatively small population of load and discharge ports and routes in the western and central of Mediterranean Sea. Crude oil shipment from Novorossiysk (Russia) to the Mediterranean destination and from Sidikerir to both Mediterranean destination and ports west of Gibraltar as well as exports from the Persian Gulf through the Mediterranean via Suez dominated the major traffic lanes. (Unepmap, 2008) The largest vessels observed operating in the Mediterranean are crude oil tankers**.** Crude oil tankers calling at Mediterranean ports average 125,000 DWT - an increase in size of 26 per cent over the past 10 years. During the same period the number of crude oil tanker port calls within the Mediterranean has increased by 41 per cent**.** Conversely, average crude oil tanker sizes for vessels transiting the Mediterranean have fallen by 31% to 160,000 DWT whilst the level of transit activity has risen significantly by 147%. The Mediterranean is both a major load and discharge center for crude oil. Approximately 18% of global seaborne crude oil shipments take place within or through the Mediterranean. North Africa port in Libya, Algeria, Tunisia, and Persian Gulf oil shipped via Egypt account for over 90% of all crude oil loaded in the Mediterranean. Italy accounts for nearly half of all crude oil discharged in the Mediterranean. Exports of crude oil from black sea ports averaging at over 100 million tons a year are expected to continue to rise, resulting in continuous seaborne transits via the Bosporus and increased use of eastern Mediterranean ports linked to new pipeline intended to bypass the Bosporus. The resumption of Iraq; crude supplies via Ceyhan in turkey and via Pipeline development will increase oil exports from eastern Mediterranean sea load terminals, but if black sea exports continues to increase, this may not result in a significant fall in oil exported through the Bosporus. (Statoil, 2013) Around 80 per cent of Mediterranean ports are located in the west and central Mediterranean region. The majority of Crude Oil consumed by Mediterranean countries transported by pipeline. Spain is currently an exception in transporting a large portion of its Crude Oil supplies by ship to its six terminals (3 of which are in the Mediterranean). Several Mediterranean countries have plans underway to develop Crude Oil terminals in order to lessen dependence on a small set of supplier counties. (Ports, 2014) Due to all this information should establish a demonstration project same the MEH system in the Straits of Malacca and Singapore.

4. Marine Electronic Highway (MEH) Demonstration Project

The International Maritime Organization (IMO) implemented the Marine Electronic Highway (MEH) Demonstration Project in the Straits of Malacca and Singapore (SOMS) following the signing, on 19th of June 2005, agreement between the Global Environment Facility (GEF)/World Bank and IMO. This project was developed by a separate grant from GEF/World Bank to IMO with the participation of the three littoral States and shipping associations. The MEH Demonstration Project was a collaborative agreement between IMO and the littoral States of Indonesia, Malaysia and Singapore and in partnership with the Republic of Korea, International Hydrographic Commission, the International Chamber of Shipping and the International Association of Independent Tanker Owners. The regional demonstration project aimed to link shore-based marine information and communication infrastructure with the corresponding navigational and communication facilities aboard transiting ships, while being also capable of incorporating marine environmental management systems. The overall objectives were to enhance maritime services, improve navigational safety and security and promote marine environment protection and the sustainable development and use of the coastal and marine resources of the Straits' littoral States, Indonesia, Malaysia and Singapore (Sekimizu, 2006).

The MEH system with its environmental modules can be used in marine pollution response and control such as to predict the direction and speed of oil spill and aid in response and clean-up. It is also possible to use it to identify and track ships that illegally discharge their bilges or dump other oily wastes. The Marine Electronic Highway (MEH) is envisioned to be a regional network of marine information technologies linked through the ENCs-ECDIS. The availability of differential global positioning system (DGPS) with accuracy of 1 to 5 meters enhances the navigational accuracy of ENCs-ECDIS especially in congested and confined waters. Recent enhancements in maritime safety infrastructure and regulatory mechanisms have improved navigational safety and traffic flow. Singapore has an efficient radar-based ship position monitoring system covering the Singapore Strait. In 1998, the three littoral states of Republic of Indonesia, Malaysia, and Republic of Singapore jointly commissioned a mandatory ship reporting system (STRAITREP) for the most congested 300 kilometer section of the Straits from One Fathom Bank to the Singapore Strait, which combines radar and automatic ship identification and tracking. However, the threat of collisions and groundings and of consequent environmental damage is still significant and, with rapid traffic growth, is increasing. (IMO, 2016b)

5. Development of technologies to detect oil spill

In dealing with oil spill, a number of technologies have been developed to detect and deal with oil spill. Some of the technologies developed include; Geographic Information System (GIS), Satellite-Mounted Synthetic-Aperture Radar (SAR), Ground Penetrating Radar (GPR) and Remote Sensing Technology (RST). The Geographic Information System (GIS) is proven to be an excellent management tool for resource assessment, oil spill response, and planning damage assessment. GIS approach to a problem of oil spill mapping includes integration of the geographical, remote sensing, oil &gas production/infrastructure data and slick signatures, detected by SAR, in GIS as shows in figure 3. Compiled from data of several sources including nautical maps, geo-databases, ground truth and remote sensing data, GIS allows retrieval of key information, i.e. predict spill locations, reveal offshore/onshore sources, and estimate intensity of oil pollution. SAR and GIS technologies can significantly improve identification or even classification of oil spills allowing making the final product - oil spill distribution maps.

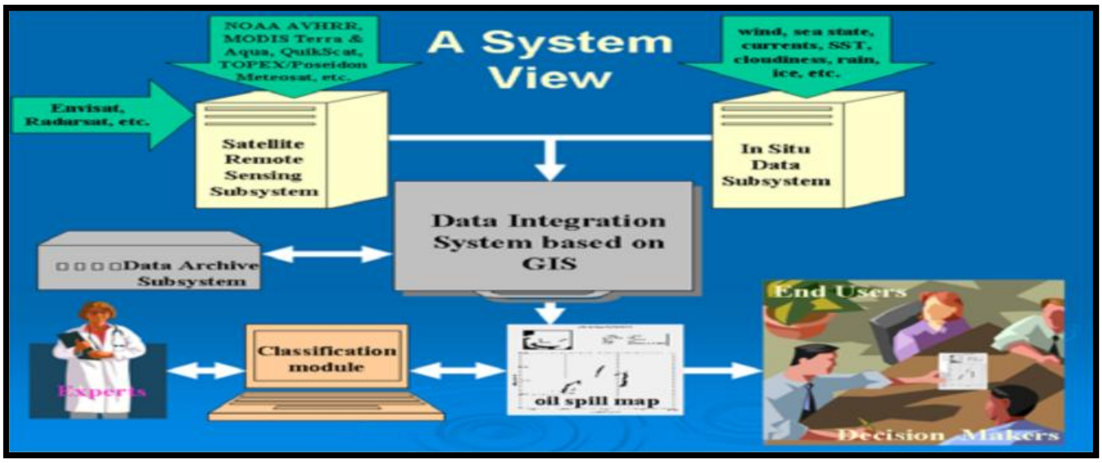

Figure 3 A view of oil spill monitoring system based on GIS
Source: (Scanex, 2009)

GIS became widely used for spill planning and response because they support integration and preparation of geospatial information on the location, nature and sensitivities of different resources with rapid access. Developments in geospatial and remote sensing technologies have also assisted improvements in GIS systems for oil spill management. Recent examples include the use of real-time multisensory satellite information, development of internet-based GIS systems, which better support sharing of GIS information among users and the public, and oil spill drift models. GIS is especially useful in oil spill sensitivity mapping, planning and response because these systems allow the integration of information from many different sources and allow the displaying this information. (Scanex, 2009) The Space borne Synthetic Aperture Radar (SAR) is the primary method for oil-spill detection involves satellite-mounted synthetic-aperture radar. This technology, which can see through clouds and in the dark, involves bouncing radio waves from orbiting satellites off the surface of the sea. (Businessinsider, 2012)

This component provides for the production of the navigational information on which the MEH system will be based. The activities comprise: first the navigational and hydrographical activities Install and operate tidal and current equipment on the Republic of Indonesia’s coast of the Strait of Malacca, including provision of relevant maritime navigational facilities, second the hydrographic survey which carry out of multi-beam hydrographic survey within the Traffic Separation Scheme of the strait Malacca and Singapore, third the Electronic Navigation Charts (ENC) which Production of high resolution ENC for the Project Area, including provision of ENC software licenses to the Republic of Indonesia and Malaysia, fourth and finally the information exchange system which establishment of a MEH information exchange system, including data servers, data exchange protocols and training of staff in data exchange, which part of the MEH Data Centers. (MEH, 2005)

6. Proposed (ANS) project for the Mediterranean Sea

The Mediterranean Sea plays a historical role in the maritime trade; it continue to be a vital area for international shipping today and considered to be world’s sensitive shipping lanes, primarily due to its proximity to the oil and gas field in the area. Most of the ships that use the Mediterranean Sea for transportation purposes are large tankers, whose travels often conclude in Asia, Africa or Europe.

The new system (ANS) based built upon a network of electronic navigational charts using electronic chart display and information systems (ECDIS) and environmental management tools as shows in figure 4, which use main station nearby Sicily island and another seven substations distributed upon some countries in the Mediterranean Sea by integrated system between all of them, all combining in an integrated platform covering the region that allows the maximum of information to be made available both to ships and shipmasters as well as to shore-based users, such as vessel traffic services. The overall system –which would also include positioning systems, real-time navigational information like tidal and current data, as well as providing meteorological and oceanographic information –is designed to assist in the overall traffic management and provide the basis for sound marine environmental protection and management. Characteristics of marine traffic are becoming intense, with faster and bigger ships of all categories. The potential for accidents with dangerous cargos involving chemical or oil pollution has been stated and underlined many times during the past decades, so need to tract the movement of ship had become evident, especially in narrow and curved channels which are difficult to monitor and required much more complicated rules of procedures.

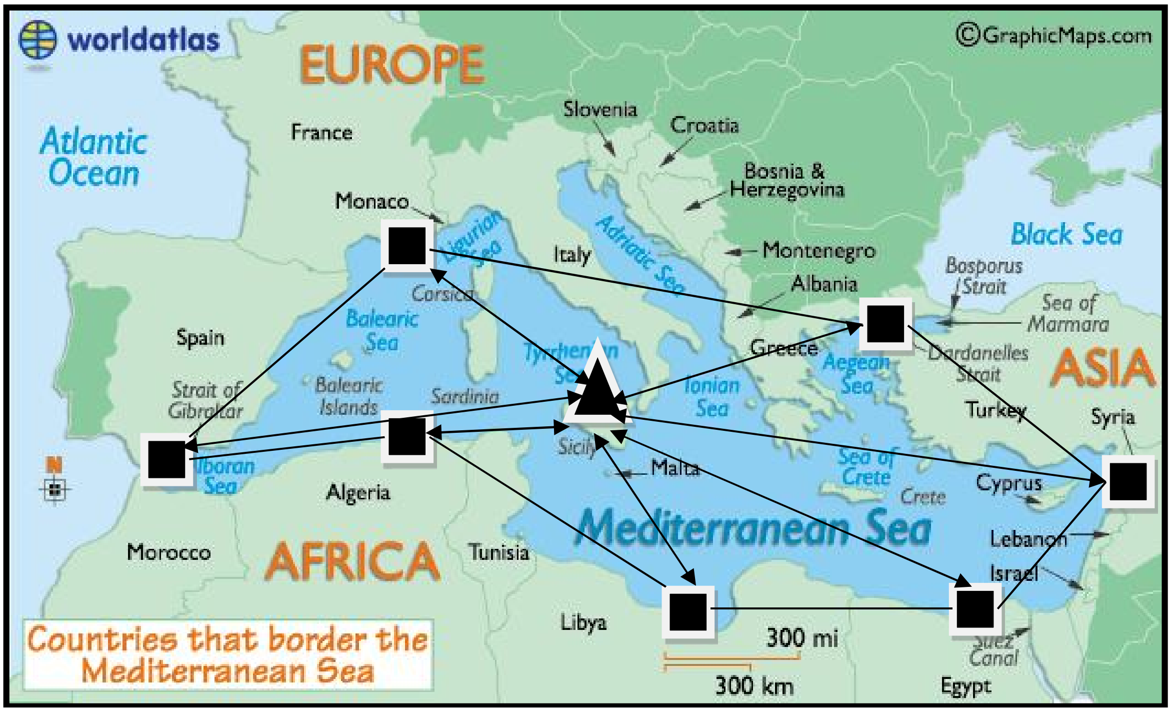

Figure 4 Demonstration Project in the Mediterranean Sea
Source: (Worldatlas, 2016)

Improve the performance of maritime safety and maritime security and protection of the maritime environment in the region. The Proposed project for the Mediterranean Sea could be initiated and run through stages**. First stage** is to be developed for the purpose of gathering the data and information of current situation of the VTS system, Marine Communications, SAR system, Marine Pollution. **Second stage** is planning and organizing the project component and action plans for different aspects which may include baseline Survey, Ship Board Equipment and communications, Marine Environment Project, Emergency Response system and Management system. **Third stage** is to establish the information system includes Electronic Navigational Chart (ENC) for the Area, Tidal Equipment and Automatic Identification System (AIS) stations. **Fourth and last stage** is to carry out in addition a continuous monitoring and assessment of the technical functionalities. It provides a host of potential opportunities and benefits not only for the shipping industry, but also to a variety of users. Its application may be extended to environmental management programs, search-and–rescue operations, anti-piracy program, environmental impact assessment, and fisheries/aquaculture management, among others. The implementation of the Project and the lessons to be learned will thus be much anticipated.

7. Conclusion and recommendations

7.1 Conclusion

Amongst the numerous environmental concerns we are facing, the marine environment is one of the top priorities that must be addressed. The Mediterranean Sea is one of the most important and busiest seas in the world in terms of maritime transport, and shipping activities, with about 30% of international marine trade taking place among the ports of Mediterranean and nearby seas. The Mediterranean is both a major load and discharge center for crude oil. Approximately 18% of global seaborne crude oil shipments take place within or through the Mediterranean. There are more than 40 refineries with a combined capacity of around 458 million tons per annum. The largest exporters of oil are in Libya, Algeria, Egypt, and Syria, with major imports taking place into France, Italy, Spain and turkey. Oil spills only make up about 12% of the oil that enters the ocean, but it is still the worst form of ocean pollution, with its effects being immediate, long-term and extremely damaging. The oil spreads rapidly, and forms a thin, film-like layer on the surface, as it cannot be dissolved. The oil slick suffocates fish, gets caught in marine birds' feathers, and blocks light. With a long-term outcome, oil spills can cause reproductive and growth problems in marine creatures.

Furthermore, the Mediterranean Sea is considered as an area with a high risk of accidental pollution due to the density of traffic, the large number of ports and the existence of a large number of scattered islands and other insular features situated at short distances from international shipping routes. The use of information systems in more mature and expansive applications such as in a marine electronic highway that integrates maritime safety technologies and environmental management systems will improve the performance, situational awareness and innovative applications to enhanced monitoring system. Offshore exploitation activities increase the risk and potential for a major oil spill incident. As such, it creates new demands and challenges to Mediterranean countries which must not be underestimated.

7.2 Recommendations

1) Initiate the application of a pilot project which integrates maritime safety technologies and environmental management systems to improve the performance, situational awareness and innovative applications to enhance monitoring systems in the Mediterranean Sea.
2) The potential efficiency of cooperative and joined ventures of oil response should be recognized, facilitated and any mutual support of regional agreement must be included in exercise programs to ensure their effective integration into response efforts.
3) The National Maritime Administrations, in the Mediterranean Sea Region after identify and establish personnel with high degree of preparedness and equipment to support oil spill contingency plans.
4) Familiarizing personnel with oil spill management and mitigation techniques.
5) Establish a link between all the ECDIS and the AIS systems on all the platforms operating in the Mediterranean Sea to share and exchange information (data) which will be helpful in the event of an oil spill.
6) Take full advantage of the Geographic Information System (GIS) and Satellite-Mounted Synthetic-Aperture Radar (SAR) for full coverage of the Mediterranean Sea, and the necessary information should be relayed to the platforms and ships operating within the Mediterranean Sea.

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Construction of Global Shipping Big Data Platform Based on Information Sharing

Shulong Dai[1], Shuping Liu[2], Jian Sun[3], Linhai Du[4], Yuguang Gong[5]

1. Dalian Maritime University, shulong88@126.com, Nautical Training and Research Centre, Dalian Maritime University, Liaoning, China. Tel: +86 18098836630/13478529326.
2. Dalian Maritime University, lspdlmu@163.com.
3. Dalian Maritime University, dreamsunjian@dlmu.edu.cn.
4. Dalian Maritime University, 13664266331@163.com.
5. Dalian Maritime University, 1025439420@qq.com.

Abstract With the development of the maritime technology and technique, Maritime Education and Training (MET) and safety of navigation confronts with great challenges. First, there is a regional imbalance for different countries, especially in MET and safety of navigation. Second, for the seafarers, they have rarely chance to get further career development education and professional advice. In addition, the rate of maritime accidents keeps increasing in recent years. It has become a challenge for global shipping that how to give the maritime students from different countries the equal chances to receive high level MET, and create chances for seafarers to receive career development education, including techniques, career planning, occupational psychology and so on. Therefore, it is necessary to develop a comprehensive studying platform for all maritime students and seafarers with different levels, backgrounds and countries.

This research proposes to construct the Global Shipping Big Data Platform (GSBDP) using the optimized MET and navigational resources collected, which can predict navigation dangers and provide useful information for maritime users. Based on the idea of Big Data, the GSBDP builds several databases by analyzing and processing these data from all kinds of maritime resources, and provides to different users in different ways after a recombination. Generally, GSBDP includes two main parts, MET and safety of navigation. For MET, it consists of two modules, which are college education and career development education. With a method of modular learning, it offers the maritime students and crew all the learning resources they need, such as professional courses, international convention and regulation, crew business, working procedure, etc. For safety of navigation, GSBDP can predict navigational dangers and offer important information for seafarers to ensure the safety of navigation and ship's security by collecting and analyzing a large amount of navigational data and accidents. Above all, GSBDP can play an important role in improving and balancing the level of MET and safety of navigation worldwide, strengthen the cooperation of different countries, and advance the development level of global shipping.

Keywords: Big data platform, Maritime education and training, Safety of navigation, Information sharing, Career development education, International cooperation

1. Introduction

This research aims to bridge the gap among different countries in MET (Maritime Education and Training) and ensure the safety of navigation. With the rapid development of marine science and technology, the global shipping has raised to an unprecedented level. However, due to the differences in foundation, emphasis, and investment of different countries, there is a regional imbalance in the development of global shipping, especially in MET and safety of navigation. The developed countries, like Britain and the United States, have rich and high-level educational resources, and take a leading part in MET. However, developing countries are lack of information and educational resources. To a certain extent, this situation restricts the healthy development of global shipping, lowers the quality of international MET, and is prejudicial to the safety of navigation worldwide.

At present, the research of big data is still in a stage of exploratory, and has been successfully applied in some fields like politics, public transportation, biomedicine, network information, etc. In politics, the

U.S. government launched “Data.gov” platform, which aimed to build an “open government”, and opened about 390000 data, covering about 50 classes by December 2012. In public transportation domain, there are papers like “Big Data Platform Structure in Public Transportation” written by JI Qianqian and WEN Haoyu. In biomedicine, Biomedical Big Data Training Collaborative (BBDTC), which aims to bridge the talent gap in biomedical science and research, supports the biomedical community to access, develop and deploy open training materials for users at all levels. [1] Although the Big Data Platform has been successfully applied in some domains, it has rarely been proposed in MET. In recent years, E-learning is a more popular way in MET, like Directorate General of Shipping, the ministry website of shipping government of India. However, E-learning has disadvantages, such as incomprehensive, monotonous resources, lack of cooperation, etc. Some countries may conduct E-learning well, but they concern more on MET in their own countries, and are lack of international cooperation.

Generally, big data system has five main characteristics, summarized as 5 V, which are large amount of data (Volume), speed (Velocity), type (Variety), the value (Value), authenticity (Veracity) [2]. With regard to global shipping data, it, which features with large quantity, much variety, and precious value, can provide users with accurate information, meeting exactly the characteristics of 5V. Therefore, it is necessary to build a professional and comprehensive platform based on shipping data, which covers all MET respects and provides all professional courses and information, easy to access for users from different countries.

This paper suggests to develop the Global Shipping Big Data Platform（GSBDP）, which, as an community, can share MET and navigational resources with all maritime related staffs, and predict threats to ships, tendency of global shipping, problems in MET and safety of navigation, etc. On the one hand, it collects, proposes and shares all kinds of MET resources from maritime universities, training institutions, shipping companies, websites, etc., in order to optimize the resources and decrease the gap in international MET. On the other hand, it collects and analyses data like personal experiences, navigation data, accidents, meteorological data, etc., to give supervision and prediction.

2. The framework of Global Shipping Big Data Platform

Global Shipping Big Data Platform (GSBDP) is a platform that conducts collection, collation, analysis and verification of all MET and navigational resources to optimize the resources, and predicts dangerous, sharing with all maritime students and crew in different levels and backgrounds worldwide. It aims to provide an equal resource sharing platform for students, crew, ships, shipping companies and related institutions of different countries, which is more comprehensive, systematic, practical and easy to access.

2.1 Structure of Global Shipping Big Data Platform

The GSBDP includes three parts, which are data source, storage and processing, and data output (Figure 1). Data source is the foundation of the whole platform, whose function is to collect all kinds of MET and navigational resources in different formats from different locations and instruments. Then the data is sent to storage and processing. This part is the brain of GSBDP, where all the raw data is pre-processed, stored, analyzed and processed. Specially, the raw data is converted into practical information we need. Furthermore, databases are established in this part, which will detail in 2.2. After that, in data output part, the practical information is output as forms of courses, operation videos, predictions, danger warnings, etc.

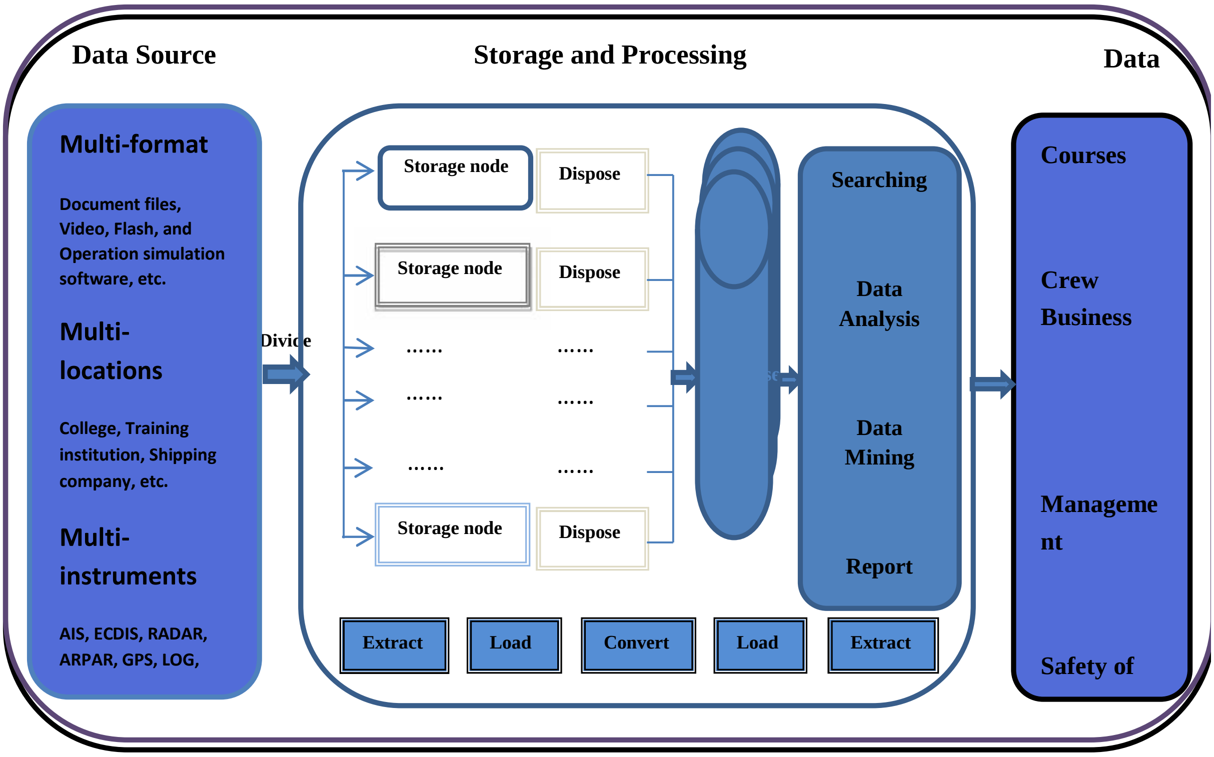

Figure 1 Structural diagram of GSBDP

2.2 Database of Global Shipping Big Data Platform

The database of GSBDP includes mainly three parts, which are MET, Safety of Navigation and Expert Database (Figure 2). As a key part of the GSBDP database, MET database includes different kinds of data, like professional courses, practical training, international convention and regulation, working procedure, etc. Safety of Navigation database contains mainly voyage data, navigational instruments data, accidents, etc. Expert Database brings together experts in shipping industry, and gathers their experience, intelligence, resources, and technical assistance. Although the three databases are constructed respectively, they are of interdependence. MET can provide theoretic support for Safety of Navigation, and Safety of Navigation in turn offers practical support for MET. When they meet some problems, Experts database can help them with experience, intelligence and technic.

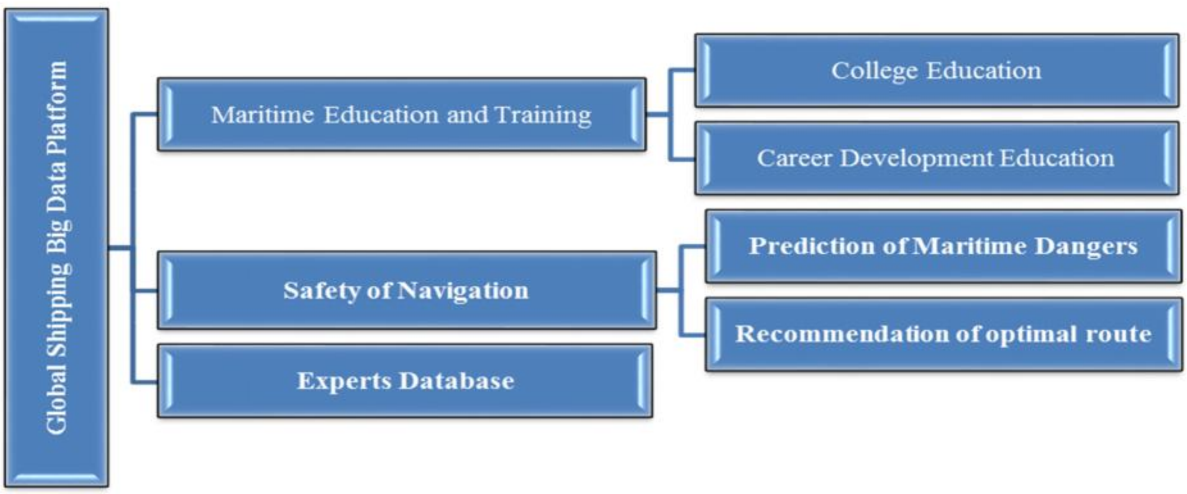

Figure 2 Structural diagram of GSBDP database

Data is the foundation for this platform. How to acquire a comprehensive, correlated, and huge-volume data is critical to this project. For MET data, it can be collected from universities like IAMU members, who are willing to share education resources, training institutions, who are willing to promote their training level, shipping companies, who can offer practical resources, management experience and so on, and the Internet. As to safety of navigation, data mainly come from ships and the Internet. Ships can offer data recorded by ECDIS, GPS, AIS, RADAR, ARPAR, SOUNDING, Main Engine, Auxiliary, etc., and all kinds of accident data. In addition, the Internet can also provide all kinds of safety of navigation information worldwide.

As the quantity of data is very large and the types of data are various, a data processing system is needed to convert raw data to useful information. Figure 3 shows the basic flow of big data processing.

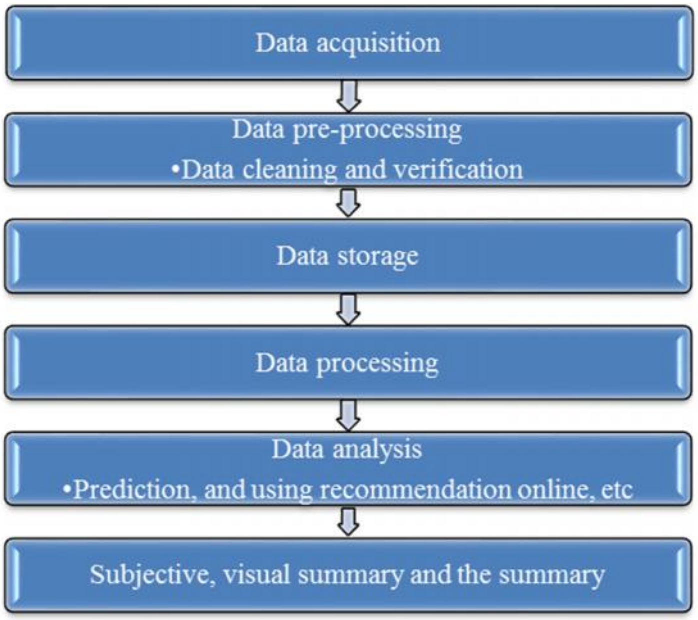

Figure 3 Flow chart of Data processing

3. Key Modules of Global Shipping Big Data Platform

3.1 Maritime education and training

To meet the requirement of on-board working, this module provides theoretical and practical courses, real scene English conversation, working procedure demonstration and so on. However, it shouldn't be used as a replacement for in-class instruction, but as a supplement. Formal education is designed to provide the knowledge for the students to undertake their future tasks on board. This is also the case with MET: its main purpose is to give the students the theoretical background and the knowledge that they require on-board ship, but in practice it is not doing so. The problem is what is taught for certification assessment does not coincide with what is required on-board ship, so that the students learn to pass tests rather than learn for on-board work. [3] There are two main modules in this part, which are college education and career development education.

3.1.1 College education

College education, a main module of MET, provides outstanding education resources for students, teachers, researchers and administrators, etc. As to students, according to the requirements of the 2010 Manila Amendments to International Convention on Standards of Training, Certification and Watch keeping for Seafarers (STCW), the platform collects all kinds of professional education-related materials, including video public class, teaching plan and material, notes, PowerPoint and extending knowledge, etc. Materials collected are provided by each cooperating college and institution. Related experts are responsible for resources integration and reorganization. By doing this, all the professional knowledge is covered, which satisfies the needs of different learners of different levels and backgrounds. The courses are mainly theoretical and practical parts. Specific forms include open courses, text interpretations, video demonstrations, flash demonstrations, operations of simulation software, etc. There are mainly four items in this module, which are professional courses, practical training, professional English and international convention and regulation.

(1) Professional courses

Facing to anyone who wants to receive professional and comprehensive MET, this module offers open courses involving all the related fields, like navigation, marine engineering, electrical and electronic engineering, marine law, etc. With a selection and combination of professional courses in global maritime universities and colleges, it will provide appropriate courses for the users all over the world. The courses are classified according to the fields, which are carefully organized to help users study systematically. In addition, users can link to extensive knowledge in their learning process. This module plays an important guiding role in the international MET integration and resource sharing. Open courses of navigation, marine engineering, marine law and so on, are recorded by professors and instructors in different maritime universities and colleges. After carefully chosen and classified, more professional, systematical, and authoritative courses are available for the users. As for students in backward areas, it will be a fully supplement and support to the education they received.

(2) Practical training

Different from traditional practical training, this module carries out training in the way of video, flash, and operation of simulation software, etc. Video demonstration and flash demonstration are mainly for practical parts. Videos record real working scenes on board and exemplify typical operations in detail, including demonstrations of entering enclosed space, releasing lifeboat, working aloft, repairing failure of the main engine, dealing with man overboard, etc. Flash, which makes the content more vivid, mainly presents some regular operations, including operation procedure of fire extinguishing system, garbage classification, usage of oil preventing equipment, etc. Operation of simulation software mainly helps to be familiar with operation instruction. It can improve crew’s practical operation ability, including steering simulation software, radar operation simulation software, positioning simulation software, collision avoidance simulation software, stowage simulation software, etc.

(3) Professional English

Maritime English, as a common language on board, is more and more important to both routine work on the ship and external communication. There're a total of 26 modifications and supplements directly to the maritime English in the 2010 Manila amendments to STCW convention. The basic principle does not change, but general requirements are higher. In addition, the convention has a special emphasis on the seafarers' language accepting ability, especially reading and listening ability. This module presents the users how to communicate in all kinds of scenes on the ship in English. This method, more vivid than text interpretation, can put the crew in the specific scene and help them to memorize the professional English. Taking the business of the third office as an example, English communication scenes consist of the organization of fire-fighting practice, organizing drill, steering and steering orders, loading and unloading, gangway watch, etc.

(4) International Convention and Regulation

This module includes all the international conventions, regulations, rules and relevant documents. As mandatory rules or suggestion, international convention and regulation plays important roles in international shipping to regulate the behavior of shipping companies, crew, relative institutions, etc. They include but not limit to the International Convention for the Safety of Life at Sea (SOLAS), the International Convention on Load Lines, the International Convention for the Prevention of Pollution from ships, the International Maritime Dangerous Goods (IMDG) Code, the International Maritime Solid Bulk Cargoes (IMSBC) Code, the International Regulations for Preventing Collisions at Sea (COLREG), the International Code of Signals, etc. For example, in the 2010 Manila Amendments to STCW, it stipulates explicitly that captain, officers and engineers should have knowledge of related international maritime conventions and recommendations, and national legislation.

3.1.2 Career development education

Based on the crew's responsibility, this module helps the crew to enrich their business related knowledge systematically, and aims to become an encyclopedia for seaman career development education in the way of modular learning. The ways of training can be video material recorded, a demonstration of job operation process, the summary of crew's own experience, or experiences and lessons drawing from accidents. Based on modern methods, the platform will build a large database of maritime career development education. In addition, it will make every effort to help the crew to solve the problems they meet, such as lacking of career related information, without professional support and unsystematic process of study. By establishing information database and expert database, it will make the maritime vocational education more open, professional and diversified, and achieve the goal for optimization of nautical education system. There are mainly two items in this module, which are crew business and ship quality management.

(1) Crew business

On the basis of the 2010 Manila amendments to STCW convention, this module is divided into different units according to different positions, and focus on the practical operations. This module mainly combs and spreads the business knowledge of corresponding positions on board, aiming to contain all relevant business. For those who want to make development and improve their business ability, it provides them a self-learning opportunity, making it easier for them to understand and research in their business.

(2) Ship quality management

This module provides a platform to share resources for those who want to know something about the safety management system of other companies or departments. In addition, this module also offers some mature management experience and successful cases as part of effort to provide references for new recruits or the crew having such demand. On this basis, the platform adds teacher link module, which gives solution and guidance online to solve the problems encountered in the process of autonomous learning.

3.2 The safety of navigation

In this part, we establish a database of maritime accidents. With a statistical analysis of them, it can provide suggestions for accidents prevention and control. At the same time, as a communication platform, when some accidents or dangers happen at sea, the first ship finding it can post the message on the platform, thus ships passing through can take measures to keep away from distress. There are several modules that play different roles in this platform.

(1) Prediction of maritime dangers

The most valuable advantage of big data is prediction. The advantages of this module includes accident statistics and prevention advice, early warning of maritime dangerous, prevention and against of the pirates, etc. Firstly, by collecting different kinds of navigational data, the platform can predict the dangerous about to happen, which is very important for safety of navigation. Secondly, by collecting, classifying and statistical analysis of maritime accidents, it can obtain the reason, percentage and result of different kinds of accidents, so that suggestions or procedures preventing accidents from happening can be acquired. Thirdly, when some accidents, bad weather or other dangers, happen at sea, the first ship who finds it can post the message on the platform, warning ships passing through this area. Finally, it makes a statistical analysis of global pirate attacks, for example types of attack, the way pirates board ship, weapons and outfits equipped and the successful case out of danger and so on, and marks different colors on the chart according to the probability of pirate attacks happened in different areas. This will help the ships passing through these areas be well prepared for piracy earlier and give some suggestions to prevent the pirate attach.

(2) The recommendation of optimal route

By collecting and analyzing different kinds of navigational information from different ships, this module offers a choice of optimal route to meet ship's requirement. First, navigation information is collected from navigation equipment, such as electronic chart, Radar, AIS and so on. Then, after series of data processing, it will provide recommended routes for ships navigating around the world, such as economic priority route, distance priority route, and time preference route, etc. Meanwhile, the users can optimize the recommended route combining with their own needs. After choosing the recommended route, some related information can also be labelled on the route, which ensures the safety of navigation. The information includes all hazards at close range, shallow water, narrow channel, traffic dense areas and any dangerous on the way. Besides, it can also provide some other information, like reporting point, reporting frequency, regulations of ports, etc. Users can obtain the above content only by inputting the GPS-coordinates of the departure point and destination point.

3.3 Expert Database

This module links to maritime experts so as to give online or email instructions to students and seafarers. They can help them solve practical problems, build up correct career development plan, and improve professional abilities. Experts will be selected from eminent professors in maritime colleges and universities, and remarkable captains or chief engineers in shipping companies. They must be well-versed in their own business, have an acute insight, be good at discovering and solving problems, and be willing to share their precious experience. Upon meeting thorny problems, designated relevant expert is requested to give an online guidance. Every few months, experts are called up to discuss problems recently happening together in a way of video conference to find out solutions. It can not only save time and energy, but also make good use of the integrated resources. Furthermore, it is also a great chance for maritime elites to cooperate together.

4. Conclusion and expectation

To balance the international maritime education resources and provide help for the safety of navigation, this paper proposes a creative idea of constructing the GSBDP. Through establishing MET database, it will provide the same opportunities for students from different countries to receive high level maritime education, help the crew to improve their business, and solve the problems they meet in work. In addition, it will also contribute to safeguarding and providing favorable conditions for navigation. GSBDP will strengthen the cooperation of different countries in MET and safety of navigation, and play an important role in pushing forward the development of shipping industry worldwide. On this basis, we can establish a feedback system of crew tracking and assessment, which helps to evaluate the working process of the crew, collect the difficulties and confusions they meet in work process. Furtherly, if we can improve the database, form a closed loop, and make continuous improvement, it will play an immeasurable role in pushing forward the shipping development.

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Logistics and supply chain finance: managing financial risks and optimizing financial flows in logistics and supply chains

M. Com. Thuy Duong Dang [1]

1. Faculty of Management and Finance - Vietnam Maritime University, duongdt@vimaru.edu.vn

Abstract. Logistics and supply chain management (SCM) play more and more important roles in modern world and have great potential for improving bottom line results. In the literature, there are a lot of contributions towards managing physical risks, information and goods flows while issues related to managing financial risks such as market risk, credit risk, currency risk and optimizing financial flows have not been discussed adequately. This article will focus on this research gap to enhance efficiency of logistics and supply chains by applying finance to develop the framework to optimize cost flows of those companies taking capital structure, cost of capital and various cost drivers into consideration and also recommending the use of derivatives such as forward or future contracts, swaps, option to hedge different financial risks that logistics and supply chain companies may face in global context.

Keywords: Logistics and Supply chain Finance, risks, derivatives, hedging, financial flows, cost optimization.

1. Introduction

The modern business world has put logistics and SCM into practice because they are considered to be essential drivers of differential competencies for the companies and value maximization for the shareholders by optimizing goods, information and financial flows within a company as well as the whole supply chain. While there are many academic contributions toward issues related to the flows of goods and information, the financial flows were less paid attention. The integration of finance and logistics and SCM is research gap with huge potential to explore and develop both theory and practice. Logistics and SCM are applied widely in order to lower cost (65%) and increase revenue (25%) however not many companies know how to direct their investment in this field to maximize the business performance (D'Avanzo et al. 2003). Logistics and SCM decisions can have a great influence on the capital structure, risk profile, profitability and market value of a firm. Therefore, logisticians and supply chain executives are required to understand and communicate in the "language of finance".

Since the global financial crisis in 2008, it has been more difficult for logistics and supply chain companies to assess to commercial bank loans while those firms will require more and more capital in both short – term and long – term. The key to the success of a logistics and SCM decision is that the firm profitability is higher than its capital cost rate. Supply chain finance (SCF) solutions can help not only improve the efficiency of order cycle and working capital management but also reduce the cost of capital (CoC).

According to a report by the Supply Chain Management Faculty at the University of Tennessee, in a survey among over 150 different supply chain managers, none of them hired external experts outside to assess their supply chains risks; 90% of companies do not quantify risk when outsourcing production; and 100% of supply chain executives considered insurance as a highly effective risk mitigation tool, but it was not in their purview. The study also analyzed over 800 supply chain disruptions that occurred from 1989 to 2000. Firms that experienced major supply chain disruptions saw the following consequences: Sales were reduced 93%, and share returns were 33-40 % lower over a three-year period; Stock price volatility was 13.5% higher; Operating income reduced by 107%; and Return on Assets (ROA) declined by 114%. By nature, risks cannot be completely eliminated but they can be identified and mitigated. Many research findings (e.g. Meulbroek JACF 2002 and Stulz JACF 1996) noted that risk management can and does add value to the firms.

This paper examines the importance of financial flows and the impact of logistics and SCM on these flows regarding cost of capital and risk management perspective. Firstly, based on the SCF framework, SCF solutions are analyzed in regard to some case studies from different perspectives of small and medium size companies in supply chains (SME), logistics service providers (LSP) and financial institutions (FI). Secondly, this paper will analyze generally how logistics and supply chain risks can be hedged by employing derivatives.

2. Background literature

SCF is an innovative model with significant applications dealing with the financial flow of a supply chain in the modern business world. Stemmler and Seuring regarded the term of "supply chain finance" as the financial flows control and optimization induced by logistics. Gomm (2010) defined SCF as optimizing the financial structure and the cash-flow within the supply chain. More specific definition is stated by Pfohl and Gomm (2009) as "the inter-company optimization of financing as well as the integration of financing processes with customers, suppliers, and service providers in order to increase the value of all participating companies". According to Gomm, SCF's target is to reduce the cost of capital and improve cash flow by the financial process optimization across company borders. Stenzel noted that "logistics financing" creates more opportunities of competence for LSPs. SCF literature can be divided into two aspects. The typical qualitative research is a framework for financial issues in SCM proposed by Gomm and quantitative approach is a mathematical model developed by Pfohl and Gomm.

3. Logistics and Supply Chain Finance framework

SCF approach suggests both financial and operating collaborations within supply chain members and financial market to reach the optimal decisions.

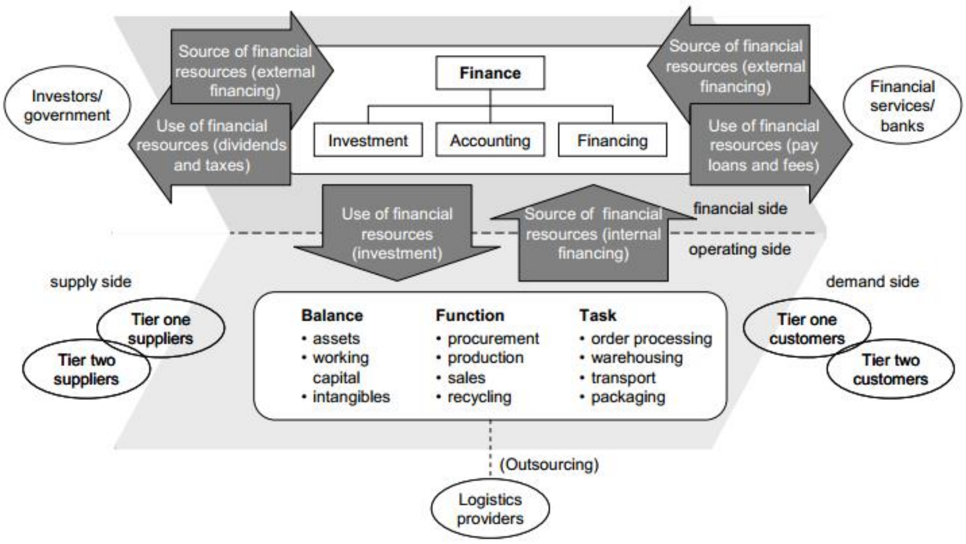

Figure 1 SCF approach - Source: Hofmann, E. (2005)

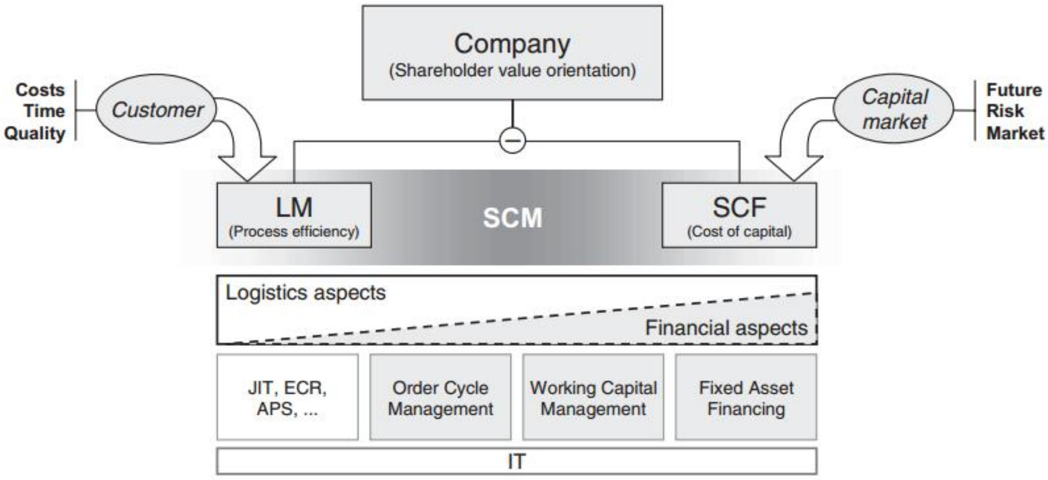

Figure 2 Integration of SCF into SCM - Source: Gomm (2010)

In order to increase the value of a single company as well as the overall supply chain, there should be an optimization combining three major financial aspects of SCF: order cycle management, working capital management and financing of fixed assets.

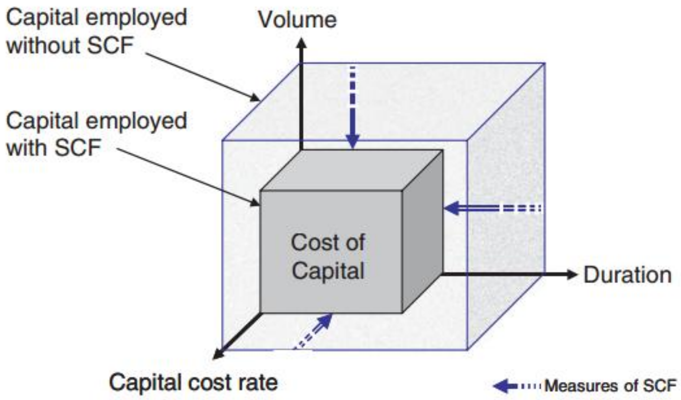

Figure 3 The SCF cube - Source: Gomm (2010)

SCF solutions decrease cost of capital and maximize firm value by reducing three dimensions of financing: duration, volume and capital cost rate.

There are many market segments in SCF offering business and investment opportunities for different players including platform providers acting as technology components such as Prime Revenue, Orbian, Bolero, CGI Proponix,...; transactional risk managers for example UPS Logistics provider and Instream – a credit data processor; finance providers such as JP Morgan Chase, HSBC, GE commercial finance etc.

Case study: SCF program at P&G

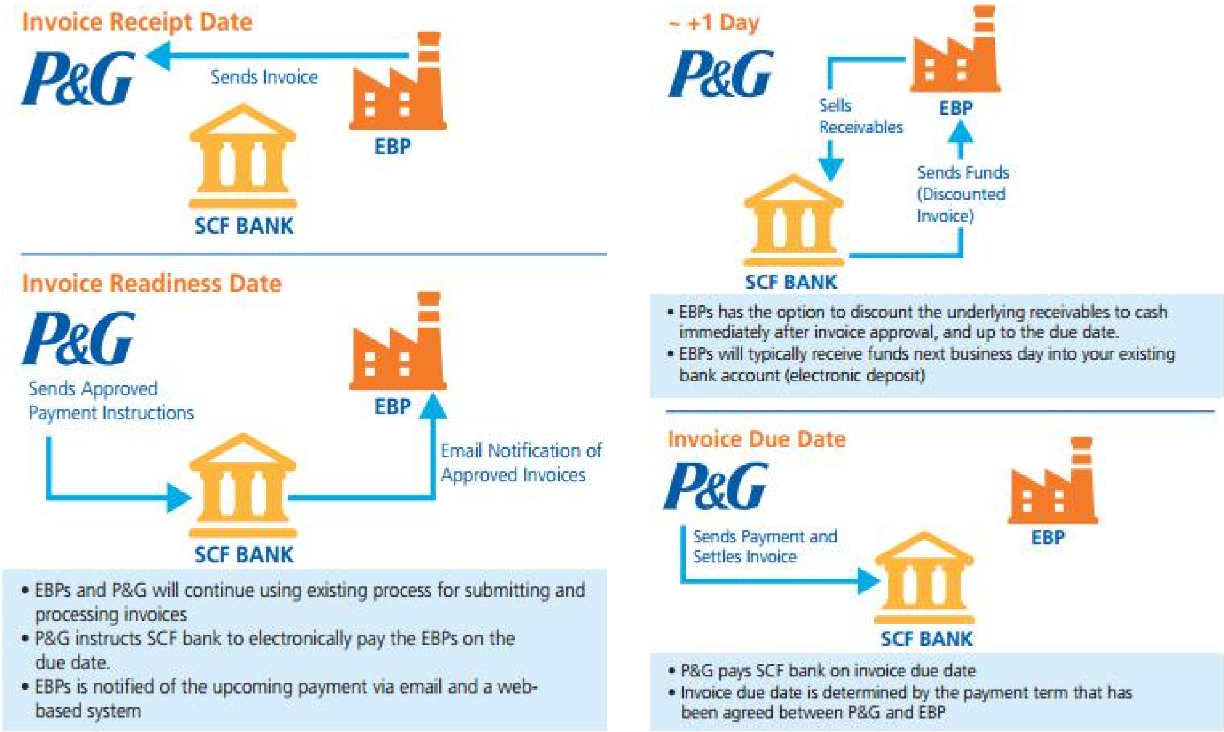

Figure 4 SCF process at P&G (Source: P&G)

P&G developed this modern financing way with many strong benefits for its suppliers which can be SMEs by selling their P&G receivables to receive non – resource cash at an attractive discount rate. In addition to the discount rate that the suppliers are charged on the face value of the receivable, there are no other fees associated with this program for example joining, maintenance or exit and banking fees.

SCF banks including Citi Bank, Deutsche Bank and JPMorgan are liquidity providers in P&G's SCF program which offers an effective financial tool to P&G's External business partners (EBPs). The determined discount rate is based on LIBOR plus the bank spread which depends on P&G's credit rating. The key point is that the annual discount rate is normally significantly lower than EBP's weighted average cost of capital (WACC) and can be lower in comparison with short term debt interest rate because P&G often has better credit rating than its EBPs which are SMEs. By implementing this program, suppliers receive the payments early to lower Days sales outstanding (DSO), optimize working capital and improve liquidity without increasing debt, reduce cost of financing as can be seen from Figure 5 below.

$$\text{Payment Amount} \times \underset{\text{(Libor + Bank spread)}}{\text{Annual Rate}} \times \frac{\text{Days Left in Term}}{360} = \text{Discount Charge}$$

$$\$100 \times \underset{(0.30\% + 1\%)}{1.3\%} \times \frac{75-15^{*}}{360} = \begin{matrix} 0.21\% \\ \$0.21 \end{matrix}$$

	Old Terms	New Terms	New Terms w/SCF Program
Assumed Invoice Amount	$1,000,000	$1,000,000	$1,000,000
Payment Terms	Net 45 days	Net 75 Days w/out SCF	Net 75 Days, w/SCF
Days Sales Outstanding	45 days	75 days	15 days
Days to Invoice Approval	15	15	15
Days Additional Financing	30	60	60
Assumed Cost of Money after invoice approval (Day 15)*	5.25%	5.25%	LIBOR + Bank Spread % (0.3% +1% = 1.3%)
Total Cost of Financing	$4,375	$8,750	$2,166
Total Payment Made to EBP	$1,000,000 on day 45	$1,000,000 on day 60	$997,834 on day 15
Cash Gain vs. Old Terms		-30 Days	+60 Days
Savings with SCF Program (vs. Extended Terms without SCF)			$6,584

*Estimation only

Figure 5 Cost saving estimation – Source: P&G

The program leverages P&G's credit rating, solves its suppliers' liquidity management challenges during GFC because strict and demanding banking requirements make their cash flows stressed when financing the extended payment terms, saves a huge amount of financing cost. It also can be considered as a good tool to mitigate risks.

4. Financial Risk Management in Logistics and Supply Chain

L. K. Meulbroek 2002 introduced a guide to integrated risk management approach and suggested that risk management can add more value when the firms identify and assess collective risks and implement firm – wide strategy to manage those risks, aggregate risks to account for inter-relationships and make operating, capital structure decisions and financial derivatives usage jointly. There are a limited number of applications of derivatives in managing the risks confronted by logistics and supply chains such as freight rate risk, interest rate risk, exchange rate risk, market risk of commodity price and energy price, uncertainty of demand, counterparty risk, etc. This section will analyze some typical risks and recommend to hedge by using derivatives products instead of insurance policies.

Natural disasters and catastrophic bonds (CAT bonds)

Extreme events such as flood, earthquake, wildfire, hurricane, tsunami, etc. can cause serious disruptions and huge losses for logistics and supply chain firms. Insurance (and reinsurance) is the most popular way for the companies to mitigate the impact of such catastrophic risks but in many cases, the capital capacity of insurance and reinsurance companies is not enough to underwrite extreme losses. CAT bond is security innovation which can assess to larger pool of capital from big institutional investors with attractively high yield.

Customer demand uncertainty risks and Separating options from supply contracts

Demand uncertainties can have a negative influence on the operation and financial performance of a company by causing under production resulting in losing sales and over production leading to excessive inventory. Some policies and terms in a supply contract such as buyback and quantity flexibility conditions act as “embedded options” which have a number of limitations in risk management. A firm not only can operationally manage the risk but also reduce it financially with derivative instruments. Shi, D. et al. 2004 introduced a simple call option whose underlying asset is the customer demand level. They proved that with greater flexibility in comparison with embedded options, this derivative can facilitates risk sharing and risk taking among different supply chain partners, financial intermediaries such as banks, hedge funds, insurance companies etc. which have various risk appetites and risk bearing ability, therefore, enhance the whole supply chain coordination and performance.

Freight rate risk and Freight rate derivatives

The major part of a transportation logistics companies’ income is freight rate. The operating cash flows and profitability of a shipping company for example will highly exposure to the freight rate uncertainty. The research by Stefan, A. et al. 2011 indicates that the volatility of freight prices is much higher than that of equity or bond and also cyclical, seasonal. Besides, its distribution shows “fat tails” and negative skewness. Especially, during GFC (global financial crisis), the standard deviation of freight rate leapt significantly.

There are many compound factors affecting the change in the derived demand for freight services, for instance, global economy, and international trade, the seasonality of commodity consumption and markets, vehicle or vessel size and contract maturity.

Common freight rate derivatives such as forward freight agreements (FFA), freight rate future contracts and freight rate options can be more flexible and cost – effective solution to hedge risk and integrate with the classic methods of operation management and capital structure adjustment.

The Baltic Exchange provides information and indexes of maritime transportation markets which are used for the trade and settlement of derivatives contracts. BIFFEX (the Baltic International Freight Futures Exchange) is an organized exchange located in London trading ocean freight futures contracts which are settled based on the Baltic Freight Index.

CME Group is one of the largest options and futures exchanges. FFAs offered by CME group are divided into two main groups: wet freight for different routes (Baltic and Platts) and dry freight based on different time charter index made public by Baltic exchange.

Wet freight options designed for different routes are European type and settled at average price. Additional tailor - made products are being developed to meet various requirement of all ranges of market participants.

In the past, most freight derivatives were traded by the network of dealers in OTC (over – the – counter) market. Nowadays, more and more futures and options are traded on or traded off and then cleared through standardized exchanges such as NYMEX.

Asset Value Risk and Scrap Derivatives

One typical example is that ship owners can manage vessel value by employing forward products such as FOSVA (Forward Ship Value Agreement) which are cash settled contracts, similar to the structure of plain vanilla FFAs and whose underlying assets ‘prices are based on BSPA index (the Baltic Sale and Purchase Assessments). The drawback of this market is that it is less liquid than the traditional forwards market.

Another index of demolition values is BDA (the Baltic Exchange Demolition Assessments) which can be treated as the underlying assets of derivative instruments created to trade on vessel scrap.

5. Conclusion and Recommendation

One common issue of SMEs in supply chains is capital constraint. SCF opens the access to cheaper sources of fund by taking the advantage of the gap in the refinancing interest rates of different companies in the same supply chain due to credit rating and solving agency problem caused by information asymmetries between supply chain insiders and external parties from financial market. SCF solutions create a win – win situation for all involved participants by converting supply chain information and knowledge into accelerated value by improving financing methods and reducing risks.

In the volatile business environment, depending on risk appetites and comparative advantages, logistics and supply chain companies have to determine which risks and how much risk should be borne and managed internally, which risks should be transferred to financial market who can bear the risks at lower cost and in more efficient way. More and more sophisticated and innovative financial instruments have been designed to satisfy the various demand of risk management and diversifying alternative investment. However, both risk managers and investors must understand and be cautious when using those tools because of their complex structures with attractive and flexible characteristics.

In Vietnam, logistics and supply chain industry seeks lending capital from commercial banks which offer very simple and basic products with strict financial requirements. There is a lack of SCF application to leverage and exploit the potential of logistics and supply chains to achieve the sustainable economic development. The recommendation would be further research and cooperation at both micro and macro level between logistics, SCM with financial services providers such as investment banks, hedge funds, and insurance companies etc. to develop variety of comprehensive SCF solutions to replace the classical one – size – fits - all method.

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