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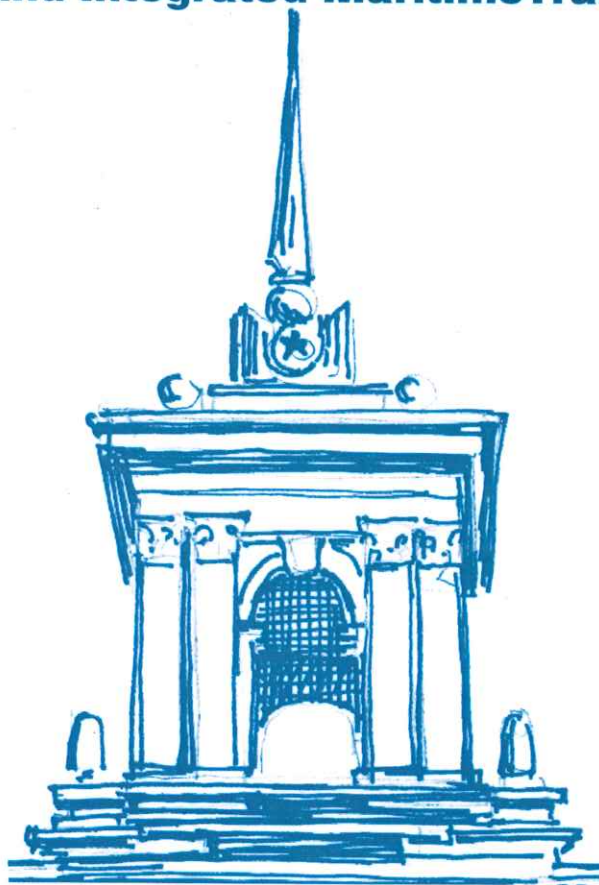
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**18<sup>TH</sup> AGA 2017**

**ANNUAL GENERAL ASSEMBLY**

**Global perspectives in MET:  
Towards Sustainable,  
Green and Integrated Maritime Transport**



**Volume I**

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**18<sup>th</sup> Annual General Assembly  
of the International Association of  
Maritime Universities**

**Global perspectives in MET:  
Towards Sustainable, Green and Integrated  
Maritime Transport**

**Volume I**

**Varna, 2017**

The **18<sup>th</sup> Annual General Assembly** of the International Association of Maritime Universities together with the **Scientific conference** was held in Varna, Bulgaria, 11-14 October 2017 supported by Nippon Foundation. The Conference consist of two main workflows depending on the status of authors: researchers/lectures and students.

On the Conference “**Global perspectives in MET: Towards Sustainable, Green and Integrated Maritime Transport**” were presented researchers/lectures and students from Maritime Universities.

The research papers were arranged in three thematic sections:

- Education and Training in Maritime Professions, and Support for Seafarers
- Sustainable Maritime Transportation Systems
- Environmental Protection, Green Industry and Blue Growth.

Also the research papers are issued in 3 volumes.

- The first volume includes all the papers that pass the refereeing procedure. They are included in the index of scientific citation.
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# Training skills and assessing performance in simulator-based learning environments

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**Abstract:** This article reports the results from a research project on the use of simulator technologies in the training and assessment of professional performance in maritime training. The research draws on ethnographic fieldwork and analyses of video-recorded data to examine how maritime instructors make use of simulator technologies during instruction. Our results reveal an instructional practice where the need to account for general principles of good seamanship and international regulations is at the core of the basic maritime training. The meanings of good seamanship and the rules of the sea are hard to teach in abstraction, since their application relies on an infinite number of contingencies that have to be accounted for in every specific case. Based on this premise, we are stressing the importance of both in-scenario instruction and post-simulation debriefing in order for the instructor to bridge theory and practice in ways that develop the students' professional competences. Moreover, our results highlight how simulator technologies enable unique ways of displaying and assessing such competences by enabling instructors to continuously monitor, assess and provide feedback to the students throughout training sessions. Our results imply that training models advocating isolating and targeting technical and non-technical skills during training conflict with training for rule-governed maritime operations where such skills are intricately entwined. Furthermore, our results show that debriefing models that recommend a linear chronological order of discrete phases could be misleading. Although this structure might provide an overall resource, processes of connecting principles and rules to a multitude of specific circumstances in the training scenarios are at play throughout the debriefings.

**Keywords:** Maritime training; Simulator-based training; Instruction; Assessment; Debriefing

## **Introduction**

In maritime education, simulators have been used for navigation training since the 1950s (Hanzu-Pazara *et al* 2008). Simulators provide opportunities to train for high-risk professions such as shipping, aviation and health care in a risk-free manner, providing opportunities to train skills that are time-consuming and costly to practice on board a real vessel (Dahlstrom *et al* 2009). The controlled simulator environment also has pedagogical advantages, as exercises can be designed to train and assess specific learning outcomes in a way that is adjusted to the level of the students' developing competency (Maran & Glavin 2003). Today, the use of simulators is mandatory for certain parts of the curriculum for maritime training and is regulated by international standards, that is, by the *Standards of Training, Certification and Watchkeeping for Seafarers* (STCW). In order to ensure that future mariners are able to act properly and safely, the STCW Convention stresses that simulators are to be used for both training and assessment. The latest update of the STCW Convention—the 2010 Manila amendments—has a greater focus on technical proficiency and so-called non-technical skills compared to previous Conventions. The former skills are related to handling the equipment of the ship, while the latter are often described as cognitive and communicative skills, such as situation awareness and decision making, as well as skills involved in teamwork, such as leadership and communication (Flin 2008).

When much of the training of maritime skills and practices are conducted in simulation-based learning environments, theoretical knowledge and written knowledge tests have been deemed irrelevant for developing and testing certain types of competencies. As a result, there is a need for upgraded forms of training and assessment that, on the one hand, acknowledge the multifaceted nature of the performance in simulation-based training and, on the other hand, meet the criteria for training and certification set up by the Convention (Emad 2010). A recent literature review on the use of simulators in bridge operation training showed that although the use of simulators is both well established and well regulated in maritime education, few empirical studies have addressed the pedagogical aspects of simulator-based training in this domain (Sellberg 2017). In regard to this, the research project draws on ethnographic fieldwork and analyses of video-recorded data to examine the pedagogical matter of how maritime instructors make use of simulator technologies for instruction in order to develop the students' professional competences (cf Heath *et al* 2010).

## **Background**

Several studies on maritime simulations have been grounded in human factor perspectives (Sellberg 2017). Research in this tradition regularly draws on classical cognitive theories for

describing processes of work and learning. In previous studies on simulator-based training, the cognitive approach is seen through research designs that strive to isolate skills for training and reflect an interest in underlying cognitive models during learning activities. Moreover, there is often a focus on the technical fidelity of the simulator (Sellberg 2017). Instead of taking a classic cognitive approach, the current research project draws on theories that situate work and learning in the social, material and cultural context (Goodwin 1994; Hutchins 1995; Suchman 2007). This approach implies an interest in the specific details of educational activity in terms of the interactions between instructors, students and the simulator environment, with a focus on how the students develop their perception and understanding of professional practice. In maritime educational research, few studies can be found that take a situated perspective on simulator-based training. However, initial results show promise of being fruitful for understanding how participants are learning the professional knowledge of a mariner (Hontvedt 2015a; 2015b; Hontvedt & Arnseth 2013).

For example, in a study on students training together with professional pilots on a full mission simulator, Hontvedt and Arnseth (2013) found that the practices trained in the simulator are closely entwined with the maritime profession's hierarchy and work roles. Moreover, they found that expert feedback is crucial in order to structure simulator training in a way that enhances professional knowledge. The importance of professional guidance during simulator-based training is seen in results from studies on simulations in other domains, such as healthcare and dentistry (Hindmarsh *et al* 2014; Rystedt & Sjöblom 2012). In a study on professional pilots' continuous training, results revealed that the pilots' professional vision of the work environment was in conflict with an instructional strategy that isolates skills for learning from the experienced exercise (Hontvedt 2015b). While the potential for simulator-based learning is that professional knowledge and expertise can be taken into account and developed, specific skills are not easily separated from maritime work practice and cultural notions of what constitutes good seamanship. In line with these results, the classical cognitive division between technical and so-called non-technical skills is problematic in practical training. Instead, the different skills are increasingly intertwined in the different work tasks. This, in turn, requires an analytical framework that takes into account the practical and contextual aspects of learning on the ship's bridge (Hontvedt 2015a; 2015b).

An almost unanimous conclusion in the research across domains highlights the importance of post-simulation debriefing (Dieckmann *et al* 2008; Fanning & Gaba 2007; Wickers 2010). Allowing for retrospective feedback and reflection is necessary for participants to learn from their experiences in a way that forms the basis for prospective strategies on how to manage

future situations. In general, a structure is suggested involving three phases: a description of what happened, an analysis of what should be done differently and a concluding part to summarize the lessons learned (Fanning & Gaba 2007). In debriefing, it is common to use different technologies for feedback. In teamwork training in healthcare, for instance, the use of video is recommended to assist debriefings (Dieckmann *et al* 2008). A pedagogical rationale for using video is that it provides a record of the actions taken during a scenario that allows for the participants to view their prior actions from an observer's perspective. The main idea is that gaining an observer's perspective on one's own conduct allows the participants to see how they performed, instead of how they thought they performed, which is expected to reduce 'hindsight bias' in debriefing (Fanning & Gaba 2007). Further, different forms of visualization have been used in military and maritime training to revisit and learn from the exercises.

A common technology for debriefing in navigation courses is the use of an electronic map with a replay of the simulated scenario displaying the actions of multiple crews from a bird's-eye view (Hontvedt & Arnseth 2013). While empirical studies on the use of playback technologies in navigation training are still lacking, results from studies of simulations in healthcare show that the use of video has pedagogical potential because, among other things, it provides a third-person perspective on one's own conduct and makes it possible to reconceptualise prior events in professionally relevant ways (Johansson *et al* 2017). Such outcomes, however, regularly demand substantial efforts by facilitators to highlight critical aspects of what is shown and to demonstrate how the situation should be understood (Goodwin 1994). This conclusion concurs with studies in other educational fields, pointing to the need for systematic instruction if students are to be able to make sense of film clips of their own conduct (Erickson 2007). Although video as a playback technology is quite different from visualization tools in navigation training, it points to the fact that visualizations are far from self-explanatory and there is a need to scrutinize instructors' practical use of playback for instructional purposes.

To summarize, the results seen so far highlight three aspects of training in simulators as especially important for learning for the maritime profession: the role and importance of professional guidance during simulations, the close relationships between technical and non-technical skills and the role and importance of debriefing for learning from the practical exercises. This research project adds to these results with knowledge on *how* instructions in a simulator environment are carried out, but also *why* instructions should be designed in certain ways.

## **Methods**

The research design is based on three well-tested principles for video-based research (Heath *et al* 2010). The first principle is to explore human-technology interactions as they naturally occur in the setting under study. This implies that instructional activities at the simulator centre were studied with no intention to manipulate the activities taking place during training. Second, when studying highly technical workplaces in complex domains, such as maritime navigation training, ethnographic fieldwork is considered essential for developing an understanding of the practice and the context where interactions take place (Heath *et al* 2010). Since 2013, the first author has spent hundreds of hours on observations and informal interviews with instructors in order to be able to analyse the activities that take place in simulation-based maritime training sessions. Observations included several different simulators and types of training, such as cargo operations, engine control operations and radio communication, as well as field trips to different simulator centres across Europe. The third principle puts emphasis on the complex relationship between the temporal, technical and social environments in simulation-based training (Heath *et al* 2010). This makes video data an important source for analysis, since video creates stable records for analysis of the interactions that take place during training. Approximately 75 hours of simulation-based training in a bachelor level navigation course were video recorded in 2013–2014. When using multiple cameras to capture instructions that were distributed in time and space during exercises, close to 400 hours of film was recorded. When narrowing down the selection of video data for further analysis, six different scenarios and their subsequent debriefings emerged as analytically interesting. In the next step, instructions between the instructor and students were transcribed and analysed both individually and collaboratively, drawing on competencies from professional mariners, educational sciences and human factors.

## **Results**

Although simulator-based training in maritime education might encounter challenges similar to those in other domains, our results reveal that there are also some crucial differences. While simulation training in other realms often focuses on technical and non-technical skills, the need to account for general principles of good seamanship and international regulations is at the core of basic maritime training (Sellberg & Lundin 2017). The meanings of good seamanship and the rules of the sea are hard to teach in abstraction, since their application relies on an infinite number of contingencies that have to be accounted for in every specific case (Sellberg & Rystedt 2015). During simulator-based training, this premise poses different instructional challenges for the maritime instructor in the different phases of training.

*Briefing* is commonly focused on practical information regarding the upcoming scenario and the learning objectives and takes place in a classroom in close proximity to the simulators (Fig. 1). The spatial layout of the classroom sets the frame for instruction, and the technologies used for instruction in this phase are common classroom technologies, such as documents, PowerPoint presentations and overhead sheets, which are prepared by the instructor beforehand. In this phase of training, the instructions given to the students were rather open and straightforward (Sellberg & Rystedt 2015). Examples of such open instructions are directives to ‘follow COLREG’ or to use the TRAIL-function in a particular scenario. Before the scenario is played out, all the specific contingencies of the scenario are yet unknown. For the instructor, the openness of the instructions is a necessity in order to handle an infinite number of possible courses of events that may occur in the upcoming scenario. For the students, this is a classical problem of following instructions: of turning open and partial descriptions into practical action towards a desired outcome (Suchman 2007).



Fig. 1. From briefing, through scenario, to debriefing in simulator-based maritime training.

After briefing, a *scenario* plays out in the simulator. In the scenarios chosen for further analyses, the exercises take place in the dense traffic of the Dover Strait and in the confined waters of Great Belt Strait, where the students are training in teams of two (as officer-of-the-watch and lookout) in bridge operations simulators. These kinds of exercises are used to train proficiency in handling the instruments on the ship's bridge, as well as in bridge teamwork and application of the rules that regulate traffic at sea (COLREG). During scenarios, the instructor monitors the students' on-going teamwork on the different bridges from the instructor's room. Our results show a close relationship between assessment and instruction in the midst of the action (Sellberg & Lundin 2017).

During scenarios, *assessment* is a continuous and on-going process that reflects the instructor's ability to recognize the fit or the gap between the learning objectives and the students' activities in the simulator, as they unfold (Sellberg & Lundin 2017). These

assessments rely both on technology, that is, on the monitoring technologies in the instructor's room and the radar technologies in the simulator, as well as on questions to the students. Moreover, when the interactions between instructor and students are taking place in the simulators, the instructor can use a variety of navigational technologies in a maritime context as a basis for his or her instructions (Sellberg & Lundin 2017; Sellberg & Rystedt 2015). For the instructor, being there, in the midst of the action enables him or her to attend to specific details of the students' conduct, such as how they are managing their gaze and attention when integrating information from different sources on the bridge (Sellberg & Rystedt 2015). The students' actions as well as their understandings of the situation that are shown in their answers to questions are then used to continue the instructions in a way that supports each student bridge team (Sellberg & Lundin 2017). For example, the instructor can choose to clarify or correct the students' actions as necessary, or just to ratify their actions as correct behaviour. What is interesting with these instructions, in relation to the instructions in the briefing phase is that they can be delivered in a way that takes the contingencies of specific situations into account (Sellberg & Rystedt 2015). In this way, instructions during scenarios take the initial partial and open instructions and show how they apply to the specifics of a concrete situation. Such immediate and detailed instruction is known to 'keep the roof up', addressing skill acquisition issues that are difficult to address anywhere else, at any other point in time (Suchman 2007).

Lastly, in the *debriefing* phase, the use of the playback of the prior scenario is at the core of recreating a shared view of how all students navigate, and provides a basis for revisiting critical events. The playback forms a shared point of reference for demonstrating alternative solutions by contrasting what was done in the scenario and what should be done differently in order to follow the rules of the sea and maintain safe conduct in similar situations. A range of different instructional resources can be combined in this process. The overview and dynamic playback of the scenarios can function as an essential background on which gestures, pointing, drawings and discussion can be directed to create a common view of typical problems and how these should be addressed. In this process, issues such as where to look, which instruments to use, when to turn and when to adjust speed, can be elaborated to demonstrate how to keep a safe distance and how to show clear intentions to other ships. In this way, the application of the rules of the sea can be addressed in terms of practical and timely actions in relation to the ever-changing and situation-dependent character of navigation practice. Accordingly, the use of dynamic playbacks during debriefings offers opportunities to portray rules in a context in which their meanings can be tied to situations as they were

actually carried out and to demonstrate more preferable alternatives. Most important, the use of tools for navigation can represent a learning objective, that is something for students to master, and can also work as an instructional device of crucial importance in exhibiting nautical problems and demonstrating good seamanship in all its intricate details.

What is clearly illustrated in all of our studies is the role and importance of professional guidance, from briefing, through scenario, to debriefing. The instructional work accomplished in the simulator environment connects the simulated events with the students' experiences of the work practice encountered during on-board training, as well as showing the relevance of theoretical and abstract principles in practical situations.

### **Conclusions**

Based on results from the research project, the following guidelines for maritime instruction are provided:

1. Highlighting the details of the students' performance together with explanations on general principles and formal rules at the core of good seamanship are key to developing the students' understanding of professional competency.
2. Following this, the results stress the role and importance of providing students with specific instructions both during scenarios and in debriefing, which is crucial for the process of bridging theory and practice in ways that develop the students' professional understanding.
3. During scenarios, the timing of instructions is crucial. In order to be able to provide immediate instructions, there is a need to closely monitor the students' actions in the simulator. For this purpose, simulator technologies that offer monitoring opportunities are of great use for the maritime instructor.
4. During scenarios, instructions draw strength from the specific details that are at play in the midst of the action. To use the navigational instruments, for example, the radar display, together with artefacts such as nautical paper charts as a basis for highlighting and explaining the specific details makes the lessons concrete and grounds them in practices of good seamanship.
5. The debriefing phase is decisive for deepening the analysis and synthesising the lessons to be learned from the scenarios. The use of playback technologies for visualizing the prior scenario is essential for recreating prior events on a sufficiently detailed level where specific details of the students' performance can be highlighted and explained.

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# METHODOLOGICAL APPROACH TO TRAINING MARITIME SPECIALISTS FOR THE RISK ASSESSMENT OF EMERGENCIES IN NAVIGATION

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**Abstract** The paper considers the methodological bases of the maritime specialists' readiness formation to the risk assessment and predicting an emergency development. To create the special competencies an approach to definition of the educational content for creating the special competencies is proposed. It allows future maritime specialists to make appropriate decisions both to assess possible emergency situations and to make actions to prevent its occurrence. Also a practical-oriented methodology of assessment of the risks of emergencies and their development is considered on a real example of the navigation practice. It is assumed that the operating analysis of the current technical state of the ship, long-term statistics of its navigation practice allows to determine the character and causes of the possible failures of ship's equipment. In order to assess the situation and to make a correct decision an algorithm of actions of the ship officers is suggested to fulfill the use of the scenarios method and the method of the fault tree analysis (FTA). The paper illustrates the concrete scenario with two versions of the most unfavorable dynamics of emergency development and describes approaches to the calculation of probability assessments of the events.

**Keywords:** risks prediction, emergency situation, scenario method, fault tree analysis, sample of emergency.

## 1. Methodological bases for the formation of readiness of maritime specialists to assessment and management of the risk of emergencies

The reliable assessment of risks in navigation and their effective management come to the choice of methods and means to provide specified (normative) values of safety indicators with the minimum amount of necessary resources for realization. The system of the risk management is a set of interrelated processes and operations aimed at achieving a single goal: reducing the level of the risk. The risk management system is characterized with the most important processes and operations: monitoring the ships operating conditions, identification

and analysis of risks that occur or may be possible; developing, planning, organization and the control measures implementation to eliminate or reduce the level of risks; an analysis of the effectiveness of planned and implemented measures and their long-term consequences; positive achievements and negative experiences; a risk factor analysis based on retrospective data and expert assessments. The system based on the requirements of the International Safety Management Code (ISM Code) and Formal Safety Assessment (FSA) is used now into the safety management practice. But shipping companies solve the issues of assessing and managing the risks of emergencies mainly at the empirical level (the control of compliance with the requirements of normative documents in terms of safety of navigation is made). This is due to the following reasons: 1) The methodological basis for assessing and managing the risks of emergencies in navigation is insufficiently developed at present; 2) Maritime specialists do not receive proper educational training in the context of the development of relevant competencies in the field of the risk assessment and management. Thus, on the one hand, reducing the rate of casualties requires the search for new effective methods for managing the safety of navigation. On the other hand, the level of the competence of maritime specialists in assessing and managing risks is insufficient. Also the further development of the methodology of the assessment and risk management is required. It is possible to eliminate this contradiction by solving two main tasks: educational and scientific (Moiseenko, 2004).

The present paper is devoted to the methodological approach to determining the contents of training and the formation of functionally necessary competencies for future maritime specialists in the field of the maritime safety management and the risks of emergencies at sea. The definition of a set of competences and the elaboration of programs for their formation requires, first of all, the study of maritime transportation processes and risk management operations. It is possible to determine the external and internal factors affecting the process, to identify casualties' risk factors as a result of the study. Development of the analytical readiness of the maritime specialist is a necessary condition for the analysis of processes and risk factors. It is formed through the development of such competencies as: the ability to use knowledge in the field of mathematical disciplines, the systems theory and analysis, the philosophy and the logics. The knowledge of these subjects is necessary for the analysis of processes and systems (for example, transport), information, the accident rate. It is also very important to get abilities for monitoring external and internal environment; to generalization and formalization of processes. The study of technological processes of maritime transportation allows to determine the main competencies that are necessary for solving the tasks of risk management. For example, the maritime specialist has to have the abilities to

assess the level of the risk of the maritime cargo transportation on the basis of knowledge of the transport and physical properties of the cargo; to perform calculations of fastening deck cargo and assess its reliability and the "behavior" of the ship under extreme conditions of navigation (Moiseenko, 2004; Moiseenko and Meyler, 2011). The knowledge of the theory of risks and the research of operations, theoretical bases of managing and decision-making, organization of maritime transportation and transport logistics form the special competence of a maritime specialist. He will be able to identify qualitative and calculate quantitative risk assessments and its price; to develop measures to reduce risks, to elaborate administrative decisions, etc. Thus, in the process of training, the future specialists study almost the whole set of disciplines, whose knowledge is used to solve the problems of assessing and managing the risk of emergencies. However, as our analysis shows, they are not fully ready functionally to solve the tasks of risk assessment and management. The main reason is that specialists do not have a methodological approach to risk assessment and management, since there are no an integrative discipline or sections in the training programs where the issues of risk assessment and management would be systematically stated. In this regard, the task of monitoring the level of competence of maritime specialists in the field of risk management and safety of navigation, as well as determining the content and methods of developing professionalism in this area of activity is relevant. It is associated with certain difficulties, which are due, first of all, to the specifics of the activity of seafarers.

Firstly, for the effective implementation of this work the specialist should be qualified to solve various practical problems in the field, for example, navigation or fish catching, technical exploitation of the ship as well as the production - economical, commercial and legal activities. Secondly, it often has no a possibility to get qualified third-party assistance when a ship works at sea; there are difficulties with diagnosing problems. Thirdly, due to the specificity of their work, maritime specialists should use self-development and self-improvement as priority forms of professional development (Moiseenko, 2004). The content of maritime specialists training is represented as a combination of the following components: a system of subject' theoretical knowledge and the main trends in the development of the scientific and technological progress; professional activity and social experience; abilities and skills of researching the object of activity, i.e. skill in handling to the method of the system analysis; abilities to integrate knowledge in different subjects and use them to solve practical problems.

## **2. Assessment of the risks of emergencies and the dynamics of their development**

Let's consider a practice-oriented methodology for assessing the risks of emergencies and the dynamics of their development on a concrete example from the navigational practice (Moiseenko, 2009). The m/v "JOHN N" has a course 20 degrees to port of Durban along the Eastern coast of South Africa. An analysis of the technical condition of the ship and the statistics of work of the main engine and steering shows that there is a possibility of a failure. In particular, the forced shutdown of the main engine was happened about 20 times, the steering system breakdown occurred 5 times within last 3 years. It is necessary to note that the ship was far from the best technical condition and its age was more than 20 years. In order to ensure the safety of navigation, we show on this example the method of forecasting of the risk occurrence and the development of an emergency situation. Initial information for the analysis: the distance to the coast is 15 miles; the nature of the coast is rocky; the depths under the keel are more than 150 m.; the wind NNE 7 m/s; the current of the south direction at a speed of 1 to 1.5 knots. In this situation, there are risks of failure of the main engine or steering. What should be the algorithm for immediate action of commanding officers of the ship in the case of an emergency?

The first action of the captain of the ship: to report to the ship-owner and the insurance company about the existing problem (an incident) and the current situation. Then, if it is possible, to contact to the near situated ships with a request to be in touch (within a few hours of a trip) till a full assessment of the situation and decision making. Actions of the chief engineer of the emergency ship: to find out the reasons for the engine shutdown or the steering system breakdown and the nature of these failures. The main threat is that ship can run aground or go on the rocky shore under unfavorable circumstances if the route of the ship is near the coast. At the open sea it should pay main attention to the stability and other seagoing abilities of the ship. The algorithm of further actions of the ship officers is suggested to fulfill using the method of scenarios (Lindgren and Bandhold, 2003) and the method of the Fault Tree Analysis (Sutton, 2011) in order to assess the situation and to make a correct decision. The comprehensive method of scenarios is proposed for predicting complex processes with structural changes. It consists in establishing a logically connected sequence of step-by-step transition events from the existing state of the prediction object to the future state. Time is usually an essential factor when predicting by the method of scenarios, i.e. the process develops in time. The scenario of the development of the emergency situation is shown in Fig. 1. The scenario presents the two most unfavorable variants of the dynamics of the emergency development. The analysis of the scenarios allows to state that the most unfavorable variant includes the events: 1 - 2 - 3 - 6 - 8 - 9 - 11 - 14 - 15. However, the second

variant: 1 - 2 - 3 - 7 - 8 - 10 - 12 is also dangerous, but such a danger can arise only if the wind increases to the level of "storm". Let's further to assume that the weather forecast at this area is favorable for the next three days. Let us consider the threats to the ship on the variant № 1 of the emergency situation development. The anchor does not hold in this variant because of the depth is more than 120 m, and the ground is rocky. As a result the ship will drift with the speed of around 1.7 miles per hour under the wind speed of 7 m/s and the current speed of 1.5 knots. In this case the ship will drift 6.5 hours to a depth of 120-150 m. At this depth the ship will be situated at the distance of 3.5 miles from the shallow. The anchor will be on the rocky ground and the ship will continue to drift with the speed of about 0.4 miles per hour. The ship will be on the shallow within 8.7 hours. Thus, the ship will be on the coastal stony ground after 15 hours from the moment of the engine failure. Let us suppose that the cause of the main engine failure is associated with a fracture in the ground of the plunger of the cylinder and damage to the exhaust manifold (due to an explosion of oil cooling the ground of the plunger). In this case it is necessary to replace the plunger and put the bandage on the fracture in the manifold. According to experts, these works will take 15-17 hours. Therefore, it is necessary to "keep" the ship at a safe distance from the coastal shallow for at least 18 hours. In this regard, the rescue ship should be at the area of the emergency ship in full readiness in the next 5-6 hours. The decision to involve a rescue ship for towing the emergency ship should be taken on the basis of an analysis of the dynamics of the emergency situation development. A tree of failures reflecting the dynamics of the emergencies development is shown in Fig. 2. The tree is developed in order to identify the cause-effect relationships and calculate predictive assessments of the emergency development. Grounding the ship and its damage is the top of a tree (the point M). Two events which can lead to the ship grounding are branches of the tree. These events are connected to the top of the tree by the condition "and" because of grounding can occur under the condition of simultaneous occurrence of both these events. There are difficulties to determine quantitative values of probabilistic estimates of the events occurrence. Two cases can be here: 1) The distribution law of random variables/events is known and there is a representative statistics which is typical for frequently recurring events; 2) The law of distribution of random variables/events is unknown, which is typical for conditions of an uncertainty, i.e. the occurrence is weak studied.



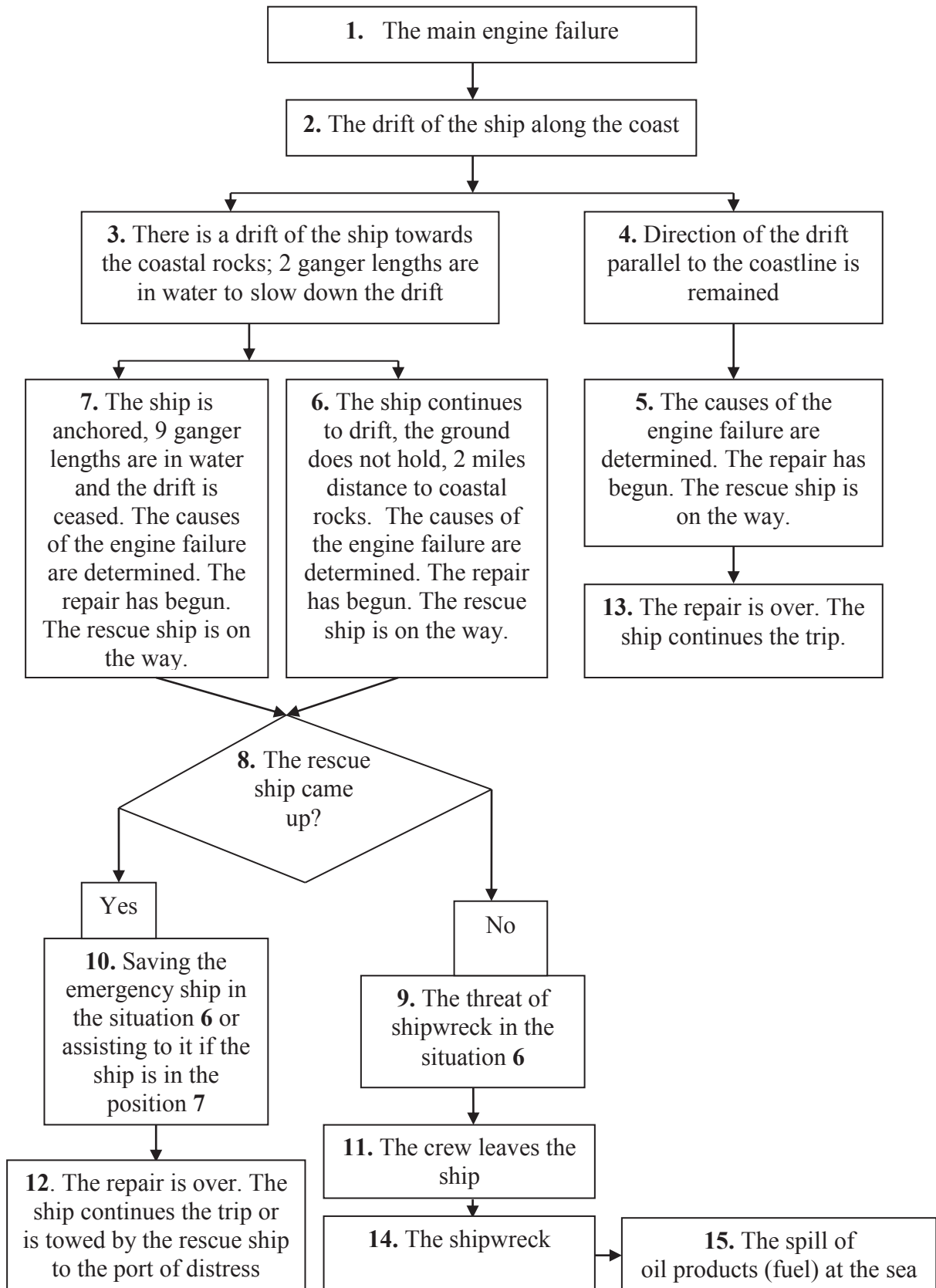


Figure 1. The scenario of the development of the emergency situation

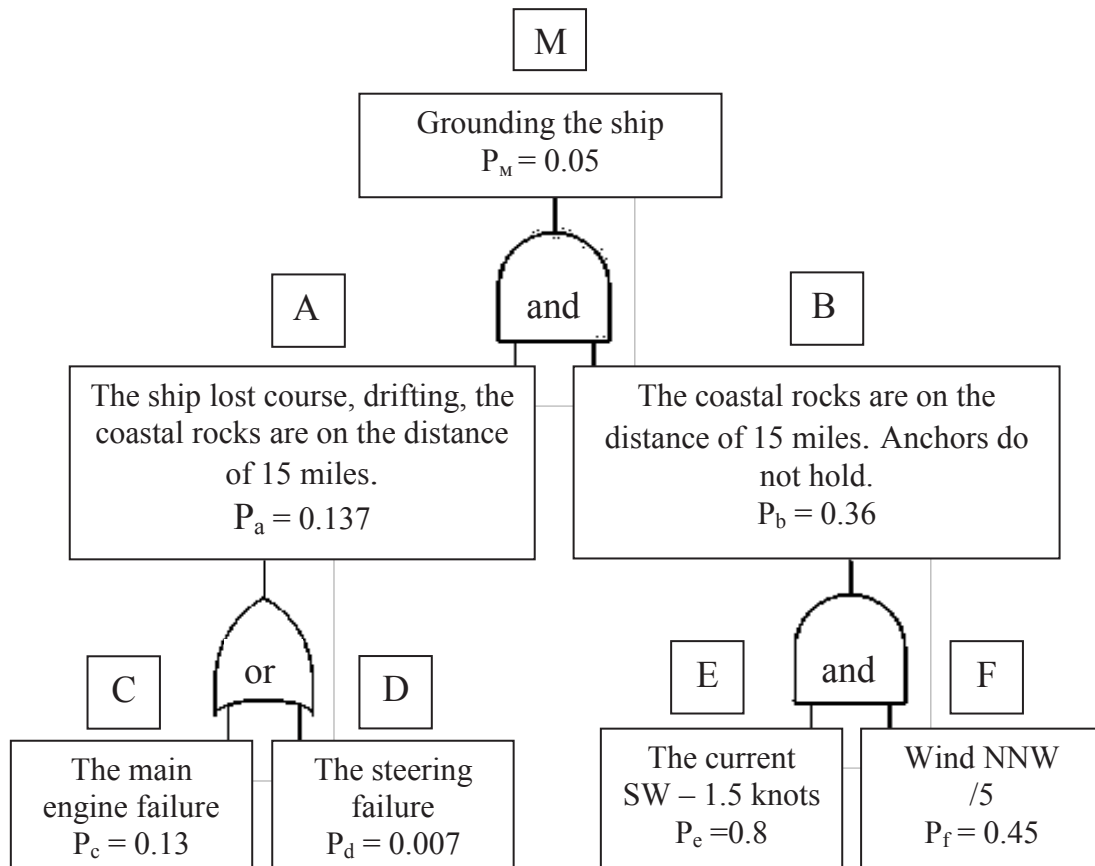


Figure 2. Tree of failures (faults)

Thus, obtaining quantitative estimates of probability is not difficult in the first case. In the second case, if the law of distribution of random variables/events is unknown, it is assumed that the random variables have a  $\beta$ -distribution. The choice of this law cannot be strictly justified. It has a density function that resembles the Gaussian law but is limited to the left and the right. The  $\beta$  - distribution considered in the context of the described problem is chosen to calculate the probability of a random event occurrence and the dispersion by known formulae (Ventzel and Ovcharov, 2016). The minimum, most probable and maximum values of the probability are determined by experts. The experts' opinion was based on the analysis of data on the failures of the main engine and steering system of the "JHON-N" ships type (Moiseenko and Meyler, 2011). Probabilistic estimates for the current and wind were determined on the basis of the analysis of the wind rose for the considered season/month of the year, the current' map and the sailing directions data. Synoptic maps and weather forecasts of coastal hydrometeorological stations were analyzed in the short-term perspective. The probabilistic estimates for each of these events are shown in Fig. 2. The signs "and", "or" are used when events changed. Probabilistic estimates of events are multiplied in the case of

the "and" sign. The estimates are added in the case of the "or" sign. For example,  $M = AB$ ;  $A = C + D$ ;  $B = EF$ . Probabilistic estimates of the events occurrence can be determined by the method of fuzzy numbers, but this method is more time consuming and requires a large number of calculations and also gives an approximate result. The Failure Tree Analysis (FTA) shows that the risk of the ship grounding i.e. the frequency of the occurrence of an event is within  $(10^{-1} \div 10^{-2})$ . There is a case of the critical event. The risk will be lower than the allowable one if safety measures are taken. It may be advisable to set the course of the ship at the definite distance from the dangers. In this case the ship can drift on clean water 18-20 hours, i.e. time required for repairing the main engine failure. The main task of the captain is to take all possible measures to keep the ship on deep water before the arrival of the rescue ship. It is necessary to develop and implement a plan of measures aimed for reducing the risk of grounding. Thus, the scenario and the tree of failures reflect the dynamics of the emergency situation development. Two main outcomes are possible in case of grounding of the ship: 1) Constructive destruction of the ship in case of severe weather conditions (winds of the western directions with the speed over than 20 m/s); 2) Damages of the hull are limited by holes in the bottom of the ship and the weather allows rescue operations. So, the ship-owner and the insurance company will take the decision to remove the ship off the rocks. The damage will be calculated either based on the fact of the ship destruction, or on the fact of the ship removal off the rocks and its towing to the port of distress. The tree of failures described above is a variant of the forecast of an emergency situation development and all calculations should be considered as a priori. How to assess the situation in the case of real events, when an emergency engine shutdown has already occurred? In this case the calculation of the risk of the ship grounding should be based on the already occurred event, i.e. the failure of the main engine. So, the probability of the failure is assumed equal to  $P_c = 1$  and hence  $P_a = 1$  also. Then the probability of occurrence of the ship grounding, i.e. the event M:  $P_m = AB = 1 \cdot 0.29 = 0.29$ . This is already a high level of a danger which belongs to the critical group according to the scale:  $10^{-1} \div 10^{-2}$  (Baldin and Vorobiev, 2012). It requires additional security measures. The most effective measure is towing the emergency ship by a rescue ship. Further, depending on the situation with the repair of the main engine, a decision is made: either continue the trip or to tow the ship to the port of distress.

## **Conclusion**

Training maritime specialists for the risk assessment is an important element of their education. Therefore, it is necessary to improve the methodological basis for assessing and managing risks in navigation in order to develop appropriate competencies and, as a consequence, to reduce the accident rate on the fleet. It is necessary to include in the curriculum disciplines that provide knowledge of the system theory, the system analysis, the risk theory and operations research, the theoretical foundations of management and decision-making, the organization of transportation and the transport logistics. The above is supported by a concrete example of the possible development of an emergency situation at sea. A real methodology for forecasting and making decisions is demonstrated. The maritime specialist should be able to "design" an emergency scenario, to give probabilistic assessments of events and to analyze the development of the situation.

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# OPTIMIZATION OF DISTANCE LEARNING IN THE SYSTEM OF SEA SPECIALISTS' POSTGRADUATE TRAINING

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**Abstract.** The growing demand for skilled and competent seafarers requires relevant delivery of qualitative training and education. The Manila Amendments of STCW provided new opportunities to distance delivery of courses to seafarers that are required for advancement in certification level. Developing courses for distant learning revealed on one hand the necessity of constant searching new forms and methods for presenting material and on the other hand the need of optimization of the existing distant learning system corresponding to challenges of modern level of maritime industry development.

The paper shows that organization of e-learning in Maritime University is aimed to support training under STCW. Composition and characteristics of e-learning environment are justified. Factors and conditions for its implementation and operation, determining the adequacy of new educational results according to Conventional and the national requirements are considered.

The contradiction between the constantly increasing requirements to the system of Maritime education, and their reflection in the content of postgraduate education is shown, and the way to resolve this contradiction is grounded. Experimental verification of the proposed content and methodology of e-learning environment are shown.

The paper proves, that despite the fact the e-learning is an integrative part that unites both contents and delivery of distance education, it has advantages and disadvantages which should be accounted while e-learning arrangement.

Specific issues on teaching technical subjects are considered and possible ways of implementation of the developed by the University courses in a learning process are shown.

**Keywords:** e-learning, distance education, maritime education, professional competence.

## Introduction

The growing demand for skilled and competent seafarers requires relevant delivery of qualitative training and education.

The analysis of the different models of lifelong learning shows that one of the most effective ways of implementing the principle of continuity in education is postgraduate education, presuming professional development of a person. It is designed to solve social and personal problems of professionals providing a sustained support for their social and professional activity.

While analyzing the state of the distance learning in Maritime education in modern conditions we highlight the following trends: improving of the educational level of the sailors; the increasing need to expand access to educational programs at all levels, including postgraduate and doctoral studies; increased interest of specialists to enhance their professional skills and training according to growing requirements of the Convention STCW 78-95 taking into account the Manila amendments 2010 [1]; the increase in the number of part-time students combining study with work etc.

### **Part 1. Postgraduate professional education for marine professionals**

Postgraduate professional education for marine professionals does not include only special social characteristics, contributing to its institutional status [2]. There is need for constant updating of knowledge, awareness and massive needs in the promotion and development of professionalism. Primarily, this occurs due to the requirements of the STCW Convention and relevant Code relating to continuous retraining in different professional spheres [1].

Currently, the following types of postgraduate professional education are distinguished: self-education, involving the implementation of individual educational programs; retraining, i.e. the possession of new specialty and practical training. The main purpose of these forms is to secure in practice the acquired knowledge; training and further advancement in a certain profession.

Analysis of the current system of postgraduate Maritime education has allowed us to highlight the contradiction that exists between the constantly increasing requirements to the system of Maritime education, the growing level of development of information society, a reflection of these processes in the postgraduate education and abilities of the pedagogical system of maritime institutions to meet growing demands of marine industry.

One way to resolve this contradiction is a wider use of distance learning. This is proved by the revised STCW Convention (the Manila Amendments of STCW) which provides for the use of distance learning and e-learning in Maritime Education and Training. Section B-1/6 of the Convention contains guidelines for training by distance learning and e-learning. These guidelines help in much in developing new courses for distance learning.

It is necessary to mention that the convention in much has simplified the task of educational institutions because it contains requirements to e-learning programs arrangement. These instructions include development of clear and unambiguous instructions for the trainees to understand how the program operates; demand to structure of a program in a way that enables a trainee to reflect on what has been learnt by both self assessment and tutor-marked assignments; and it provides professional tutorial support through different methods of communication. The convention also states that each participant should ensure that approved assessment procedures, that presumes selection of specific information to trainees and conditions of tests and examinations arrangement. Moreover, this support provides analysis of learning outcomes of a trainee (selected test questions; validation procedures to record results, etc.).

Postgraduate developing courses designed for distant learning revealed on one hand the necessity of constant developing new forms and methods for presenting material and on the other hand the need of optimization of the existing distant learning system corresponding to modern level of maritime industry development and opportunities of educational institutions.

## **Part 2. Opportunities of distance learning in maritime education**

It is evident, that distance learning based on modern information technology brings into the educational process new features: the combination of high economic efficiency and flexibility of the educational process, wide use of information resources, a significant expansion of the possibilities of traditional forms of learning, and the ability to build new and effective forms of teaching and learning.

Qualitative provision of distance learning in much is influenced by different factors and conditions. Their correct accounting while the process of its implementation and operation, determines the adequacy of new educational results according to Conventional and the national requirements.

Study of existing distance learning experience of future marine specialists allows us to conclude that the quality of distance learning provided by various Maritime universities, differs in much from the quality, achieved while traditional learning [4]. It can be explained by influence of several external and internal factors. For example, the quality of distance learning depends on the ability and competence of teachers, available resources, the level and effectiveness of the administrative system, etc. Hence it is impossible to judge the quality grounding only on the quality of educational material. The whole teaching experience is also very important.

The wide introduction of distance learning has significantly changed the higher education [3; 4; 5]. It also concerns traditional courses, indicating necessity of constant improvement in delivery methods and pedagogical support of the educational process. Among widely famous programs used for distant training of sea specialists are Videotel and Seagull. Admiral Ushakov State maritime university bought and implemented these programs to provide additional or alternative opportunities for sea specialists training.

Popularity of Videotel is explained by the fact that it is available both onboard and on shore. Moreover, there is a very impressive online library of training materials. Results are collected locally and stored centrally in the cloud making the training experience seamless and giving a person a single point of consolidated data for record keeping and training management.

The courses offered by Videotel include informative video, dynamic animated content and a substantial range of test assessment questions to motivate seafarers to learn and retain knowledge. Participation of experts in developing training materials makes them more effective and attractive both for instructors and for trainees.

Another worldwide famous provider of e-learning material for seafarers is Seagull. It offers a comprehensive library of training and onboard courses for regulatory compliance and improved seafarer knowledge. Founded in 1996 by experienced mariners it has grown into a dynamic company in partnership with leading shipping companies which deliver a full range of competence management, training administration, assessment and training tools that ensure meeting and exceeding STCW and other IMO standards [1]. Benefits of using Seagull courses are explained by the fact that they are developed in compliance with the current rules and regulations and are approved by several major flag states.

Nobody will argue the advantages of using these famous providers of distant maritime learning, but to implement them in the Russian national educational process is possible only partly. The matter is they do not fully account the Russian system of higher maritime education due to different educational standards and language of teaching.

Analysis of the best practices is valuable to any institution interested in adopting and expanding online courses, programs and degrees. Advantages of implementation of distance learning programs are evident. First of all due to flexibility that allows to work when and where it is most convenient; significantly cheaper costs; social interaction, i.e. opportunities to work in network via online forums; choosing preferred means of studying, etc.

Grounding on the fact that distance education is a system, which implementation in the learning process allow achieve certain educational qualification by trainees we can presume that it will become the basis for their further creative work and will help trainees in employment. Admiral



Ushakov state maritime university (AUMSU) has started the work on developing distance learning system accounting both conventional and national educational standards.

### **Part 3. Difficulties in implementing distance learning to overcome**

The proposed by AUMSU system is able to contribute to the solution of many urgent problems of development of Maritime education. However, it is necessary to create favorable conditions for strengthening and development of the most productive forms of specialists' training and retraining and improving the quality of their professional level providing at the same time both training in English and Russian languages and compliance with the Conventional and National standards of education, which very often do not coincide.

Productive arrangement of postgraduate education in regime of distance learning is possible in case the following problems are solved [5]:

- the lack of availability of quality services for sailors in different regions;
- the limited staff and teaching/methodical resources of distant learning arrangement;
- the increase in training volume for seafarers (financing and training time);
- facilities for instructors to supervise a trainee's achievement;
- facilitation and coordination of work on updating the content for learning;
- harmonization of methods of supplying the training material;
- increase the availability of educational services;
- reduction of financial costs for the provision of educational services, etc.

At the same time, in connection with the use of modern computer and telecommunication technologies in education there are significant changes in teaching, which also should be taken in consideration. Among them we can distinguish place and role of teachers in the educational process and their basic functions, namely:

- complexity of activities in the development of courses for distance learning;
- development of special skills and techniques of curriculum development;
- higher requirements to quality of training materials;
- the increasing role of a learner in the educational process;
- strengthening pedagogical support of a student during the learning process;
- accounting of feedback between a teacher and a student, etc.

It follows from the above mentioned that the tendencies of the organization and development of distance education for seafarers can be viewed as a two-tier system that includes both methods of organization of educational process of distance learning system, and technical equipment, which includes the channels and networks that provide network services [3].

We are sure that the main mechanism for improving the quality of distance education services is the integration of stakeholders in the educational process. Such integration is only possible when it becomes mutual benefit for all participants of educational space: the state, universities, students, employers, and so on. This requires sustained communication among experts, involved in marine field and developers of the distance courses material and the pedagogical staff participating in the educational space which must be convenient for active multilateral cooperation, search for most beneficial solutions and innovative forms of distance learning arranging. This situation dictates the need for additional training of the teacher to create distance learning courses and work with them, which in turn leads to new problems to be solved. In other words, the issue of creating and effective implementation of distance education is not easy and requires special consideration and study. It is necessary to take into account the following aspects of the traditional form of higher education:

- territoriality (inability to provide everyone with the opportunity of obtaining education);
- inertia (low adaptability of educational systems to changes in social and economic situation);
- locality (specificity of Maritime education obtained in a certain educational institution);
- limitations (inability of regional universities (branches), e.g. lack of special equipment, etc.).

One of the main task to be solved while developing national system of maritime distance education is the implementation of coordinated training of qualified personnel on the basis of agreed innovative educational programs in the field of priority interest for professional and social development of sea specialists.

At present AUMSU already has succeeded in developing several courses for distance learning of sea specialists' postgraduate training. Among the most popular are the following:

- Quality systems and organizational management;
- Maritime economics and logistics;
- Risk management in maritime sector;
- Maritime casualty investigation;
- Prevention and combating of marine pollution, etc.

These courses are provided by means of different technologies for distance education, among them are the following are:

- case-technology, which is usually reflected in structured training materials which are sent to the learner for self-study;
- TV-technology, that is based on the use of TV lectures with consultations of tutors;
- network technology, by means of which trainees are provided with instructional material and interactive communication.

All three variants are offered for postgraduate students but the most acceptable is networking technology. It can be explained by rapid development of the telecommunication transmission medium, improvement of access devices to the communication medium data and software.

The didactic cycle offered for study includes virtual lectures, seminars, practical and laboratory classes, tests, exams, etc. Networking technology allows distance education to be involved in the process of training of marine specialists.

Network support of trainees using developed distant courses removes time and spatial constraints of the interaction of teachers and helps to improve skills, share experiences and find like-minded people to support professional communication, etc. Pedagogical support of distant courses provides the educators the experience of long-life education, develops skills of professional communication and collective activities in educational space of maritime university. This support is also regarded primarily as the training that is developed and is being implemented to assist in effective professional and personal development, the formation and development of necessary competences and experience of a qualified performance of professional activity.

Experience in various technologies in Distance education led to the understanding of the need to build a universal educational space of Maritime education [2]. This space should combine the various educational institutions (secondary and higher education) by opening their virtual offices, to be distributed and to have a single means of navigation, providing the user with opportunity to quickly and easily find the information he needs.

## **Conclusion**

Currently learning software products usually are developed on selected topics of different disciplines without software support. At the same time a large number of courses, developed on good didactic basis and of deep contents is not always well graphically designed. Sometimes they are difficult in use and not always provided by the appropriate methodical materials. So, it requires further development in this direction.

The purposes of the implementation and use of information technology in Maritime education, assume correspondence with the requirements of the marine industry to the level of competence

of marine specialists, which in turn, creates new opportunities for the educational system to develop new forms and methods.

This paper has noted the significance of the inclusion of the guidelines for use of distance learning and e-learning in the training of seafarers. The paper also recommends some key criteria relevant for the selection of distant course management system for sea specialists, giving consideration to the guidelines stated in Section B-I/6 of the STCW Convention.

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## **DISTANT LEARNING ASSESSMENT SYSTEM OPPORTUNITIES FOR IMPROVEMENT QUALITY OF MARITIME EDUCATION**

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**Abstract.** No one industry can be improved and developed without professionals. It as well concerns the shipping industry, which needs well educated and trained specialists whose professionalism should meet the appropriate international maritime standards. Maritime Education and Training is essential factor for the contribution to the sustainable maritime industry development. All maritime institutions define learning outcomes by the competences the students are expected to have upon graduating. But despite the adopted standards for competence assessment and certification of seafarers there is a lack of uniformity in the adopted assessment methods and learning outcomes.

The paper describes the educational portal created on the basis of software «e-Learning Server 4G». It is proved that implementation and use of this portal in the educational environment of the Maritime University allows solving various tasks that focus on the organization of the educational process, assessing its effectiveness and quality, and also on managing the professional development of educators involved in this process.

The paper proves that modern electronic resources allow us to approximate the effectiveness of the distant form to an internal form of education, making the emphasis on independent learning. It is grounded that implementation of the developed educational portal opens new ways both for students and teachers who acquire extensive technical opportunities in the learning process.

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

## **Introduction**

Professionals are people who make industry attractive and prosperous. Any industry cannot be improved and developed without them. Well educated and trained sea specialists whose professionalism should meet the appropriate international conventional standards can be considered as the core of the sea industry in any state.

Maritime universities providing education and training of future professionals are the platforms grounding on which contribution to the sustainable maritime industry development is possible.

Further improvement of maritime education presumes the arrangement of qualified specialists' training according to the requirements of the national educational standards and international conventions. This situation requires seeking for new productive methods, forms and means of teaching.

Distance learning is one of the forms, which becomes more and more popular «Distance learning, especially targeting seafarers at sea is becoming an attractive alternative in MET... advanced software programs, simulation tools, and associated hardware enable multi-mode distance learning options ranging from passive delivery of material to interactive audio-visual sessions» [2]. Among different models of distance learning the following are distinguished: training on the type of external studies; learning based on cooperation of several educational institutions; autonomous learning; integrated learning through multimedia programs; the case-technology etc. Possibility to use modern data information technologies opens up new perspectives for increasing the efficiency of the educational process, that is a benefit for the trainees to have the opportunity of working with educational materials in accessible mode and volume. At the same time there are some weaknesses of distance learning, for example, the lack of direct communication between educators and learners, as well as inability to conduct training in distance courses in all specialties effectively. One more weakness is a lack of uniformity in the adopted assessment methods and learning outcomes.

### **Part 1. Multilevel information educational environment of the Maritime University**

Among different factors (international integration, conventional standards; growth of accidents in the Maritime transport sector; development of technologies and their implementation on ships and others) the quality of maritime education is determined by the information educational environment in which this quality is formed. Multilevel informational educational environment is formed from information and educational resources developed for different purposes and levels. As a rule, such resources include: electronic textbooks,

manuals, reference books, virtual laboratories, simulators, training programs of various complexity levels for different users. These resources can be used not only for the formation of knowledge and skills in a particular discipline, but also as a means for self-development. Multilevel information educational environment of the University is the structure with combination of complementary hierarchically related subsystems:

- public (usually presented on an official University server, and intended for common use);
- specialized (intended for specific faculties, departments, courses, etc.);
- advanced (covering the optional courses, additional programs, and designed primarily for self-study mode).

This approach to the organization of learning processes and knowledge assessment allows to get rid of unnecessary paper routine, providing the transparency of the educational process, facilitating functions of the lecturers, performing assessment and controlling functions.

Despite the large number of available software means, it makes sense to indicate a number of problems in the selection and implementation of the assessment system while a training process: incompatibility of existing systems and training materials; additional work on optimization of existing programs both by programmers, and trainers; strict requirements of many systems to technological and hardware platforms; necessity of integration into the common information space and technological infrastructure of the University, etc.

Despite all known advantages, distance learning is designed primarily for self-study, therefore, forms of control acquire new qualitative characteristics. In this regard, there is an additional opportunity for promotion of low-quality educational services, demand for which continues to be high. In this regard, the quality of education is not always the main criterion for successful employment and further professional growth of a specialist.

Mentioned problems cannot be solved immediately. Their solution requires a thorough analysis of opportunities for distance learning, a clear scientific and methodical support, high technology and accuracy in the process of its implementation and application at all levels of the education environment.

Undoubtedly, having such advantages as flexibility, modularity, cost-effectiveness, technological effectiveness, access to global information resources, etc., with appropriate scientific and methodical support, distance learning provides a high level of knowledge and thereby already takes its place in the market of educational services.

For achieving the main objectives by any Maritime institution providing training of marine specialists it is necessary to provide high quality of all conditions of the educational space, including scientific and informational content. The system of distance education may include

programs and courses of different levels (secondary, secondary vocational education; higher education; postgraduate education; professional development courses and others). Among indicators of the quality of distance training we can distinguish the following [4]:

- the availability of distance learning;
- the quality of educational services;
- resource provision of the process of distance learning;
- the effectiveness of distance learning.

Another important aspect is criteria to assess electronic resources:

- ease of access to resources;
- affordable cost of network materials;
- ability to assist users and training of users;
- stability of network resources;
- the possibility of obtaining long-term access to network resources;
- facility of license agreements;
- delays in access to materials due to congestion;
- determination of the degree of reliability of the seller and the possibilities of further cooperation with them;
- the degree of potential use (based on numbers of users and frequency of access to materials);
- easy computer interface for users, etc.

All mentioned above is included in the field of scientific and methodical support, but not only these ones. The scientific and methodical support assumes analysis of a professional field of marine specialists' activity, development of forms, methods of training and others. Moreover, the academic staff is to provide appropriate assessment tools that would allow reflect the true level of achievement of intended learning outcomes under STCW requirements.

## **Part 2. The specificity of the scientific and methodical support of distance learning in Maritime education**

The scientific and methodical support is understood as the unity of techniques, methods, means and conditions for promoting the educational objectives with use of information technology. This unity presumes: a) the need to create psychological and social conditions favorable for the educational process; b) the consistency of actions of all participants of process of learning to its distance arrangement. Scientific and methodological support of educational process of training of marine specialists should be oriented to free and responsible



choice to the trainees own educational trajectories. Its organization should be aimed at implementation of the goals set, to develop students' abilities to work in any educational environment, to implement training and quasi-professional activity in real conditions [3; 4; 5]. The main methodical requirement for research and pedagogical support of distance learning is the consideration of its essence, the internal arrangement and mechanisms governing the interaction of its components. The scientific and methodical support of distance learning for sea specialists training should be based on the following principles:

- systematic approach for ensuring target competencies and outcomes;
- modularity, implying the division of educational process into structural elements;
- poly-profile character of the content of teaching, providing knowledge in different subjects included in one's professional field;
- interactivity of educational aids;
- staging, involving a sequence of changes in the level of requirements to knowledge;
- the interrelation between methods and forms of teaching and educational process;
- adaptability, requiring the organization of the educational process, providing the sequence of formation of knowledge, abilities and skills [5].

The organization of the educational process in distance learning is expedient on the basis of situational and functional approach, under which the actions of a teacher and a student are performed in two autonomous functional systems: a leading and decisive. In the first system a leading person is the teacher, who imposes the task and leads the student to poly-profiled communicative situation, and the student accepts it. In the second system the decisive person is a student, who grounding his knowledge and skills intends to solve the obtained tasks [3; 6]. The result is the assimilation of new information, acting incrementally to an existing state of cognition. Reliance on this approach provides a gradual formation of students' knowledge and developing their competence. Teachers, organizing training and information professionally-oriented environment focus on information model of teaching that incorporates all sources of information (manuals, modeling software, databases and knowledge, information and expert system) and active participants in the educational process: teacher, introducing new teaching methods and using new teaching manuals to support the learning process and the student as an object of obtaining information and interpreting it in the form of their own knowledge and skills [3; 6]. In this regard, the issue of lecturers' skill, their level of knowledge and training is of great importance.

While constructing the scientific and methodical support of distance learning the fact of performing by a trainee both the subjective and objective actions should be kept in mind.

Their ratio should be adequate to educational activities. The student acts as an object with respect to the teacher and as a subject of his own actions. In the process of obtaining knowledge, development of competences, his role is changing. The organization of training and information professionally-oriented environment requires structuring information on different levels, systematization of the process of presentation of information, interactive communication [3; 6]. Implementation takes place by means of creation computer educational-methodical complexes on different disciplines and model courses.

Conditions of realization of distance learning for future sea specialists are depended on the following:

- the focus of distance learning on the content for studying and learning outcomes of students, their compliance with both national and international educational standards;
- poly-profile and communicative approach to the selection of educational materials for the assimilation by distance learning;
- adaptability of the methodical system of distance learning to the university space;
- the creation of the corresponding educational servers and the availability of mediation access to educational resources;
- optimal choice of forms and methods of training for distance learning;
- training and retraining of pedagogical staff for work with distance technologies;
- implementation of pedagogical monitoring of the status and results of educational process of distance learning;
- optimal system of indicators reflecting achievements in training;
- applicable version of the rating system of quality management of specialists training, etc.

Scientific and methodical support developed for distance maritime education performs the following functions:

- designing function (correspondence to the modern technological level);
- constructive function (allows select the content for the distance learning activities, choose appropriate forms and methods);
- informational and educational function meet the requirements for standards of competence, (prescribed in the relevant sections of the STCW Code and national education standards);
- communicative function (provides feedback in the communicative environment).

### **Part 3. The educational portal on the basis of «e-Learning Server 4G» software.**

Distance learning implies a shift in the focus of the educational process for self-study work of a student, which in itself should be welcomed, because only in the process of independent

consideration of tasks of a various degree of complexity a learner can obtain any "qualitative" knowledge. The definition of "quality" is in quotes, because it hardly can be used in relation to the concept of education because of poor knowledge simply does not exist.

It should be noted that distance education existed in Russia before, in the extramural form. It is assumed that part-time students independently by means of books and other auxiliary material study all disciplines and perform the necessary written works (abstracts, mathematical and graphic works, course projects, etc.). All completed individual assignments are sent by mail to an institute (the faculty of distance education) for further verification by teachers; in the case of availability of remarks, institute sends them back to finalize. Once a year part-time students are required to come to the institute for the session for submission of all tests and examinations.

Moreover, students are taught theoretical and practical parts of the planned academic disciplines under short programs, and they perform laboratory works. Typically, the duration of the session is 1,5-2 months, hence the main disadvantage of this form of training is lack of time to learn all the material that a full-time student passes for a year. That is why skeptical attitude to such form of education, to the quality of knowledge always exists.

With the development of electronic means of information transfer on distance and achievement of an acceptable stability of communication, distance education has gained a more attractive opportunities, which currently are constantly improved and new tools appear. First of all it refers to so-called educational portal (EP) providing information and educational digital space for a full-scale organization of the educational process. Now the role of self-study work of a student is becoming defining in achieving the goal of acquiring knowledge (some of the students as the main target mistakenly consider getting of a diploma). The role of a teacher in this case is not reduced at all, but now he needs to create such methodical developments that can significantly help a trainee in self-study work.

Today, leading educational institutes of Russia increasingly use in the learning process innovative methods and forms of education on the basis of remote technologies. In AUMSU the EP is created on the basis of eLearning Server 4G software.

The system solves various tasks, including:

- the creation of information and educational portal;
- development of training courses, tests, surveys, interactive exercises;
- organization of educational process and management of staff development;
- control of knowledge and registration of educational achievements;
- organization of users interaction in the learning process;

– assessment of the effectiveness of training.

It should be noted that this form of training is "more native" to modern students, and much easier in use due to its mobility and the timing of a course. At the same time, a teacher in real-time mode can control not only the results of the tasks, but their duration and intensity. For contact with the certain student it is not required to appoint particular days and time, as EP provides the opportunity at any time to contact the teacher or ask him a question.

The main conclusion of the above can be as follows: modern electronic resources allow us to approximate the effectiveness of the distant form to a full-day form of education, making a major bet on self-study learning. The teacher receives extensive technical possibilities in the presentation of information (graphics, animation, video, etc.).

## **Conclusion**

Irrespective of the chosen pedagogic approach, active student taking subjective position in the educational process is the main key to successful distance education. In this case active student participation presumes a shift from teacher-centered education to student-centered learning.

No matter what technology is used, educators should provide the quality of the outcome, corresponding to the STCW Convention requirements [1] and sustain the motivation of the students. The quality of education offered through distance learning technologies must be available. This quality to a greater extent is determined by scientific and methodical support including such aspects as:

- analysis of the functional adequacy of information and educational resources (content, a variety of methods and forms of automated teaching and knowledge control, simplicity and ease in use of these resources in the mode of self-study, consultation, etc.) for the purposes of training;
- the adequacy of the forms and modes of interaction of teachers and students using distance technologies in study.

Implementation of distance learning in a unified information and educational space provides for interdisciplinary relationships of special disciplines and the possibility of their use not only in accordance with the work plan of the specialist training in a particular semester, but when preparing diploma or studying development courses.

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# E-LEARNING ENVIRONMENT FOR SELF-STUDIES IN MARITIME EDUCATION AND TRAINING

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**Abstract.** This paper presents the educational potentials of applying Soft Model Course Database (SMCD) for self-work in maritime education and training. The paper acknowledges that model courses for self-work can be used to create a learning environment to support the teaching and training of numerous subjects under the STCW and other international conventions. The idea of the offered «SMCD» Project is directly derived from the IAMU key purpose, to create a network and forum to communicate and exchange the best maritime ideas, practices and scientific solutions and corresponds to Objective 1 «Strong IAMU membership and engagement, listed on the Annex to the Tasmanian Statement.

The proposed «SMCD» Project is the attempt to give an extra tool for developing innovative methods of the MET system. The main idea is to develop database serving as a roadmap for the creation of international or multi-national standards of self-study that could be used by maritime universities around the world.

The paper describes the main principles and the criteria of Soft model courses arrangement.

It is shown, that once properly deployed, the Soft Model Courses Database can become a constantly growing knowledge repository that enables maritime institutions to continuously extend knowledge platform. When applying in combination model courses in classroom and soft model courses in self-study modes, they can complement each other and contribute to achieve competence that is required of highly skilled professionals.

**Keywords:** model course, self-study, maritime education, e-learning

## Introduction

Existing standards of maritime education and training mandated by the International Convention on Standards of Training Certification and Watch-keeping for Seafarers (STCW) [1] and specified in terms of desirable abilities and skills of future seafarers as well as of those who work in shore companies, provide a framework for development of different approaches to selecting

among known and new methods of teaching. Today the first-priority task is not only to train specialists, whose qualification meets the Conventional requirements, but to form their skills to acquire new knowledge and skills independently.

MET system relies on the minimum standards laid down by STCW convention to achieve the required standards of competency and qualification of seafarers. But the main idea of any educational system is to prepare future specialists for advance. In this connection training of students to work in self-study regime opens additional perspectives. Maritime universities face the need to strengthen the role of self-study work of students, and therefore reconsider approaches to its organization in the educational process.

### **Part 1. The essence of self-study work**

Analysis of organization of self-study work of students from different faculties has allowed us to highlight the contradiction between the changed character of self-study work in the system of training and outdated approaches to its organization.

Self-study work of students should be provided with methodically correctly organized system of tasks that are arranged in a sequence of successive and complementary tasks of various kinds. While the learning process these tasks should be changed from reproductive to creative ones.

Maximum use of the system of self-study work of students in the educational process promotes not only the assimilation of the content of the subject, but provides the development of students' independence as an important quality of a future professional.

In didactics there are different approaches to understanding the essence of self-study work, but the idea of the most of them is to organize pedagogical conditions and a set of learning tasks, which are designed in accordance with the content of the subjects and methods of their teaching.

The important component of the considered system is the content, the selection of which usually is directed either to repeat the learned material during class hours, or to understand educational material, mastery of which is occurred in self-study regime. In this connection we've distinguished the following principles of selection of the content for self-study:

- sufficient reflection of the issue in the scientific and methodological literature;
- the accessibility of the studied material;
- its relative locality;
- gradual increase of complexity of the presented material;
- compliance with the certain level of a student training;
- module arrangement of the material.

Moreover, students should understand the role and place of the issue in the study course, as well as its logical structure in general. Providing students with appropriate literature and other

resources for the organization and execution of self-study work also should be taken into account. The means of arranging and management of self-study work of students include: tasks, instructions and methodical recommendations for their implementation, means of intermediate control, and self-control, tests, assignments, software, etc.

Another important component of the system of self-study work is control, whether current or final which is chosen depending on the type of self-study work. The form of control also is determined by the changing nature of the cognitive activity of students.

Very often the information model of education prevailing in marine specialists training mainly leads to fragmentary views in their minds. In result, the graduates with higher education do not have the experience of self-study work, and often it influences on performance of their activity in professional practice.

## **Part 2. Educational potentials of Soft Model Course Database for self-work in maritime education and training**

The idea of the Project «Soft Model Course Database» (SMCD) is directly derived from the IAMU key purpose, to create a network and forum to communicate and exchange the best maritime ideas, practices and scientific solutions and corresponds to Objective 1 «Strong IAMU membership and engagement» and Objective 4 «Achieve IAMU functional and regional cooperation», listed on the Annex to the Tasmanian Statement.

Soft model course is characterized as a course designed for self-studies which could be arranged in a different way than a Model Course. The Soft Model Courses included in the Database are meant for different methods of teaching: ranging from traditional face to face and distance learning to e-learning and blended learning, aimed at students seeking employment at sea and ashore in the entire spectrum of maritime careers at levels spanning from under graduates to post graduates. The under-lying criterion which will unite courses to be included in the database, is self-study. The Soft Model Courses included in the Database should be of optional character and both lecturers and students have the right to choose them according to their preferences. Educators from different countries and universities can participate in creation of the Database, provided they are developed on the basis of the set criteria.

The main idea of the SMCD Project is in the following:

- designing the main framework of the database of SMCD, which will include information on new ideas and courses developed and offered by maritime universities;
- developing cross national standards of self-study that may then be used to track and ensure quality of MET training;



- developing the mechanism for regular exchange of Soft model courses which can be implemented both for regular curriculum and for self-studies with the aim of providing for academic collaboration among maritime universities;
- creating free database of Soft Model Courses with purpose to offer extra opportunities for educators from different countries to maintain appropriate communication channels through the database and use them in order to improve quality of Maritime education in Universities;
- encouraging both beginners and experienced educators to develop new Soft Model Courses for optimization of educational and training process and research.

The advantages of the proposed approach to arranging self-study work of students are the following:

- reflexive-educational environment as a basis for the self-study allows the students to form stable, adequate self-esteem;
- trainees can choose any course according to their preferences among a wide range of courses which are offered for self-study;
- there are more opportunities for students in self-educational activities.

Thus, the Soft Model Course Database is a system of specially designed model courses for training of future sea specialists of different specialties and levels of training built under the Conventional and national requirements and guidelines for their use and designed for centralized storage and multi-use by Maritime universities. The offered model of the Soft Model Course Database (SMCD) presumes the following:

- regularly updated information database of disciplines (electronic textbooks and manuals, demonstration, test and other assignments, samples of completed projects, etc.);
- modular design of courses in different disciplines;
- automated system of knowledge assessment which facilitates the work of a teacher and promotes openness and objectivity of evaluation of students self-study work).
- choice of an information resource (optimum combination of electronic and traditional learning resources).

To have the courses more used they must be subject to constant update. But it should be kept in mind that due to differences in educational systems and the cultural backgrounds of trainees, the content of education varies considerably. Moreover the model course material should be designed to meet both the conventional and national requirements and recommendations.

The implementation of the Database of Soft Module Courses in the educational process helps to integrate general, special and interdisciplinary knowledge; to develop professional competences; and to develop experience in self-study.

Work with a Database of Soft module Courses as a reflexive-educational environment allows ensure access of a student in an active research position in relation to self-educational activities.

A systematic participating of students in a reflective role allows identify personal changes, to trace the dynamics of personal development, significantly influencing on the structure and the content of readiness for self-educational activities.

We have distinguished the following set of criteria and indicators of efficiency of self-educational activity of students:

- personal criterion (cognitive view of motivation includes the need for exploration, activity, stimulation, new knowledge, etc.);
- cognitive criterion (understanding of the essence of self-study activity, its role in the learning process and professional education);
- instrumental criterion, which indicates on general educational skills; constructive and practical skills; reflexive skills.

As for the organizational and pedagogical conditions we have defined the following:

- familiarization of teachers with the mechanism of students self-study work;
- creation of the methodical support for students in their self-study activity;
- optimal access of students to necessary educational resources, designed for self-study;
- providing of administrative assistance to students in the process of their self-study activity;
- free choice of means of self-study activities;
- poly-professional interaction of the teachers in the development of a software product;

Poly-professional interaction is one of the most important conditions of the SMCD functioning. This statement is grounded on the fact that being influenced by many factors such as constantly developing technologies, globalization and integration in economic and political spheres, sea specialists need to be equipped with interdisciplinary skills and knowledge to handle the dynamics and uncertainty of professional reality. This means that members of MET should use all opportunities to upgrade and exchange knowledge and experience in teaching future seafarers.

An educational module for self-study can be used as a full training course or as a certain part of the course. The module to be included in SMCD must contain a complete cycle of activities for student development including self-assessment.

A set of teaching methods used in the SMCD should provide:

- the interactive nature of the learning process (between learners and instructional material, a student and an educator, students and the virtual environment, trainees and vocational field of activity);
- the intensity of mastering of the educational content;

– the continuity of the movement of students from knowledge to understanding, to action, to creativity, providing the increase of competence of future specialists.

The offered model of the Database of Soft module Courses can play a role of extra tool to support traditional distance learning. It can be used in combination with web-based, internet-based learning programs. It is a new learning tool in a MET curriculum which can improve an educational value of the training process. Opportunities of the Database of Soft module Courses implementation are great. When applying in combination model courses in classroom and soft model courses in self-study modes, they can complement each other and contribute to achieve competence that is required of highly skilled professionals [2].

While arranging self-study work of students in the framework of the developed project, an educator acts in accordance with the algorithm shown below: 1) defines the purpose of the Soft Module Course (SMC); 2) defines the private-didactic purpose of SMC; 3) selects the content of SMC; 4) chooses the method of study; 5) chooses the form and means of SMC control.

The use of this algorithm allows define a set of tasks for self-study work for achievement by a student the required level of knowledge. And moreover, it allows change methods and tools of teaching directly in the process of passing the contents and presentation of teaching information based on the analysis of student activities.

Analysis of self-study work of students in terms of their interaction with the teacher has allowed establish that the method of activity is of great importance. In this regard, we have identified two types of self-study cognitive activity – reproductive and productive. Each of them is characterized by a certain level of independence. Both kinds of activity are closely interrelated.

### **Part 3. The organization of educational process under Soft module Course on the basis of situational and functional approach**

Any educational process should be organized in order to achieve the best planned result. In the context of our paper we consider the procedural model of SMC arrangement, as one of the possible way of the SMC development. This way represents the educational situation considered by us as a set of conditions which performance is necessary for existence of educational process. This model was designed on the basis of situational and functional approach, firstly proposed and worked out by E. Malinochka and then developed in different works [3; 4; 5; 7; etc.]. The main term here is the arrangement of the content on the basis of the analysis of professional poly-profile activity of specialists [4; 6].

This model consists of three functional blocks (readiness of students for actions on formation their competences; readiness of a teacher for formation of the certain competence of students; means of competence formation at students), which are allocated as components of the system of

activity as structures reflected in them are components of real activity. During formation of a situation, its component structure is defined, functional interrelations among components are established and there is a development of separate components by way of providing achievement of the purpose – readiness of process of competence formation [3; 4].

While functioning of the process, this situation continuously changes owing to enrichment of a current condition of erudition of students. The precise organization of educational functional system during training of future seafarers allows correspond to changes of requirements for a level of the specialists in connection with constant development of the branch, and to rate of mastering of a material. Influence of separate components can be changed under different circumstances, nevertheless, this is a self-organizing system which, finally, leads to formation of competence.

Conditions of the organization of process of the future sea specialist training under SMC include:

- a) creation of the situation developing imitation of a poly-profile and communicative industrial issues, current erudition of a student, readiness of a program and means of quasi-professional actions performance;
- b) performance of these actions, analyzing of their current results, correction and the further development on their basis of carried out actions;
- c) use of modern forms, methods, means of educational process (material and ideal means, information technologies, distant training, creation of the conditions simulating the future industrial poly-profile relations).

There is a transition of participants of the training process from a simple educational situation to a situation on the basis of integration of the content of training. This transition has inconsistent character. On the one hand, it is carried out to provide readiness of process of formation of poly-profile communicative cognition at students. On the other hand, this transition consists in increase in quantity and complication of the processed facts and theoretical knowledge about various objects of activity of sea specialist and objects of activity of his partners with the purpose of change of its quality, creation of cumulative integrated ability – poly-profile and communicative competence [2; 3; 4; 5].

The educational situation of future specialists is usually developed on the basis of the analysis of their future professional poly-profile activity. During formation of the educational situation its component structure is defined, functional interrelations among components are established. Moreover, there is a development of separate components in view of achievement of the purpose – readiness of the process of formation of the competence. Organizers of the educational process should keep in mind that during this process this situation continuously changes owing to

enrichment of a current condition of students' erudition [2]. And accounting of this fact can provide successful result in formation of learning outcomes.

## **Conclusion**

Technological knowledge is getting older every 3-4 years, with a steady positive dynamics of this process. While maintaining the same educational technologies by the end of University studies knowledge of a graduate will be largely outdated. As a consequence, the competitiveness of graduates in the labour market is not at a high level. Activation of self-study activity of students, their professional training, in fact, requires permanent search of possible ways and methods of advanced teaching. Modern information technologies offer new opportunities to improve the efficiency of the educational process. The increasing role belongs to methods of active learning, self-education, and distance educational programs.

The proposed SMCD can be considered as a means for developing of the MET system. The use of database served as a roadmap for the creation of international or multi-national standards of self-study opens extra opportunities for maritime universities around the world.

The Soft Model Courses Database is also an additional instrument in the learning process both for students and for educators in creating new methods of teaching and introducing them around the world.

When applying in combination model courses in classroom and soft model courses in self-study modes, they can complement each other and contribute to achieve competence that is required of highly skilled professionals.

Collaboration of participants of the offered Project is not locked in one region. The originality of the idea of the proposed Project is consistent with IAMU goal to invite new potential members, including different representatives of maritime industry and provide 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.

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**ONLINE TRAINING COURSES FOR MARINE ENGINEERS  
AT THE NVNA BY THE DISCIPLINES “MECHANICS OF  
MATERIALS” AND “FLUID MECHANICS” – AN  
ASSESSMENT OF THE FIRST RESULTS**

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**Abstract**

The main purpose of the project is the creation and approbation of online tests for the evaluation of Bulgarian and foreign students from the specialty Marine Engineering to the disciplines “Mechanics of materials” and “Fluid Mechanics”. The final goal is the development of a complete training course by the pointed disciplines.

The course of “Mechanics of materials” was created in e-learning platform of the NVNA - LMS Moodle. The model displaces the focus from the theoretical methods and mathematical assumptions used for the proof of basic definitions on the basic knowledge and skills that are necessary for learning of the special disciplines. Control of obtained theoretical knowledge by the form of tests and quizzes check both theoretical knowledge and obtained skills for their application. Usage of questions that use parameters allows the test to be used in the evaluation of the skills for solving the practical problems, which is especially important for the course “Mechanics of materials”. It is used for current control during the semester and to form the final grade to the discipline. The achieved results by the students are analyzed, which provides guidance for the development of new issues, dropping the others, poorly formulated or very difficult issues, and also the test gives the directions of the teacher about what was absorbed well by the students and what is not.

The course of “Fluid Mechanics” was created in e-learning platform of the NVNA - LMS Moodle. The course of that discipline offers developed test system for evaluation of theoretical knowledge and practical skills of the students from the specialty Marine Engineering

to the discipline “Fluid Mechanics”. It has been introduced electronic scale in the model course of “Fluid Mechanics”, which is based on the given number of correct answers to the test questions and practical problems, showing the final score of the student. On that basis is made an analysis of obtained theoretical knowledges and practical skills of the students from the discipline “Fluid Mechanics” which appears as feedback for the teachers and give them an indication of what should be emphasized at organizing and presenting the theoretical and practical material in form of lectures and lab exercises.

**Keywords:** Mechanics of materials, Fluid Mechanics, e-learning, Moodle, marine engineers staff

## **1. Introduction**

Specialized training of the marine engineering staff with engineering profile is provided by two main directions of the study disciplines. The first includes fundamental disciplines that give basic theoretical knowledges. The second direction includes profiling courses. The last one is characterized by their pure practical orientation. For their study, simulation complexes or high-cost computer simulators are needed.

The disciplines “Mechanics of materials” and “Fluid Mechanics” which are studied at the Department of Technical Mechanics at Nikola Vaptsarov Naval Academy have a theoretical character. To gain a good understanding of the theoretical knowledge get during the lecture course, many practical exercises are required, including solving problems and labs exercises. Due to the imposing tendency for decreasing of the total number of hours of the general engineering disciplines, this need is difficult to realize. On the other hand, another unfavorable trend is the decreasing level of students’ preparation to Mathematics and Physics with which they enter the school. At foreign students are adding something else – this is the language barrier. Even if their English language skills are excellent, studying theoretical disciplines such as “Mechanics of materials” and “Fluid Mechanics” involves many new technical terms in English that they learn for the first time. The combination of all this makes the “overcoming” of the theoretical part of the exam very difficult, and for some students even impossible. These disciplines are important as the theoretical foundations of the special training of ship mechanics, so they cannot be neglected and it has to be found a suitable approach the disciplines to be learned by the students. One of the steps taken in the Department of Technical Mechanics to solve the existing problems was to replace the traditional way of learning, and the check of theoretical knowledge to be replaced with online course including an electronic test. It was



developed on the basis of the Moodle distance e-learning platform, available through <http://moodle.naval-acad.bg/>.

## **2. Methods**

The development of the course materials does not require the use of specialized software, which is often commercial or requires advanced computer skills and knowledge from the academic staff. The theoretical materials and exercises can be provided in PDF and HTML format. These formats are easily readable not only on a personal computer but also on mobile devices – smartphones and tablets. An additional advantage of PDF or HTML formats is their small volume. The formats allow them to be used in remote learning systems at low parameters communicational channels between trainer and trainees – if they are on a ship at sea or at a port outside of Bulgaria.

In the total of three electronic courses, students from the specialty “Marine Engineering” are included, bachelor’s degree. The first electronic course is “Mechanics of materials”. It includes 53 Bulgarian cadets and students. The second electronic course is in the same discipline but it is in English. It involves 26 foreign students. The third electronic course is about the discipline “Fluid Mechanics” including 40 Bulgarian cadets and students.

Electronic courses in Bulgarian for both disciplines include online learning resources: PDF lectures, exercise assignments, and exam test, [2], [3]. The exam test of “Mechanics of materials” includes 53 questions. The maximum time for solving is 1 hour and 30 minutes. The English language electronic course to the discipline “Mechanics of materials” only exam test. The exam test includes 26 questions and it is solved for a maximum of 45 minutes. The “Fluid Mechanics” exam test includes 40 questions and is solved for 45 minutes.

Using online based tests is not only a change in the form of the exam. This greatly changed the exam’s accents, which led to a change in the whole course. The online test examines the knowledge that concerns the production of different theoretical models, the hypotheses made, the final results, as well as their practical application. The test includes following types of questions: Matching, Multiple choices - Fig. 1 and Calculated. Calculated questions are parameterized with different variables for each participant. Solving such problems checks whether the students has mastered the theory and can apply it practically. An example of this is shown in Fig. 2 question.

The **cast iron** cantilever beam, shown in figure, has **T- shaped** cross section.  
Which one from two variants (**a or b**) is better (**compare the strenght**) ?

Select one:

- a. Variant a.
- b. Variant b.
- c. The both variants are equivalent.

**Fig. 1** Matching and Multiple choice question.

Calculate the shear force in bolts from bolt connection if the force  $F = 13 \text{ kN}$ . Precision **0,01**.

**Fig. 2** Calculated question.

When creating the questions, the drawings are plotted while adhering to the machine drawing rendering rules. Several of them include 3D images created with Autodesk Inventor. A similar question is shown in Fig. 3, where the test interface with navigation panel is also visible.

The change in way of conducting the exam to the discipline “Mechanics of materials” also leads to the change of the course itself – the theoretical part is reduced, referring to theoretical conclusions with all their completeness and complex mathematical transformations for the students, as well as some details of lesser practical value. Learning content is reduced by removing some topics from the classical course in the discipline. An emphasis has been

placed on the understanding of the final results and, above all, on results' practical application. A further accent focus the students' attention on the important examples of the future ship

**Съпротивление на материалите**

Начална страница ► Курсове ► факултет "Инженерен" ► Катедра "Механика" ► Съпрогат ► Въпросник, задания, тестове  
9.01.2017 11253 ; 13.01.2017 11252; 19.0... ► Преглед

**Навигация в теста**

1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31	32	33	34	35
36	37	38	39	40	41	42
43	44	45	46	47	48	49

Приключване на опита...  
Започване нов преглед

**Въпрос 6**  
Все още не е даден отговор  
От максимално 1,00  
▼ Отбелязване на въпроса  
⚙ Редактиране на въпрос

Определете минималния **диаметър** (в mm с точност **0,1**) на конзол схемата, ако  $M_{yc} = 190 \text{ Nm}$ . Допустимото напрежение  $[\tau] = 60 \text{ MPa}$ .

Отговор:

engineer, where the obtained results find application – stresses and internal forces in ship's hull, machines and mechanisms, as well as individual machine elements, problems related to temperature stresses, mounting inaccuracies, technological processes, repairs.

**Fig. 3** Computational issue from the discipline “Mechanics of materials” with test interface and navigation panel.

The ultimate goal of both “Mechanics of materials” and “Fluid Mechanics” electronic test is to be developed into a complete online course on two disciplines including a forum for communication with students, questionnaires for exams and control papers, presentations, guidebooks, useful links on the Internet, teaching materials, assignments – everything needed to prepare the students for the disciplines.

### 3. Results analysis

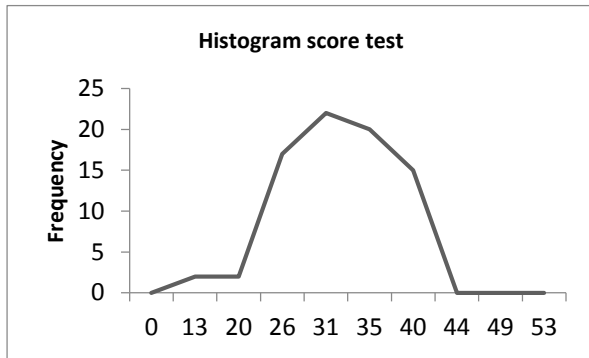
When performing the analysis of the obtained results by the students' final examinations, the following specific features for the individual electronic courses should be taken into account:

- Different learning resources in the three courses – lectures and exercises provided in electronic format;
- Different examination tests – questions, number of questions, time to solve;
- A different number of students enrolled in the courses.

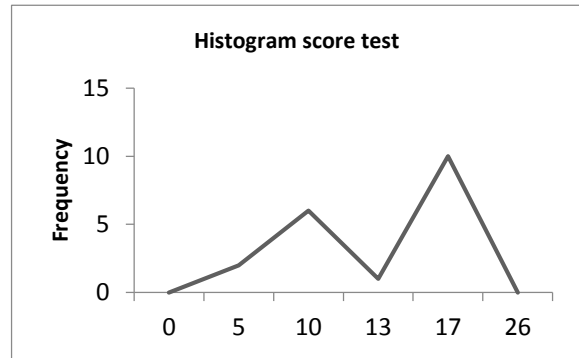
Table 1 shows the obtained statistical data during solving of the examination tests in the three courses, [1], [4]. Figure 4, Fig. 5 and Fig. 6 show the polygons of the frequency distribution of the final examination results in the three disciplines.

**Table 1**

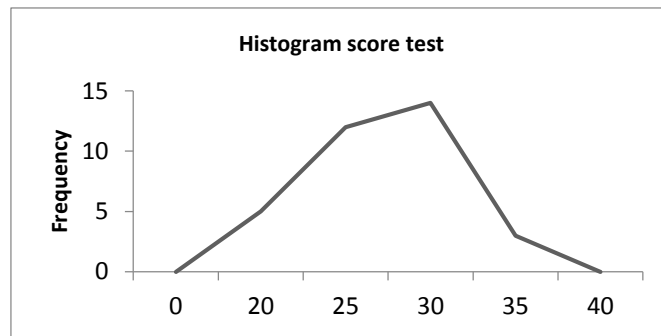
	<i>Score</i>			<i>Time</i>		
	Mechanics of materials	Mechanics of materials (foreign students)	Fluid Mechanics	Mechanics of materials	Mechanics of materials (foreign students)	Fluid Mechanics
Mean	29,616666 67	11,016842 11	24,955882 35	1:08:36	0:32:53	0:38:56
Mean (% of maximum)	55,88%	42,37%	62,39%	76,22%	73,07%	86,52%
Standard Error	0,6970885 81	0,9460580 12	0,6989831 06	0:01:47	0:01:59	0:01:27
Median	30,195	13,12	25,35	1:12:00	0:33:48	0:42:55
Mode	30,22	14,82	21	1:18:00	0:45:00	0:45:00
Standard Deviation	6,1565196 5	4,1237712 68	4,0757368 68	0:15:47	0:08:37	0:08:26
Sample Variance	37,902734 2	17,005489 47	16,611631 02	0,0001200 21	3,58139E- 05	3,42755E- 05
Kurtosis	0,5659112 75	- 1,1790143 94	- 1,0052919 12	- 0,3764184 24	- 0,0143325 5	0,7069519 51
Skewness	- 0,6726809 72	- 0,6671906 57	- 0,1949939 11	- 0,6679603 77	- 0,3295445 88	- 1,4285035 35
Range	27,92	11,97	15	0:59:10	0:31:49	0:27:04
Maximum value	53	26	40	1:30:00	0:45:00	0:45:00
Minimum	11,85	3,45	17	0:30:50	0:13:11	0:17:57
Maximum	39,77	15,42	32	1:30:00	0:45:00	0:45:01



**Fig. 4**



**Fig. 5**



**Fig. 6**

**Fig. 4, Fig. 5 and Fig. 6** polygons of the frequency distribution of the results of the finals exams in the three disciplines.

Analyzing the obtained results from the final examination tests, the following ascertainments can be made after the experiment has been completed:

- the average value of the results of Bulgarian students is over 50% of the maximum value;
- compared to the Bulgarian students, the results of the foreign students are below average;
- median and mode in all conducted investigations, except for results of the “Fluid Mechanics” final examination tests, are above average;
- in the results of the “Mechanics of material” final examination test, the frequency distribution is the closest to normal and kurtosis is positive (the polygon curve is pulled to the maximum value);
- asymmetry’s coefficients are negative for all tested parameters;
- in all conducted investigations, the asymmetry’s coefficient is negative i.e. the frequency distribution is left asymmetrical.

#### **4. Conclusions**

1. The use of online courses and test examination in an electronic version result in an average score for Bulgarian students exceeding 50% of the maximum score.
2. The use of an online version of the exam in the form of test reduces the subjective factor in knowledge control.
3. Use of pre-created online test in English reduces the influence of the language factor during the exam.
4. As a recommendation, it can be pointed out the development of teaching materials in electronic format in English and their addition to the distance learning system – Moodle.
5. An exemplary form of conducting the quiz – as current control after each of two main part of the “Fluid Mechanics” course can be a theoretical question and a calculated problem.

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# INNOVATIVE METHODS FOR QUALIFICATION IMPROVEMENT OF STUDENTS AND YOUNG SCIENTISTS BY CREATING A MOBILE COMMUNICATIONS TRAINING CENTER

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**Abstract.** Innovative teaching and learning methodologies such as lectures, simulations, role-playing, portfolio development and problem-based learning are very useful in addressing the rapid technological advances. It is important to interrogate a number of strategies and methods that become critical when there's need to motivate and increase enthusiasm in students. The aim of this article is to show how the established new training center and laboratory at Nikola Vaptzarov Naval Academy could improve their qualification. Innovative methods to train students and young specialists in the field of mobile communications and IT have been suggested. In this paper only the mobile communications aspect will be considered.

Two year work resulted in a laboratory that has been completed after gaining an approval for additional financing supported by the Bulgarian Ministry of Education and Scientific Researches Fund as well as Telenor Bulgaria. A dedicated area was built with working places equipped with PC workstations and connected in a local area network. Experimental settings were created with modern microwave radio relay stations and multiplexers to provide intranet enhancement and to establish connections to remote locations of the Bulgarian Navy. Innovative methods were introduced- such as the so called learning by doing science.

Stimulation of creative and intellectual abilities of students through modern technologies is important in order to enjoy their learning experience far more than the traditional approaches. Incidental methods, problem based learning and computational thinking have to be considered while students work with real equipment. Innovative teaching methodologies using self configured experimental staging would enhance student participation and promote interaction. A questionnaire will be introduced to assess the skills of students due to the new methods mentioned above and compared with those traditionally taught.

**Keywords.** Mobile communications, laboratory, microwave radio, IT platform, base transceiver stations, traffic measurement, field sensors, incidental learning, problem based learning

## 1. Introduction

It is uncertain nowadays if traditional methods and conventional assessment are as effective as they are believed to be. This article is about new pedagogical aspects implemented in the education by creating this mobile communications training centre. Innovative teaching and learning methodologies such as lectures, simulations, role-playing, portfolio development and problem-based learning are very useful in addressing the rapid technological advances. It is important to interrogate a number of strategies and methods that become critical when there's need to motivate and increase enthusiasm in students. What is taught should also be intelligible as the students become familiar with the expected standards. New methods should provide a free-flowing learning process [1]. Traditional didactic lectures limit the opportunities for student interaction, but recent attempts to provide greater student interactions in lectures have resulted in much higher satisfaction, higher thinking skills and enhanced motivation. The modern lecturing is definitely undergoing significant changes and with the net generation as the main audience, it will be vital for lecturing to move with the time and to adopt more innovative techniques to keep students engaged [2].

In the digital world where students have an extensive amount of visual information, in-depth knowledge of a topic and higher thinking skills could be at risk. So, implementation of innovative methods though with benefits, should be carried out with caution. For some students who are overwhelmed by media multitasking, it may seem that the traditional lecturing model of keeping it simple, could be a relief from the digital environment [3]. Active learning and collaboration are critical components of successful teaching. But one should always remember that the traditional method of lecturing will offer students the opportunity to have quality information from an expert with personal overviews that may not be available on-line [4].

**2. Materials and methods.** The project was undertaken in the period 2014-2016 in the region of Varna. Twenty-two people have been involved including the director, one coordinator, two consultants, team members and external members. It has been supported by Ministry of Education state funding and a partnership with Telenor Bulgaria.

**The aim** of this article is to show how the established new training center and laboratory at Nikola Vapzarov Naval Academy where implementation of innovative methods



to train students and young specialists in the field of mobile communications and IT could improve their qualification.

**Secondary objectives are:**

- To improve the qualification level of the engineers who intend to join the Bulgarian mobile communications operators and include the corresponding training courses in their program for professional growth.
- To promote the positive development of training in information and communication technologies in the region of neighboring Balkan countries,
- To develop virtual LAN over various communication channels.
- To create a chain of serious partnerships with communication companies – such as Telenor Bulgaria and Vivacom.

**3. Suggested innovative methods**

First method proposed is so called **learning by doing science** [5]. Engaging with authentic tools and practices such as controlling laboratory experiments can build science skills, improve conceptual understanding and increase motivation. Access to specialized equipment is now expanding to trainee teachers and university students. With appropriate support, access to lab will deepen understanding by offering hands-on investigations and opportunities for direct observation [6]. Context enables students to learn from experience. By interpreting new information in the context of where and when it occurs and relating it to what they already know, they come to understand its relevance and meaning. Beyond the classroom, learning can come from an enriched context such as this laboratory. There are opportunities to create context, by interacting with the equipment. This is a **context based learning** [8]. Working in a laboratory can be considered as learning in informal settings. This is known as **crossover learning** [9] This appears to be an effective method first to propose and discuss a question during lecture. Then learners are expected to explore that question in the laboratory, collect problems and notes, then share their findings to produce individual or group answers. Such learning experiences exploit the strengths of both environments and provide learners with authentic and engaging opportunities for learning. Students can advance their understanding of science by arguing in ways similar to professionals. This is also a method called **learning through argumentation** [10]. Argumentation helps students attend to contrasting ideas, which can deepen their learning. It makes technical reasoning public, for all to learn. It also allows students to refine ideas with others, so they learn how scientists

work together. When students argue in scientific way, they learn how to take turns, listen actively, and respond constructively to others [7].

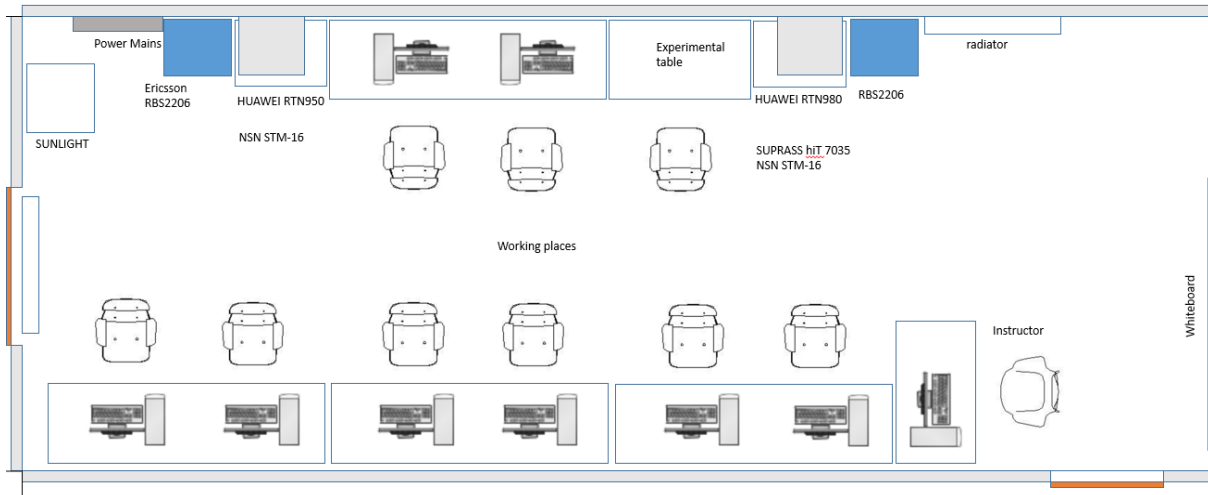
#### **4. Proposed realization essentials and learning methods**

The laboratory consists of eight working places equipped with PC workstations and connected in a local area network. (See Fig.1.) There's one instructor place operating a server running dual OS – Microsoft Windows Server 2016 and Ubuntu Linux Server 16.04.2.LTS. The practice classes included in the educational program concern three subjects – Mobile communications (including also topics on Traffic Microwave Transmission), Information Management and Communication Exchange technologies.

The place contains the following equipment –

- Power supply rack SUNLIGHT model SPSSD -3000 with incorporated battery department including 4pcs of MonoLite 100Ah 12V
- Rectifiers/ chargers SUNLIGHT model SMR-D 48VDC
- Two base transceiver stations manufactured by Ericsson - Model RBS2206 GSM/ EDGE second generation. Used for educational purposes and not connected to the transmission of traffic.
- Two STM-16 Multiplexer equipment manufactured by Nokia Siemens Networks Model SUPRASS hiT 7035
- Three hybrid microwave stations manufactured by HUAWEI model OptiX RTN 950 and RTN 980 running three radio network baseband units ensuring duplication of the digital channel communication
- Two analog microwave stations by Allgon Microwave Radio (AMR) Model R1A ensuring 4xE1 capacity transfer operating in the 18GHz band
- Antenna complex with outdoor units and feeders operating on 28MHz band utilizing dedicated channels

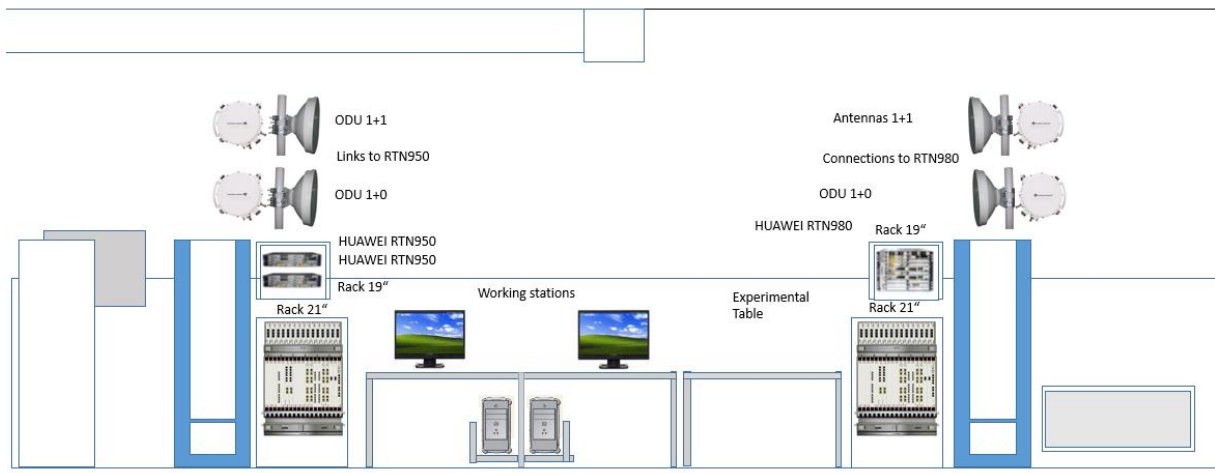
Traffic generator (VIAVI model MTS-5800) is utilized for input data to the multiplexers manufactured by Nokia Siemens Networks, having optical fibre connection between each other. The Ethernet ports and the E1 ports are configurable and a task for the students is to route the traffic from a certain port to another one on the distant side. This is a problem based learning method [7].



**Fig.1.** Allocation of the working places and the equipment from above

Second part of the task is to configure an optical fibre connection between the multiplexer and microwave station (Optix RTN 980) having such feature. Fig.2. shows side view of the equipment allocation. The traffic generated is passed from the multiplexer via the microwave equipment over radio protocol to the corresponding Huawei OptiX RTN 950 on the closer side. There is another RTN 950 microwave station receiving the traffic via Ethernet in order to supply the next destination in the neighboring campus of the Naval Academy. The software utilized is U2000WebLCT ver200R015 of HUAWEI. Using the software for configuration, it is possible to configure VLAN addressing three optional places - two in the laboratory campus and one in the neighboring campus. The configuring connection is web based over a separated port. It is a context based task. Internet access will be granted for the distant place where operates another microwave equipment (OptiX RTN 950) with autonomous and separate power supply. The power supply utilized is PowerOne model Aspiro XS19.48. The internet connectivity will be gained by the institutional LAN router with the corresponding privileges and intranet options. The outdoor units (ODU) that are utilized are HUAWEI RTN600 model 18G-HP configured to ensure 1+1 reservation and 1+0 radio connection. Measurement are usually conducted with 28MHz channel bandwidth. The center frequencies utilized are as follows:

- 28.1505GHz/ 29.1585GHz for the 1+0 configuration
- 28.2625GHz/ 29.2705GHz for the 1+1 configuration



**Fig.2.** Allocation of the working places and the equipment front side

The mentioned two microwave stations AMR R1A as described above deliver 4xE1 traffic only to each other operating on the following frequencies – 19.196GHz and 18.186GHz. The equipment is third generation indoor unit (IDU).

Code	Event Severity	Event Text	Configure
1	Minor	RSL alarm #1	<a href="#">Configure</a>
2	Major	RSL alarm #2	<a href="#">Configure</a>
3	Minor	RF ESR alarm #1	<a href="#">Configure</a>
4	Major	RF ESR alarm #2	<a href="#">Configure</a>
5	Major	RF SESR alarm #1	<a href="#">Configure</a>
6	Critical	RF SESR alarm #2	<a href="#">Configure</a>
7	Minor	RF BBER alarm #1	<a href="#">Configure</a>
8	Major	RF BBER alarm #2	<a href="#">Configure</a>
9	Critical	Security code	<a href="#">Configure</a>

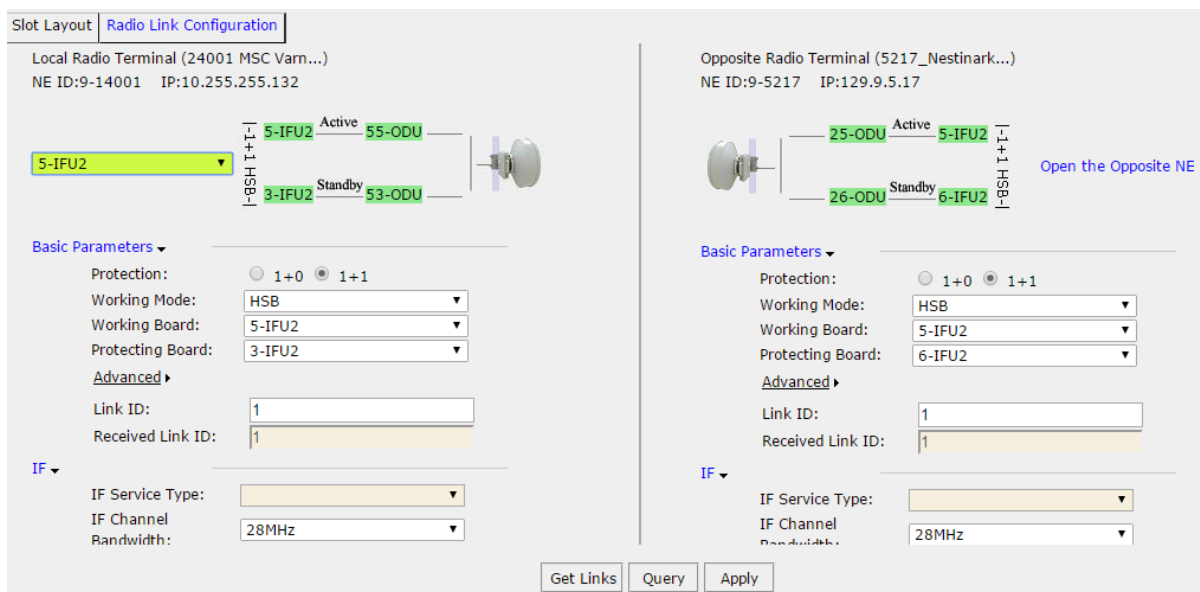
**Fig.3.** Event list of AMR R1A connected with the opposite hop partner

Using web interface configuration, the students are able to track the alarm lists, event list, event interfaces, event logs. It is also possible to conduct loop tests, radio frequency channel test, traffic channel test etc. The Fig.3. illustrates the web interface of the AMR unit, where the alarms are ordered by severity with comments and options for further action.



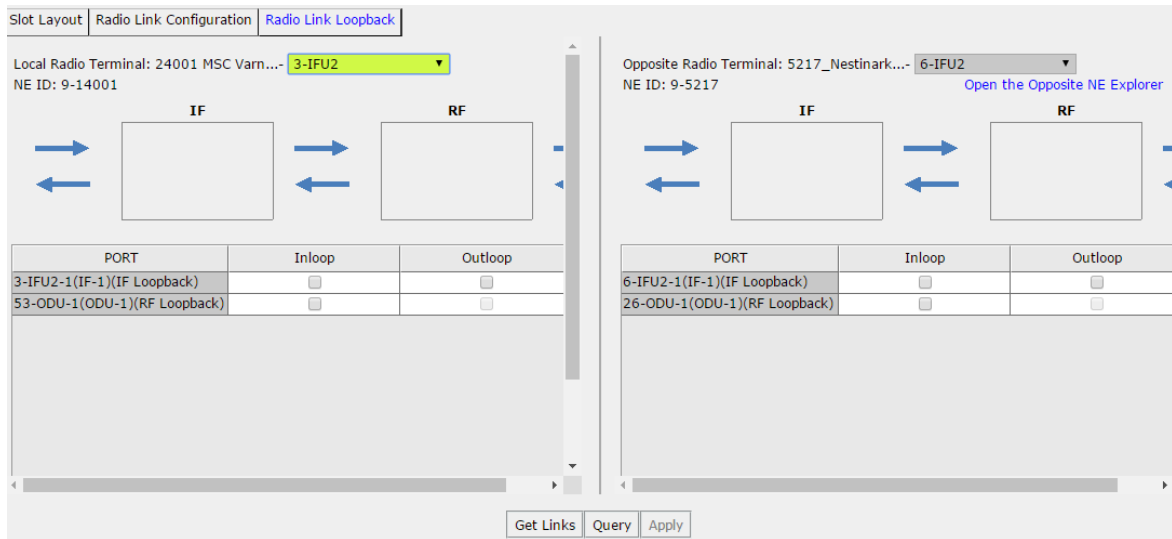
**Fig.4** Slot layout of the microwave equipment Optix RTN980

Figure 4 illustrates the main graphical interface of the manufacturer’s software where all modules are visualized with their status and corresponding alarms. Tributary/ Line loopback is also visualized and offered user friendly handling for the engineer.



**Fig.5** Radio Link Configuration showing the corresponding ODU terminals

Figure 5 shows the two microwave stations link with the corresponding IFU boards and their settings.



**Fig.6.** Configuration page used for setting radio link between microwave equipment. The IP networks, masks are entirely separate and independent. The figure 6 shows the connections between the intermediate frequency boards and the outdoor unit transceivers. It is possible to simulate loopback in order to test the sections with or without traffic.

Event	T8	T7	T6	T5	T4	T3	T2	T1
Drop Events(times/s)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
Octets Received(bytes/s)	114.4	119.6	114.4	119.6	114.4	136.4	97.6	-
Packets Received(packets/s)	1.6	1.6	1.6	1.6	1.6	1.8	1.4	-
Broadcast Packets Received(packets/s)	0.4	0.2	0.4	0.2	0.4	0.4	0.2	-
Multicast Packets Received(packets/s)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-
Packet bit error ratio(%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-

**Fig7.** Performance data using sampling interval of 5 sec.

On Fig.7 are shown performance data concerning packets received, packet bit error ratio, broadcast and multicast packets for different sampling intervals. Students are expected to trace the parameter changes and draw conclusion how to improve performance and change the configuration if possible.

## 5. Conclusions

This paper concerns stimulation of creative and intellectual abilities of students in order to enjoy their learning experience far more than in traditional approaches. Effects of innovative methods implementation will be assessed on a later stage by developing an

interactive application to measure both system performance and qualification improvement. Such innovative methodology would enhance student participation and promote interaction. Incidental methods, problem based learning and computational thinking have been considered while students work with real equipment. Automatic data collection going on in background when students work, could be applied to receive discrete assessment of the learning process. Teaching depends upon successful mode of communication and innovation. Problem based learning is a model that focuses on problem solving through self-directed strategy. The results expected are students' ability to think independently and become self-motivated. In this paper four innovative methods for qualification improvement and learning are suggested – learning by doing science, context based learning, crossover learning and learning through argumentation. Professional development can help teachers to learn strategies for learning by argumentation and overcome challenges, such as how to share the intellectual expertise with students appropriately. Since learning occurs over a lifetime, drawing on experiences across multiple settings, the wider opportunity is to support learners in recording, linking, recalling and sharing their diverse learning events. Adaptive teaching could be recommended as it uses data about a learner's previous and current learning to create a personalized path through educational content. Adaptive teaching can either be applied to classroom activities or in online environments where learners control their own pace of study.

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# LEARNING THEORIES MEET VIRTUAL CLASSROOM TECHNOLOGIES: UNDERSTANDING NEW EDUCATIONAL OPPORTUNITIES IN MARITIME EDUCATION AND TRAINING

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**Abstract.** E-Learning is transforming Maritime Education and Training (MET) systems. United Nations Educational, Scientific, and Cultural Organization (UNESCO) states that E-Learning is key in the provision of technical vocational education and training (TVET). In maritime education and training (MET) systems, the potential of E-Learning is gradually being realized. However, there seems to be a lack of attention towards a linkage between the use of E-Learning and learning theories to understand what exactly facilitate good learning practices in MET. This paper discusses the values and applications of E-Learning in MET in terms of its relevance to learning theories. An explorative case study is reported where Multi-User Learning Environment (MUVE) technologies were devised for training seafarers. Using MUVE, two virtual classrooms were developed where students from three different MET institutions, namely the World Maritime University (Sweden), Ho Chi Minh University of Transport (Vietnam), and Myanmar Maritime University (Myanmar), participated in lectures. One virtual classroom offered a lecture concerning non-technical skills and the other on technical skills for seafarers. The research was funded by the International Association of Maritime Universities (IAMU) as the project No. 2013-4. Based on the analysis and discussion of the cases, this paper furthers a structured understanding of E-Learning applications in MET by establishing a linkage with learning theories. By using the outcome of the IAMU research project on MET virtual classrooms, the paper contextualises the specific

pedagogic approaches employed in the MET virtual classrooms and makes sense of the ICT-supported methods in MET. The paper concludes with suggestions to the IAMU member universities on the use of learning theories to the introduction of ICTs in MET.

**Keywords:** Information and Communication Technologies (ICTs) · Virtual classrooms · Maritime Education and Training (MET) · Learning theories

## **1. Introduction**

A rapid development of technology and its application to education have brought a range of opportunities to Maritime Education and Training (MET). MET used to focus on mastering hard technologies, such as radar, ultrasound/sonar device, power generator, main engine, and so on. Though some modern technologies, including an electronic chart and Automatic Identification System (AIS), were added, the recent virtual, cloud-based, or robotic technologies are bringing a new phase of innovation in the maritime industry. The challenge for MET is such technologies can be adopted based on sound learning approaches to enhance the learning experiences of maritime students.

From an educator's viewpoint, this paper discusses the values and applications of E-Learning in MET with reference to learning theories. As one modern approach, Multi-User Learning Environment (MUVE) technologies are examined in connection with learning theories. Specific pedagogic approaches employed in the MET virtual classrooms from the IAMU research project are revisited to discuss the ICT-supported methods in MET for the benefit of IAMU member universities.

## **2. Modernization of MET**

This section provides an overview of MET and the application of E-Learning in education, with a particular focus on MUVE technologies.

### **2.1. MET and E-Learning opportunities**

MET is understood as part of technical vocational education and training (TVET). The United Nations Educational, Scientific, and Cultural Organization (UNESCO) promotes E-Learning as a key in the provision of TVET (UNESCO, 2012). UNESCO recognizes how ICT fundamentally impacts how we access information and how we communicate with each other

(UNESCO, 2015). ICT has a transformative impact on how we live our lives. In education, ICT developed for E-Learning and Learning Management Systems are transforming the educational landscape (*ibid*). New pedagogy and andragogy opportunities open up for delivering education in the classroom as well as through distance E-Learning. But, there are very little research about theoretical and pedagogical approaches to the use of ICT in MET.

The history of MET can go back to the Age of Sail when rather informal apprenticeship was based on on-the-job training on board ships. More formal and structured MET was developed by the adoption of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as Amended (STCW). At all time, the maritime industry has relied on competent seafarers to safely operate ships. It should be noted that seafarers are not only important to work at sea but also to use their operational knowledge in shore-based maritime jobs, such as maritime administrations, ports, educational institutions, shipping companies, and others.

MET is designed for providing specific education and training necessary to seafarers under STCW. STCW offers a comprehensive set of competence tables in which describe both managerial and operational levels of seafarers need to be trained. STCW sets out the minimum requirement of seafarers' competences and competence-based training is practised in classroom, simulators, and on-board training. There are emerging interests from both maritime administrations and industries to use online assessments for seafarers' licenses and additional certificates. More opportunities of E-Learning in MET are arriving in new model courses and train-the-trainer exercises.

Muirhead (2003) recognizes how global MET is currently subject to great change brought about by the growing impact of technology, which relates to an increasingly dynamic shipping environment and new international legislation. Muirhead's study concludes that maritime institutions can benefit from the use of new technology, but only through rational planning and sustainable staged growth.

## **2.2. MUVE technologies to transform MET**

The empirical research of this paper targets a novel E-Learning technology referred to as MUVE. MUVE describes a persistent 3D graphical environment that can be accessed over the internet and allows users to simultaneously and in real-time interact and communicate with each other (Salt, Atkins, and Balckall, 2008). A user in MUVE are digitally represented through what is referred to as an avatar, which is 3D graphical character in MUVE that is

operated by the user through a user interface such as a keyboard and mouse. A number of reputable educational institutions, including Harvard, MIT, and Open University have designed educational activities in MUVE. MUVE enables educational activities to be designed that goes beyond and complements, for example, E-classrooms that use video technologies to create shared learning spaces through introducing the dimension of space.

It is evident that the modernisation of learning experience in MET is partly facilitated by E-Learning. This paper, however, sets out to move beyond a mere excitement by technology-based learning, such as E-Learning, where the attention to learning theories may become less important in MET curriculum development processes. For this purpose, this paper uses one advanced E-Learning case (i.e., MUVE) from a IAMU research project to understand how learning theories are relevant when introducing ICT in MET, and explores the applications of modern technology in MET.

### **3. Learning theories**

Learning theories are developed to improve the understanding of how we learn in general and through structured educational activities arranged by educational institutions. In this paper, learning theories are used to improve the understanding of the application of E-Learning technologies.

Understanding how people learn has been one of the main philosophical debates since 500 BC when the Greek philosophers, such as Plato and Aristotle. While the discipline of Psychology also contributed to understand the mind of humans till the 19<sup>th</sup> century, behavioural and cognitive psychology advanced learning theories in the 20<sup>th</sup> century (Bates, 2016). According to Bloom's revised taxonomy, there are six levels of intellectual development: Remember (level 1); Understand (level 2); Apply (level 3); Analyse (level 4); Evaluate (level 5); and Create (level 6) (Anderson and Krathwohl, 2001). It is possible to assume that traditional learning practices often fall in lower levels of Bloom's taxonomy, and our research aims at transforming from the traditional MET practice of memorising information to more interactive, immersive learning with ICT.

In the use of MUVE, Pham (2012) investigated how "learning by doing" for competence-based training relates to the STCW competence tables as well as community-based learning. Pham's premise is that MUVE can be used to enable "learning by doing" through E-Learning technologies in MET. This is connected to Dewey's recognition that knowing and doing are tightly coupled (Dewey, 1916, 1958). Learning happens in the context

of an activity where a person is trying to accomplish some meaningful goals and has to overcome obstacles along the way. In addition, Pham connects the application of MUVE to practice-based social learning. This relates Wenger's (2001) notion of learning in communities of practices where learning happens through "a group of people who share an interest in a domain of human endeavor and engage in a process of collective learning that creates bonds between them".

Among many useful learning theories, this paper furthers the investigation of several relevant learning approaches to our research. A well-known pedagogical method established by Montessori is popular among the parents who have young children. In her theory, pupils' motivation is stimulated by movement which enhances thinking and learning. The teacher acts as a facilitator and creates a stimulating learning environment to develop the pupils' "absorbent mind" and make their learning experience more meaningful (Hainstock, 1997). Caine and Caine (1997) suggest a paradigm shift in teaching and assessment from memorising information to meaningful learning. A human brain accepts patterns that are relevant while it rejects patterns that are meaningless. Teachers therefore ensure that their lecture offers the right level of challenge and students are able to express their ideas in the learning process. This view is further emphasised in terms of creativity and the ICEDIP model<sup>1</sup> by Petty (1997). A learner's attitude also influences learning outcomes, hence a motivation for learning is essential (Curzon, 2006). In group exercises, Tuckman (1965) emphasises the importance of providing guidance to the team at the beginning of team formation. His group development model describes the five essential parts of the process: Forming (interaction); Storming (mingling and conflicting); Norming (problem-solving and cooperation); Performing (confidence and trust); and Adjourning (a sense of satisfaction or loss).

It is considered that the current teaching and learning practices are often based on such learning theories, which are embedded in curriculum design and delivery and designed to enhance learning outcomes. On the arrival of ICT, there is a growing interest in how people process information. A massive flow of accessible information and the availability of ICT tools in both public and private enable both teachers and students to transform the experience of education and training.

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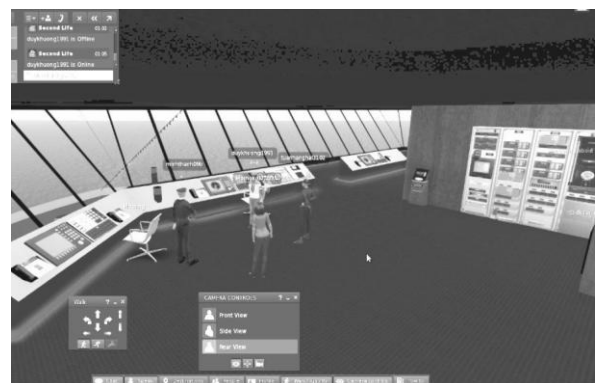
<sup>1</sup> The ICEDIP model is an acronym of six elements: Inspiration, Clarification, Distillation, Incubation, Perspiration, Evaluation. See the detail in the book by Petty (1997).

#### 4. Research methods

The paper aggregates qualitative research from two case studies that were part of a IAMU-funded research project, No. 2013-4. A common way to aggregate qualitative research is multiple case studies (Yin, 2013) or meta-ethnography (Britten et al., 2002). Multiple case studies are typically designed as such, and the cases are chosen to triangulate specific research questions. Meta-ethnography involves aggregating previously published research. This case is a hybrid between the two. In this paper, the purpose is to revisit the case studies of the IAMU research project to understand the values and applications of E-Learning in MET through the use of learning theories, which extends the analysis and discussion of the original research<sup>2</sup>.

The 1st virtual classroom as a case study focused on non-technical skills of seafarers, including leadership, teamwork, cultural awareness. Dr. Kitada of the World Maritime University (WMU) taught the class with 6 students from WMU, Sweden; 2 from Ho Chi Minh University of Transport (HCMC-UT), Vietnam; and 3 from Myanmar Maritime University (MMU), Myanmar. The 2nd case study took place on a virtual ship, focusing on technical skills of seafarers, including nautical equipment and regulations. Dr. Kitada of WMU as a teacher and three cadet students from HCMC-UT participated in the 2nd virtual ship classroom.

For analysis, the interactions both inside and outside the virtual classroom and virtual ship in MUVE were recorded by video and audio. The following section re-interprets the original empirical research and its analysis in connection to the learning theories presented in section 3.



#### 5. Empirical data analysis: Using MUVE in MET

The virtual MET classroom and ship presented a number of challenges and opportunities for

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<sup>2</sup> Find the details about the original IAMU research No. 2013-4 by Pham et al. (2014).

the application of MUVE in MET (see Pham et al., 2014). This paper focuses on the analysis of each unit of learning in relation to learning theories. Figure 1 shows the snapshots from the virtual MET classroom and ship. Table 1 and 2 make a breakdown of learning units in the respective case.

**Figure 1:** The teacher and students interacted by avatars in the 1st virtual classroom (Left) and the 2nd case on board a virtual ship(Right)

**Table 1:** The 1<sup>st</sup> virtual classroom focused on non-technical skills of seafarers

<b>Learning objectives</b>	<b>Activities</b>	<b>Achieved learning outcomes</b>	<b>Core learning theories (authors)</b>
To become aware of cultural diversity among students.	Ice-breaking. Walk around the virtual classroom and find a partner to introduce themselves.	Students engaged in talking to other students and became familiar to the diversity of classmates	The absorbent mind (Montessori)
To understand additional requirements made by the STCW Manila Amendments.	Lecture on STCW Manila Amendments	Students were able to describe what are additional requirements in the STCW Manila Amendments.	“Remember” and “Understand” in cognitive process dimension (Bloom)
To discuss and understand different needs of multinational seafarers. To understand the importance of leadership and teamwork in problem-solving.	Instruction of group work	Two groups were formed.	The group development model (Tuckman)
	Group work (A scenario was given to discuss how to use a welfare budget on board. The group worked in team and the role-play of a leader and followers was used.)	Students were able to discuss the different needs of multinational crew and reached a consensus of the wish list.	
To evaluate and appreciate the differences of crew and teamwork.	Wrap-up	Each group reported their discussion results and the teacher showed how it linked back to the knowledge about STCW.	“Evaluate” in cognitive process dimension (Bloom)

**Table 2:** The 2<sup>nd</sup> virtual ship focused on technical skills of seafarers

<b>Learning objectives</b>	<b>Activities</b>	<b>Achieved learning outcomes</b>	<b>Core learning theories (authors)</b>
To familiarise the self to the other peers and teacher.	Self-introduction.	Rapport was established.	The absorbent mind (Montessori)
To understand the different functions of nautical equipment on board.	Walk around the virtual bridge. Students need to answer the questions by the teacher.	Students were able to explain different functions of nautical equipment on virtual ship.	Meaningful learning (Caine and Caine)

To apply maritime regulations when using nautical equipment.	Students are asked which regulations relate to the operation of specific equipment.	Students were able to apply maritime regulations and explain the appropriate use of nautical equipment.	Motivation theory (Curzon); “Apply” in cognitive process dimension (Bloom)
To be creative to design a future virtual ship.	Immediate reflection and feedback.	Students were able to make suggestions and innovative ideas for their ideal virtual ship.	Creativity and the ICEDIP model (Petty); “Create” in cognitive process dimension (Bloom)

In both virtual MET settings, the learning objectives were successfully met and the relevant learning theories were applied when designing the activities of each learning unit. For example, in the 1st virtual classroom, the students’ learning was enhanced by movement (i.e., walking around by avatars) as part of the Montessori technique; the lecture on the STCW Manila Amendment was categorised as the levels of “Remember” and “Understand” in Bloom’s cognitive process dimension; the group work considered Tuckman’s group development model for effective engagement among students; and the wrap-up offered the students to evaluate and appreciate leadership, teamwork, and cultural awareness in the group work, which are relevant to the “Evaluate” level in Bloom’s cognitive process dimension. The 2nd virtual ship began again with the Montessori technique to focus on self-realisation in ice-breaking; students were excited to walk around the virtual ship and found the learning environment relevant and appropriate to themselves as cadets (i.e., Caine and Caine’s meaningful learning); with motivation (Curzon’s motivation theory), students applied regulations to the use of nautical equipment (i.e., the “Apply” level in Bloom’s cognitive process dimension); and finally students were able to present their creative and innovative ideas for a future virtual ship, and Petty’s creativity and the ICEDIP model and the Bloom’s “Create” level in cognitive process dimension helped this unit of learning.

From the analysis of two virtual MET classrooms through learning theories, it is evident that each unit of learning can be enhanced by the application of learning theories. It was assumed that learning non-technical skills would require “creativity” which is recognised as the highest level of Bloom’s revised taxonomy. Surprisingly, according to our analysis, the virtual classroom, focusing on technical skills (in this case, nautical equipment and regulations) appeared to find “creativity” and “evaluation” useful and relevant. It implies that there are a lot of potentials in MET to shift from the “Remember” level to the “Create” and “Evaluate” level in its curriculum design and delivery.



## 6. Discussion and Conclusion

In this paper, the previous IAMU research project was revisited in order to understand how learning theories can enhance learning experience of students in the virtual MET classrooms. An analysis on how learning units in MUVE are relevant to different learning theories revealed untapped potentials in MET. Even the course on technical skills can adopt the higher levels of Bloom's revised taxonomy, such as "Create" and "Evaluate". It indicates that MET can be transformed from "remembering" information to "creating" and "evaluating" knowledge in the maritime sector. The limitation of this study is the lack of consideration of various factors to influence the successful integration of ICT and learning theories in MET. It was observed, however, that students were motivated and interested in learning in the virtual MET classrooms. Further research will help to understand how effectively learning theories can be integrated in the use of ICT in MET.

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# **SIMULATOR-BASED TRAINING FOR MARITIME OPERATIONS: A COMPARATIVE STUDY**

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**Abstract** Maritime simulator-based training has attracted considerable attention in recent years. Most of the nautical institutions incorporate simulators for seafarer training. To fulfill the maritime educational requirements globally, the International Maritime Organization (IMO) ensures corresponding training requirements for all maritime educations through the STCW regulations. However, the STCW requirements regarding obligatory simulator training simply concern Automatic Radar Plotting Aid (ARPA) and Electronic Chart Display and Information System (ECDIS) training. IMO has published the model course 6.10 - *Train the simulator trainer and assessor*. The model course is a guideline and aims to promote uniformity in the simulator training. Nevertheless, the model course should not be “*implemented blindly*”, since one should acknowledge the institutions own resources and apply them in an appropriate way. Consequently, some variation in different institutions simulator training is expected. The objective of present study is to discover how such variations exist in the European full mission simulator training facilities. Semi-structured interviews were conducted to clarify each of the participating institution’s simulator training design. The interviews comprised of relevant performance indicators - e.g., Identical elements and feedback- selected after a detailed literature review. The findings present interesting variations and similarities in the European simulator training related to the designated performance indicators. Subsequently, the European full mission simulator training was found to differ, depending on whether or how, the designated indicators have been implemented.

**Keywords:** Maritime Education and Training, EU maritime institutions, Performance Indicators, Comparative study

## **1. Introduction**

Simulator-based training is now widely used by maritime institutions for nautical training programs. Simulator training can introduce different complexities depending on the simulator's fidelity [1]. The full mission simulator is described as one of the most complex simulators with a high fidelity. The full mission simulator introduces the student to complex tasks that require teamwork [2]. Therefore, a full mission simulator introduces the student to realistic tasks most similar to reality [2-4]. To fulfill the maritime educational requirements globally, the International Maritime Organization (IMO) ensures corresponding training requirements for all maritime educations through the STCW regulations. However, there are difference in training facilities available in IMO member states and therefore a variation in implementation of regulations and quality in maritime training is expected in different states. Such variation, although expected, has not been studied by academia sufficiently.

The present study aims to compare the simulator training used in different nautical bachelor educations in different states within Europe. The simulator instructors from six nautical institutions in different countries were interviewed. The comparison includes countries approved and listed on the STCW "white list" as specified by latest revision; *MSC.1/Circ.1163/Rev.9*. The study will not evaluate the simulator training in relation to specific STCW requirements, but instead, measures variations in the simulator training based on performance indicators selected from a relevant literature review. Since the main purpose of a nautical bachelor education is to educate future bridge officers to operate a vessel, the comparative study focused on the full mission simulator training. [5]. The following research question was the focus of study to support the research platform for the global maritime training programs:

*"How does the full mission bridge simulator training deviate among European countries?"*

## **2. Performance indicators**

A total of 8 performance indicators were identified. However, a detailed analysis of variation between the training facilities on these indicators will be available in a subsequent journal article. For the purpose of this paper, 2 relevant performance indicators were identified for elaboration, they are: Identical Elements, and Feedback.

### **2.1 Identical Elements**

The theory of identical elements emerged from Thorndike and Woodworth [6]. They argued that transfer of training would occur easily if the first activities in a training scenario

had identical components and tasks, as the following activity performed in real life. Therefore, a simulator training with as many identical elements as possible to reality could increase the transfer of training [3]. When establishing identical elements for a maritime simulator-based training, one must therefore look at the activity performed in real life [6]. During the bridge watch, a proper look-out shall be kept at all times [7]. The officer on watch can operate the bridge alone, except during; “*reduced visibility, costal navigation, increased traffic or other special conditions*” [8]. Subsequently, 1-2 persons usually operate the bridge. Thus, an identical training scenario in the simulator should include 1-2 students in each bridge [3, 6-8].

## **2.2 Feedback**

An important training skill during simulator training is the use of feedback [9]. A simulator session is suggested to include 4 main steps; *Briefing, Planning, Simulator Exercise* and *Debriefing*. The briefing should introduce the students towards the exercise to be executed, the objectives, and how these are covered in the exercise. After the exercise, the students usually meet the instructor for a debriefing session, preferably all together in a classroom, where the instructor has the possibility to play back the session. The debriefing is for the students to receive feedback about their performance, to review their own actions, and to learn from each other [9]. However, students can also come to rely too much on these tutoring tools [10]. If such a scenario would occur, it could reduce the understanding, instead of increasing the knowledge of the students. Such scenarios can be prevented by the instructor as long as s/he’s aware of when and how much guidance and feedback to give. This can also be called “*fading*”, where the complexity slowly increases by “*gradually withdrawing tutoring support from the training process*” [10, p. 132].

## **3. Methodology**

The research aims to understand simulator training in the participating countries, and how their facilities construct the specific training. Consequently, a qualitative research method is utilized in this research. Furthermore, since this study aims to understand how different institution’s perceives the phenomenon; *full mission simulator training*, A hermeneutic phenomenological method is utilized.

The data was collected through a semi-structured interview based on an interview guide [11]. The samples were selected based on specific parameters. All samples had to be located in different countries within Europe, presented in the *MSC.1/Circ.1163/Rev.9*. Additionally, they had to facilitate classes of approximately 30 students, increasing the comparability. Six

institutions were selected, with eight informants constituting a stratified sample of key informants. The main criteria for selecting them as key informants was the fact that they are all simulator instructors.

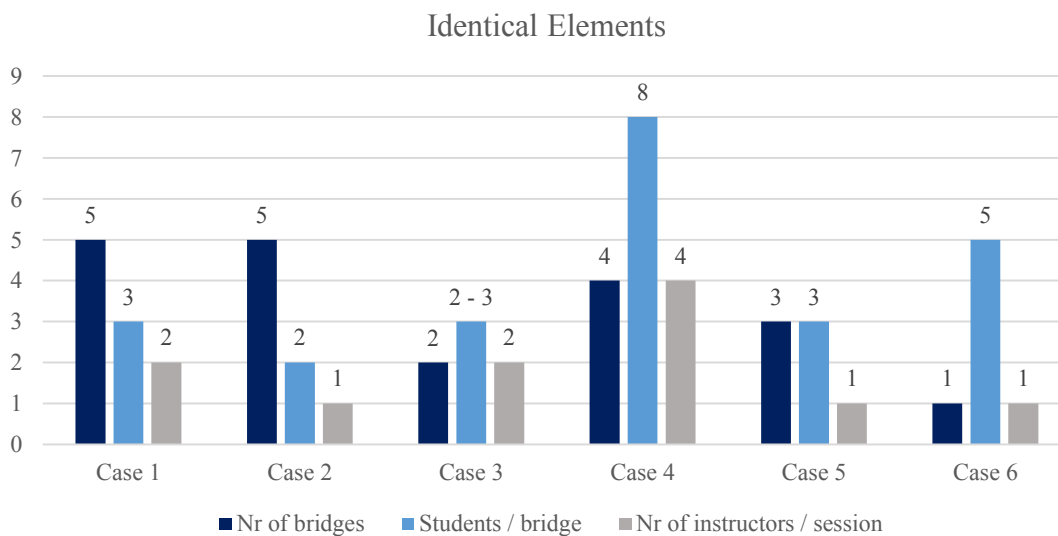
This study utilizes a *top-down perspective* where the theoretical concepts are defined first with respect to performance indicators and subsequently, the codings are presented (See Table 1). Since the codes are predefined, the coding is deductive.

**Table 1** Codings for data analysis

Main Codings	Sub Codings	Literature sources
Identical Elements	Nr of bridges	[3, 6-10]
	Nr of students/bridge	
	Nr of instructors	
Feedback	Briefing	[9, 10, 12, 13]
	Debriefing	

#### 4. Results

The simulator facilities at six participating institutions (termed as Cases) displayed some variation with respect to the identified performance indicators: Identical elements and feedback as illustrated below.



**Figure 1** Identical elements

##### 4.1 Identical elements.

Case 1's full mission simulator consists of 5 bridges, with 3 students in each bridge. The simulator training is monitored by 2 instructors. Usually one instructor is monitoring the 5

bridges from the instructor room with the use of cameras located in each bridge. Furthermore, the second instructor can enter the bridges to support the students, or act as an external person, for example as a pilot. Case 2's full mission simulator consists of 5 bridges, with 2 students in each bridge and the simulator training is monitored by 1 instructor. In the beginning of the course the instructor participates in the bridges and intervenes in the training. However, successively, the instructor decreases the intervening. Case 3's full mission simulator consists of 2 bridges, with 2 students in each bridge during the watch officer course. However, 2 extra students' works as "relieving officers". During the ship-handling course each full mission bridge contains 3 students. The simulator training is always monitored by 2 instructors which try to get the students to "*learn by doing*", and by reflecting on their performance. Case 4's full mission simulator consists of 4 bridges, with 8 students in each bridge. The simulator training is monitored by 4 instructors. The informant explained that the instructors mostly stay in the bridges with the student's, but sometimes leaves them alone for 5 – 10 minutes. Case 5's full mission simulator consists of 5 bridges, however, only 3 bridges are utilized for the students. The informant described the bridges to hold 3 students each, however each group were originally consisting of 4 students. 1 student from each group were described to be taken out, subsequently, founding a communication group. Furthermore, the simulator training is monitored by 1 instructor. The instructor monitors the students during the exercise and tries to intervene as little as possible to enhance self-learning. Case 6's full mission simulator consists of 1 bridge, with maximum 5 students. The simulator training is monitored by 1 instructor. During training, it was explained that the instructor interacts with the students via for example intercom and VHF.

#### **4.2 Feedback.**

For Case 1, The briefing was explained to occur before the exercise where the instructor describes the task they are going to perform in depth. After the exercise, an internal debriefing is conducted by the students in each bridge, followed by a debrief in the classroom. All exercises are replayed and the students can see each other's performance. For Case 2, The simulator training always starts with a briefing where the instructor explains the exercise, and different ways to approach it. After the exercise a debriefing is executed together with all students in a classroom. Information regarding what was good, and how they can improve are given to the students. Additionally, a strategy which involves thanking students who might have done mistakes is utilized. This strategy is exploited to teach the students that mistakes in a simulator is not dangerous. More importantly, both themselves and others can learn from their mistakes. All exercises were recorded as AIS-targets and

replayed during the debriefing. Furthermore, all groups performances were described to be discussed in the debriefing, among the students themselves, and among the students and the instructor. For Case 3, The briefing is mainly conducted at the first day of the course, afterwards the simulator training simply includes exercises and debriefing. After the simulator exercise the students must reflect on three questions: “*What did you do well, what could you do differently, and what have you learned?*”. Then, the student’s sailings are replayed in a classroom where the students must elaborate on the three questions asked earlier in the session. For Case 4, Briefings were described to be performed before every exercise, regarding the objective’s for the exercise, and the different scenarios. The debriefing was described to occur after all simulator exercises in the briefing room. There, the exercises are replayed, and the students are given information about what to improve. For Case 5, The simulator training usually does not start with a briefing but with a debriefing from last weeks’ exercise, conducted by the students. It was mentioned that debriefings had been done by the instructor in previous years. However, the conclusion was that “*the outcome was zero*”. During the week the designated group will prepare for the debriefing. The group will receive the replay of their exercise in combination with some suggestion regarding what they should focus on. Finally, at Case 6, Every simulator session was described to start with a briefing. The student’s receive information regarding the weather, ship data, possible faults and the routing. After the simulator session is completed, it was described that everyone will meet for a debriefing. The instructor and the student’s will analyze their performance with the use of the recorded exercise.

The results for both performance indicators: Identical elements and feedback are summarized below in Table -2.

**Table 2** Summary table of findings

<i>Main Codings</i>	<i>Sub Codings</i>	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
<b>Identical elements</b>	Nr of bridges	5	5	2	4	3	1
	Nr of students / bridge	3	2	2-3	8	3	5
	Nr of instructors / session	2	1	2	4	1	1
<b>Feedback</b>	Briefing	Yes	Yes	No	Yes	No	Yes
	Debriefing	Yes	Yes	Yes	Yes	No	Yes



## 5. Discussion

### 5.1 Identical Elements

As we can see in Table 2, there exists a variation regarding how many students each case encompassed in their simulator bridges. Furthermore, four cases; 1, 2, 3 and 5, facilitated 2 - 3 students / bridge, in comparison to case 4 and 6, which facilitated 5 – 8 students / bridge. The IMO model course 6.10 clearly states that the student's must be introduced to identical scenarios to reality [9]. Case; 1, 2, 3 and 5 utilizes approximately the same amount of student's in each bridge as they would be in a real world scenario out at sea. This indicates that the trainings are organized in a way to present the students to as identical scenarios as possible with the activities performed in real life [6, 9, 10]. Case 4 and 6 performs their training with 5 – 8 students / bridge. This indicates a negative transfer of training with a lack of identical elements [3, 7-10, 14].

Furthermore, the IMO model course 6.10 recommends that the simulator training should include minimum 2 experienced instructors [9]. The number of instructors varied from 1 respectively 4. Case 1 and 3 utilized 2 instructors during the simulator training, in accordance to the IMO model course 6.10 [9]. Half of the cases; case 2, 5 and 6, utilized 1 instructor during their simulator training's, which is below the recommended minimum requirement. However Case 4, utilized 4 instructors, which exceeds the minimum requirement, and could therefore be seen as a beneficial amount of instructors [9]. Nevertheless, if we look at the instructors intervening, it was mentioned that case 4's instructors barely leaves the student's alone in the bridge's. This indicates that the student's might come to rely too much on the instructors [10]. This suggests that the students in case 4 does not get the opportunity to practice any, or almost no, experiential learning, which could result in a reduced understanding, due to a reduced independency [9, 10].

Case 1, 2, 3 and 5, all mentioned a dynamic intervening where the students were alone at the bridges, indicating an encouragement of experiential learning. In addition, each of these case's tried to guide the students, make them aware of situations, and described how they could discuss different solutions together with the students [10]. The experiential learning in case 3 and 5 is suggested since both mentioned "*learning by doing*" and "*self-learning*" as an important factor to be aware of when interacting with the students [10, 15]. Case 1 described the second instructor to enter the bridges as for example a pilot, or as an instructor to support the students, indicating the utilization of guidance [10]. The providing of independency for the students in case 1 is also suggested, since there is only one instructors intervening in 5 bridges, enabling experiential learning [10]. Case 2 described how the

instructor tries to reduce the interaction further on in the training and subsequently, tries not to intervene at all. This could reduce the risk of the student's relying on the instructors to guide them and successively, improve the student's performance and experiential learning [10].

Case 6 described the interaction to occur via the intercom or VHF, indicating a low personal interaction with the student's in the bridges. Thus, indicating high experiential learning for the students. On the other hand, the absence of personal interaction might occur due to the fact that only 1 instructor is utilized during the simulator training [9]. Consequently, due to the absence of personal interaction, this indicates that the student's in case 6 receives less guidance during the simulator training, reducing their understanding [10].

## **5.2 Feedback**

The briefing was analyzed to be conducted by case 1, 2, 4 and 6, as can be seen in Table 2. The reason for this conclusion stems from the IMO model course 6.10, where a simulator session is suggested to include *briefing, planning, simulator exercise and debriefing* [9]. Consequently, a simulator session is suggested to start with a briefing, which four of the designated institutions complied with.

The simulator exercise was followed by a debriefing in five out of six cases; 1, 2, 3, 4 and 6. Case 5 was described to have a debriefing done by the students in the beginning of the next simulator session. Nevertheless, it was mentioned that the debriefing had been performed by the instructor in previous years, yet the outcome of this was close to zero. This could indicate that the previous debriefings performed by the instructor was conducted in an insufficient way. Primarily since feedback is found as an important tool to influence learning, and as an important part of a debriefing [9, 12]. However, this also suggests that the debriefings performed by the students may in fact enhance their learning outcome, due to an increased responsibility and hence, interaction when performing the debriefings [16]. Postponing the student's reflections until the next week as in Case 5, could however reduce the learning outcome. This is suggested since the memory of their performance could have faded and subsequently, is not as specific as if one had performed the debrief directly after the exercise.

If we look at the other cases which were found to perform the debriefing in compliance with the literature review. There is still a great variety in how the debriefings are performed and how the feedback is given. Case 1 described their debriefing to contain two distinctive segments, one internal debriefing, indicating that each group gets to reflect on their own

performance [9]. Followed by a debriefing with all the students, which suggests that all students can learn from each other, in combination with received feedback from the instructors [9]. Case 2 performs a debriefing in the classroom together with all the student's. It was described that a strategy of thanking students who might have made a mistake was utilized, since everyone can learn from this. Furthermore, this could be related to the theory of Dewey [15], "*learning by doing*".

Case 3 explained that the students must reflect on three questions – e.g., *what did I do well, what could I have done differently, and what have I learned*, after leaving the bridge. These questions can be related to the three questions; *where am I going, how am I going and where to next* by Hattie and Timperley [12], Black and Wiliam [13]. By asking these three questions the students must reflect on their performance, and thereby, enhancing their understanding [9, 12, 13]. The sailings are replayed, feedback is given to the students, at the same time they must share their three question's with each other [9]. This indicates that the student's learn from each other by sharing their reflections regarding their own performance [9]. Case 4 and 6 was described to replay their exercises, where the students receive feedback regarding their performance.

### **5.3 Limitations**

Some limitations of the study deserve attention due to research design. They would include the interpretation with respect to language, as English was used for all the participating institutions which was not native language for some of the institution. Furthermore, due to time-limitations and other factors, this study did not utilize observation as a method. Which could have been beneficial to understand each institutions simulator training in actual conditions, reducing the possibility of imprecise data collected from the informants. Finally, the scope was limited to only European countries. Future studies, with more participating countries and deeper investigation of listed performance indicators will add to increased understanding of variations across institutions and their effect on maritime training.

## **6. Conclusion**

The objective of this study was to explore different institution's full mission simulator training as a phenomenon. Since there are limited regulations regarding simulator training, thus, an existing variation between different institutions simulator training was suggested. The selected performance indicators; Identical elements and feedback, were found to deviate depending on how the different cases had implemented these indicators in the training.

Subsequently, even though some simulator trainings in Europe appears to be performed similar due to comparable proceedings, the implementations of these proceedings create dissimilarities. This study paves the way for deeper understanding of differences in the training facilities amongst the EU maritime institutions and subsequently this work is a step towards implementation of homogeneous quality in maritime simulator education across the STCW member states.

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**THE ESTUARY AS A CLASSROOM: HARNESSING  
INTERDEPARTMENTAL SYNERGIES, CAMPUS LOCATION, AND  
FACILITIES, TO IMPROVE STUDENT ENGAGEMENT IN MARINE  
TRANSPORTATION AND MARINE SCIENCE**

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**Abstract.** This study seeks to enhance opportunities for authentic learning to improve retention of course content, increase student engagement, and raise ocean literacy. The California State University Maritime Academy (Cal Maritime) is located on the Carquinez Strait, in northern San Francisco Bay, California, USA. We integrated two courses in the Marine Transportation and Marine Science curriculum to facilitate weekly oceanographic surveys aboard one of Cal Maritime's small training vessels. Students in the integrated course worked together to develop voyage plans and navigate to sampling stations where students deployed water sampling instrumentation. We anticipated that the introduction of a real-life mission would improve student engagement by providing added purpose to the class periods. By working together toward a common mission goal, students would gain proficiency in ocean literacy, navigation, and vessel operations without instruction in the formal classroom setting. To facilitate communication between the students of the two courses, a senior level student was employed as Chief Science Officer (CSO). The CSO attended every meeting of the integrated course, and educated the students in the sampling equipment operation. Student learning and engagement was assessed at the start and end of the semester using a combination of course content questions as well as surveys

addressing attitudes towards ocean stewardship. While analysis of learning assessment is still underway, here we describe the steps taken to develop and implement the integrated course model, and report on student engagement. We suggest that maritime universities should seek to identify similar interdepartmental synergies to improve student learning outcomes and student engagement.

**Keywords:** marine transportation, marine science, authentic learning, maritime university, San Francisco Bay

### **Introduction and Project Goal**

Authentic learning (AL) is learning through complex problem solving of relevant, real-world issues that are of concern to the student participants. AL is often interdisciplinary, and requires both student collaboration and peer to peer education. The authentic learning model challenges traditional models of teaching (i.e. the traditional lecture), and has been shown to lead to higher levels of interest, and increased retention of learned skills (Lombardi, 2007). AL is considered a high impact practice in higher education. There is a longstanding tradition of AL in maritime education and it is intrinsically incorporated into the curriculum of Cal Maritime's license degree programs. This project builds on existing AL in marine transportation curriculum, and expands it through a connection to scientifically relevant marine science research.

One of the greatest challenges to creating AL experiences in marine science is the ability to access the marine environment. Cal Maritime is located on the shores of the San Francisco Estuary (SFE), the largest U.S. west coast estuary (Nichols et al.1990), and one of the most studied estuaries in the world. Additionally, Cal Maritime owns several training vessels that are regularly operated as part of the license program student's sea-time requirements. These facilities are critical for AL in marine transportation and create the potential for opportunities for AL in marine science.

The project described here was funded by an internal university grant with the goal of increasing student learning and engagement in marine transportation and marine science by creating an authentic learning experience. Faculty in the Departments of Marine Transportation and Sciences and Mathematics took advantage of natural campus synergies by partnering two existing courses into a single authentic learning experience.

We predicted that the exposure of students to marine science research would improve their “ocean literacy.” Ocean literacy is defined as 1) an understanding of the essential principles and fundamental concepts about the ocean; 2) the ability to communicate about the ocean in a meaningful way; and 3) the ability to make informed and responsible decisions regarding the ocean



**Figure 1. Photograph of student and faculty participants in front of the training vessel *M/V Cub*, April 2017.**

and its resources (COSEE, 2013). Ocean literacy is generally low in the U.S. (Belden et al 1999; AAAS 2004), including among U.S. university students (Cudaback 2006) such as at Cal Maritime (Dewey et al. 2015). Maritime leaders will increasingly engage in ocean policy decision-making that should be made in the context of ecosystem and ocean-climate science. It is therefore in the

best interest of professional mariners and thus maritime universities, to develop an ocean literate workforce.

We anticipate that the introduction of a real-life mission will improve student engagement by providing added purpose to the class periods. We propose that by working together toward a common mission goal, students will gain proficiency in ocean literacy, navigation, vessel operations, and leadership, without instruction in the formal classroom setting.

### **Course Partnership**

There is a high potential for synergy between marine science and marine transportation courses. Marine science courses can benefit by gaining access to the marine environment onboard training vessels; marine transportation faculty and students can provide safe and efficient operation on the water. Similarly, marine transportation courses can benefit through partnership with marine

science courses by creating a mission to focus vessel operations training; giving marine transportation students the challenge of vessel operations to support marine science research surveys creates real-world challenges for students to solve.

Two existing courses, Navigation Piloting Lab (DL 301) and Oceanographic Instruments and Analysis Lab (MSC 200L) were partnered during the spring 2017 semester (Fig. 1). DL 301 is a weekly three-hour course where students demonstrate the practical application of voyage planning, communication, and terrestrial and electronic navigation on a power-driven small boat. Students enrolled in MSC 200L meet for 4.5 hours weekly to learn modern methods in oceanography, including the use of modern oceanographic instrumentation. Course content in DL 301 and MSC 200L was adapted to support the course partnership, but the original learning outcomes and student assessments associated with each course were maintained and students were responsible for meeting the course objectives of the course in which they enrolled. We conducted a student engagement assessment survey which consisted of four questions using a Likert-type scale and was presented to the students on week 14. Initial results of student engagement are presented in this paper.

The unique learning environment created by the intersection of ship handling and marine science also provided the opportunity for leadership development. A student was recruited to act as Chief Science Officer (CSO), serving as the link between the faculty and students. The CSO was a third-year license degree student who was pursuing a minor in Marine Science, and had previously completed MSC 200L. The CSO was responsible for weekly cruise preparation, timely sampling and collection, on-station coordination of equipment operation and deployment, and corresponding safety protocols. The CSO established assignments for each sampling position and conducted training and pre-departure meetings with students prior to each cruise.

A total of 18 students were enrolled between the two course sections. The vessel used for conducting the oceanographic surveys was 18.8 meters (65 feet) long, with a draft of 1.8 meters (6 feet). Instruments deployed on stations included a Seabird Scientific SeaCAT 19Plus profiling CTD, 10L Niskin bottles for sampling bottom water, Yellow Springs Instruments ProODO dissolved oxygen sensor, Secchi disks, and plankton nets. Water was collected for later determination of inorganic nutrient concentrations, suspended sediments, chlorophyll-a, and phytoplankton identification. The students conducted a total of nine underway surveys during the 16-week semester.



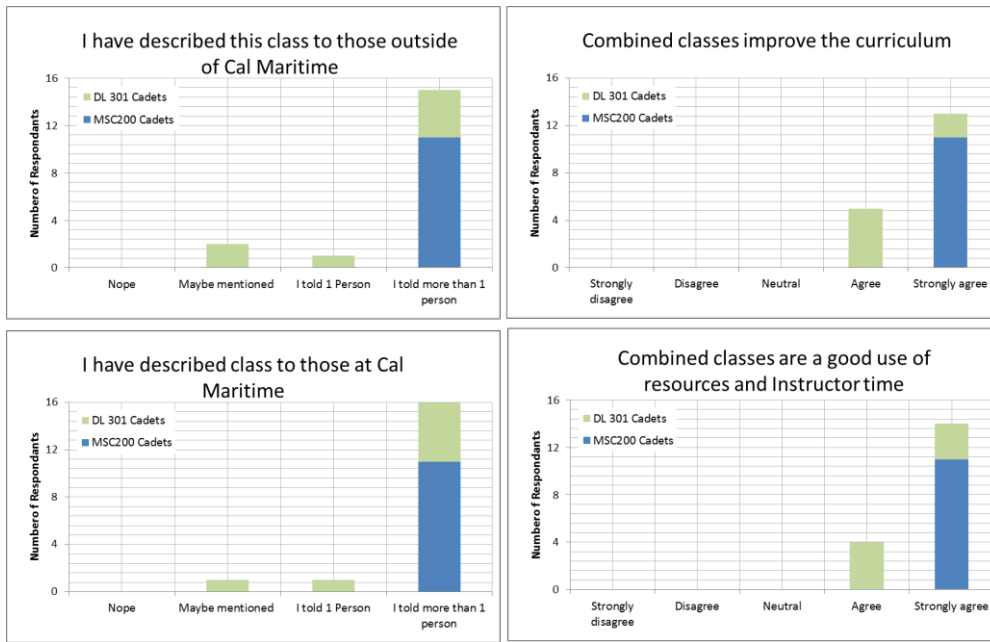
The first partnered class occurred during week two of the semester and was used for vessel and laboratory familiarization and safety. During week four, all students deployed the sampling gear at a single station and faculty hosted a professional oceanographic research technician and vessel captain to observe and advise. By week five, students were completing systematic estuarine surveys and taking on increased levels of responsibility for the project. The students were encouraged to take command of each research cruise and lab analysis, with the CSO acting as the liaison between the science team and piloting students. Students were responsible for getting and keeping the vessel on station, facilitating sampling, communicating when sampling was complete, and sharing the results with each other and the scientific community.

Marine science students were divided into three sampling teams of three or four students and the teams rotated each week. Marine science students who did not participate in the weekly survey would spend the class period working in the laboratory to analyze and process samples that were collected during the previous week's survey.

### **Initial Conclusions**

This project attempted to increase student engagement and ocean literacy through the promotion of peer-to-peer authentic learning. The observation of student engagement was inspiring. Students from both courses actively participated in the sampling operation, and DL 301 students were exposed to additional authentic learning by employing the otherwise stationary cargo boom to deploy sampling equipment. In five weeks, all students were competent in the mechanics of the operation, and were assisting with equipment deployment and recovery under the direction of the CSO. The initial time on station of 15 minutes was quickly shortened to five minutes, even with different students operating the water sampling equipment.

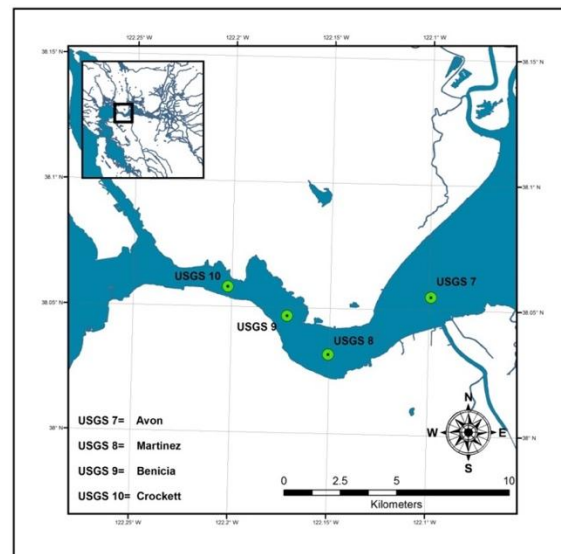
Results from the Student Engagement Survey were overwhelmingly positive. Students reported discussing the class to peers both at Cal Maritime as well as outside of the campus community (Fig. 2). All the marine science students “strongly agreed” that the partnership improved the curriculum and was worth campus resources and instructor time. Similarly, marine transportation students felt that the partnership improved the curriculum (70% “agreed”, 30% “strongly agreed”) while 57% “agreed” that the partnership was a good use of campus resources (43% “Strongly agreed”).



**Figure 2. Results from the Student Engagement Survey conducted during week 14 of project. Students were asked to respond to questions using a Likert-type scale. Marine science student responses are in blue; marine transportation student responses are in green.**

The CSO position was among the greatest successes of the project. The selection of a third-year student pursuing a minor in marine science and a major in a maritime license-granting program was an excellent fit. The CSO was an integral role in the course integration, and the lead for all sample collection. The CSO gained experience with navigation, ship handling, and use of scientific equipment while developing skills in communication, time management, problem solving, data processing, and teamwork.

One challenge of the course partnership was our limited ability to scale the program up to integrate more than one section of DL 301, and six sections of DL 301 did not have the opportunity to participate. An additional challenge was that, to maintain consistency of sampling, the DL 301 students in the integrated section were restricted to a single repeated voyage with four waypoints (Fig. 3). All other sections of DL 301 rotated through two additional routes, providing different opportunities for navigation and vessel traffic interaction.



## Next Steps

The next goal for this project is to identify additional areas for improvement, and continue to collect data which will give depth to our initial survey results. We received support for the 2017-2018 academic year and will continue to develop the partnership between marine transportation and marine science. Assessment of student learning will be ongoing and our results will be used to guide curriculum development. Peer to peer education was a critical piece of this project, but was most successful when there was some level of formal direction. We plan to increase peer to peer instruction and marine science student involvement in the voyage planning process. We will also improve oceanographic and weather observation instrumentation for the training vessel. We hope that students will contribute meaningful data to the marine science community through the dissemination of scientific data reports and online data repositories. Looking beyond the 2017-2018 academic year, we hope to integrate additional marine science lab courses with other DL 301 sections. We would like to explore the potential to invite marine science students from other institutions to join our surveys as a means for university outreach and student recruitment.

**Figure 3. Map of marine science survey waypoints occupied weekly during spring 2017.**

## Acknowledgements.

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# **HOW COULD WE TEACH CASUALTY MANAGEMENT FOR MASTERS IN MODERN SIMULATOR ENVIRONMENT? – COMBINING THE LEGAL ISSUES WITH PRACTICAL SKILLS**

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**Abstract** Simulation of the catastrophes is not the core task of the simulation environments - But avoiding them is. Therefore the simulation environment, although they are highly developed, are not yet fully ready for practicing how the casualties are taken care of. STCW has diminished the Curriculums in Maritime Universities in a way that many topics previously taught to students are now neglected. The simulator manufacturers should become interested in development of also casualty simulation in their simulators. General average situations could be taught to master through simulations if the Maritime Universities would work together with the simulations developers. The time has come to modernize the teaching in this respect. The teaching of the casualty management in general average situations like vetting the cargo, casting containers, stranding the vessel etc. is a topic, which could be combined with a modern simulator environment, if there would be interest from the manufacturer's side to hear the wishes of the training institutions. The law of general average is a legal principle of maritime law according to which all parties in a sea venture proportionally share any losses resulting from a voluntary sacrifice of part of the ship or cargo to save the whole in an emergency - For instance, when the crew throws some cargo overboard to lighten the ship in a storm. This, for example, could be simulated and practiced in the simulator environment. The next generation simulation environments for casualty management should also be generated to make it possible to train masters and crew to act according to planned scenarios. When the STCW convention does not mention it specifically, teaching GA rules has been neglected by many Maritime Universities in last decades. Bringing it back to curriculums as a practical skill of a master and crew is possible through developing the simulator environment, which makes the skills practicable instead of just theory. The article presents some ideas how this could be achieved.

**Keywords:** Casualty management, Maritime accident, Simulator teaching, Technical development

## **Introduction**

Simulation of the catastrophes is not the core task of the simulation environments - But avoiding them is. Therefore the simulation environment, although they are highly developed, are not yet fully ready for practicing how the casualties are taken care of. STCW has diminished the Curriculums in Maritime Universities in a way that many topics previously taught to students are now neglected. This issue was taken up in IAMU conference 2016 in Haiphong. This article initiated from these discussion in the conference.

The simulator manufacturers should become interested in development of also casualty simulation in their simulators. General average situations could be taught to master through simulations if the Maritime Universities would work together with the simulations developers. The time has come to modernize the teaching in this respect. The teaching of the casualty management in general average situations like vetting the cargo, casting containers, stranding the vessel etc. is a topic, which could be combined with a modern simulator environment, if there would be interest from the manufacturer's side to hear the wishes of the training institutions.

The law of general average is a legal principle of maritime law according to which all parties in a sea venture proportionally share any losses resulting from a voluntary sacrifice of part of the ship or cargo to save the whole in an emergency. The New York - Antwerp Rules on General Average (later YAR Rules), which have now been accepted by the both sides of the industry (both the ship owners and Marine Insurers organizations worldwide) have a tendency to last over three decades before a new edition is needed. Therefore, the simulator manufacturers could now be interested in development of also casualty simulation in their simulators when the YAR Rules 2016 are going to form the standard in the industry for the next decades.

The law of general average is a legal principle of maritime law according to which all parties in a sea venture proportionally share any losses resulting from a voluntary sacrifice of part of the ship or cargo to save the whole in an emergency (for instance, when the crew throws some cargo overboard to lighten the ship in a storm). This, for example could be simulated and practiced in the simulator environment. The next generation simulation environments for casualty management should also be generated to make it possible to train masters and crew to act according to planned scenarios.

In the accidents the vessels face at sea, crew members often have precious little time in which to determine precisely whose cargo they are jettisoning. While general average traces its origins in ancient maritime law still it remains part of the Admiralty law and Law of Marine Insurance and Average in shipping community.

### **Casualty management teaching before, now and tomorrow**

The before the STWC code and its implementation, YAR was taught to students worldwide. When the STCW convention does not mention it specifically, teaching GA rules has been neglected by many Universities in last decades.

Bringing it back to curriculums as a practical skill of a master and crew is possible through developing the simulator environment, which makes the skills practicable instead of just theory.

The research plan initiated at the Satakunta University of Applied Sciences is to built up a system how the Rules could be trained by the Masters, who need to implement the Rules in practice. This combines the law and practice and makes it in e-learning environment, which makes delivery of the skills possible by experts worldwide. When the Masters make the decisions worth tens or even hundreds of millions often in minutes without a possibility to ask questions from anyone in the shipping company management or insurance company, it would be fair if they would be able to practice before they make them.

The Master Mariner education still does not make use of all technology, which is available today. The simulator environment can be easily adjusted to casualty management practices if the simulator developers are financially encouraged to this work. It is up to the Maritime Universities to encourage them and lead the way by being creative and co-operative in their research and development work.

There is no scientific research available how the general average is taught at maritime Universities globally. Therefore, we need to base our information on co-operation and discussions with our member Universities in IAMU. Discussions in Haiphong 2016 revealed that the older teachers still remembered the time when this topic was lectured actively. As a general outcome from these discussions, it was found out that the topic has been more or less abandoned in the 1980's after the STCW convention came into force. Earlier generation of teachers often had practical experiences of general average situations themselves and they could use them as examples. Nowadays the situations are less common, but their financial value has been increasing. At the same time need for speed in Masters Actions has increased.

### **Simulating the casualty management**

Casualty management according to STCW includes action's in a collision or grounding. Evaluation of damages, safety of crew and passengers in these situations are basic features that need to be covered in the studies. Stability calculations are also relevant part of the casualty management. Now the physical simulation environments are not realistic enough for simulating effects of groundings or collisions as the simulators have not been planned for the purpose. Listing of the vessel, changes in ballast water tanks or cargo holds and their effects on stability of the vessel and vessels behavior in these situations are not considered even in latest simulator models. It is evident that this kind of changes would be useful even in normal navigation simulations. Especially in Northern winter conditions, it would be useful on more realistic if for example the effects of icing could be taken into account when simulating the stability of the vessel.

When evaluating different simulator environments, it was found out that oil- and chemical spills can already be simulated at certain level in some environments. It differs from manufacturer to manufacturer how realistic the spills and their effects are. Simulations for liquid cargoes are better than bulk cargoes or containers as they already can take into account stability of the vessel. Engine simulators are already more developed in taking into account casualty management and engine failures.

### **Examples of General average situations, which could be taught through simulation**

Most common general average situations, like vetting the cargo, casting containers, stranding or scuttling the vessel etc. are topics, which could be combined with a modern simulator environment, made part of the studies and combined with teaching the legal and other topics.

Rule III – Extinguishing Fire on Shipboard in YAR 2016 states the following:

*“Damage done to a ship and cargo, or either of them, by water or otherwise, including damage by beaching or scuttling a burning ship, in extinguishing a fire on board the ship, shall be allowed as general average; except that no allowance shall be made for damage by smoke however caused or by heat of the fire.”* (International)

Today one of the most common GA situations is related to container vessels and fire on board (Harvey, 2010). We have a large amount of cases where fire breaks out in one container and very often that is not the container on top of the others but one below. Sometimes the reason is that the containers with flammable materials (like packed HNS) has been placed too near the sources of heating boilers etc. Vetting all the cargo above is a costly and dangerous



procedure, which could be simulated. Simulations could also be connected to the outcome of the legal and financial outcome as well as how the simulated process affects the stability of the vessel in order to control that the vessel does not become actual or constructive total loss. Simulations like this could be connected not just in GA situation itself but if they are built on a knowledge from actual investigation and outcome of legal case law, this kind of practice could be connected to teaching the liability issues which need to be lectured also according to STCW.

In many Maritime Universities this part of STCW is taught purely based on lecturing which does not interest students very much and the outcome is sometimes poor as the topic is not made interesting enough for the students. Some Universities use case based studies or/and group work where the students learn by doing as they have to apply the rules themselves in a given casualty with practical facts. Needless to say that this works much better than just lecturing the rules.

But we could do things better. Winston Churchill said 1940 in his speech in House of Commons: “Give us the tools – And we will finish the job”. Every maritime University has a simulator, but the simulators are not yet planned for the casualty management practices, which could be combined to teaching the handling of a casualty and its consequences. Therefore, we need to address our message to the manufacturers who develop the simulators: “Give us the tools – And we will make such exercises that the casualty management and legal/liability issues can be envisaged and visualized to the future master mariners. This generation needs action and is used to learning by doing already at high school level. They are used to play in virtual environments and learning this way, is far more interesting and concrete for them than any other way of learning.

We need to think what the students are familiar with when they acquire the skills we need to teach them. The example above is quite simple and would not need much from a data development team. But let us take a further step and think about the next issue in the Rule 3 of YAR 2016: Beaching the vessel which would otherwise become a total loss together with its Cargo if not stranded.

This exercise is the most common GA situation in narrow fairways through archipelago with rocky waters, like in Finland. Typical example is that a RORO vessel is some ten meters from its course and runs on a rock, which opens a long hole in the hull. The Master makes a general average act and runs the vessel aground and beaches the vessel on a nearby island where it stays standing only partly filled with water. Simulation needed for the following GA actions would be like a game where different player could participate. First of all we would need a

salvor who arrives with his tug and barges which are needed for lightening the vessel. Generally, there must be some temporary repairs in order to refloat the vessel after the cargo, or part of it has been transshipped with the barges. After the temporary repairs, the refloating can be simulated. The tug and vessel could be combined in the same simulation – even from distance. The other vessel could be operated fully from another simulator “bridge” and they could play the same simulation. After this the towage to repair yard could be simulated. All these actions are necessities and rewarded as general average sacrifices according to following Rules and can be combined in one simulation practice. First YAR 2016 Rule V – Voluntary Stranding:

*“When a ship is intentionally run on shore for the common safety, whether or not she might have been driven on shore, the consequent loss or damage to the property involved in the common maritime adventure shall be allowed in general average.”* (International)

And YAR 2016 Rule VI – Salvage Remuneration:

*(a) Expenditure incurred by the parties to the common maritime adventure in the nature of salvage, whether under contract or otherwise, shall be allowed in general average provided that the salvage operations were carried out for the purpose of preserving from peril the property involved in the common maritime adventure and subject to the provisions of paragraphs (b), (c) and (d)*

And YAR 2016 Rule VIII – Expenses Lightening a Ship when Ashore, and Consequent Damage:

*“When a ship is ashore and cargo and ship’s fuel and stores or any of them are discharged as a general average act, the extra cost of lightening, lighter hire and reshipping (if incurred), and any loss or damage to the property involved in the common maritime adventure in consequence thereof, shall be allowed as general average.”* (International)

And YAR 2016 Rule XIV – Temporary Repairs

*“(a) Where temporary repairs are effected to a ship at a port of loading, call or refuge, for the common safety, or of damage caused by general average sacrifice, the cost of such repairs shall be allowed as general average.*

*(b) Where temporary repairs of accidental damage are effected in order to enable the common maritime adventure to be completed, the cost of such repairs shall be allowed as general average without regard to the saving, if any, to other interests, but only up to the*

*saving in expense which would have been incurred and allowed in general average if such repairs had not been effected there.” (International)*

And YAR 2016 Rule XII – Damage to Cargo in Discharging, etc.

*“Damage to or loss of cargo, fuel or stores sustained in consequence of their handling, discharging, storing, reloading and stowing shall be allowed as general average, when and only when the cost of those measures respectively is allowed as general average.”*

Examples above only visualize some of the most common casualty situations, which could be connected to simulations and teaching casualty management as well as General average and ship-owners liability issues mentioned in STCW. There’s many more some of them, which are fairly simple and some more complex to realize. One very common rule, which still needs to be mentioned, is the YAR 2016 Rule VII – Damage to Machinery and Boilers:

*“Damage caused to any machinery and boilers of a ship which is ashore and in a position of peril, in endeavouring to refloat, shall be allowed in general average when shown to have arisen from an actual intention to float the ship for the common safety at the risk of such damage; but where a ship is afloat no loss or damage caused by working the propelling machinery and boilers shall in any circumstances be allowed as general average.”*

This is a rule, which could be connected to both machinery simulations as well as bridge simulations at the same time.

The other common and quite simple one is YAR 2016 Rule I – Jettison of Cargo:

*“No jettison of cargo shall be allowed as general average, unless such cargo is carried in accordance with the recognized custom of the trade.”*

This is a rule, which is a traditional rule first expressed in the Rhodian law about 900 BC but is nowadays the most commonly used GA rule in relation to containers release to sea, when the vessels stability is endangered and made to avoid listing and total loss of vessel and cargo. (Reeder, 2013)

### **How to make it economically feasible for training institutions?**

The simulation environment is heavy investment for Maritime Universities and other training institutions. Investments to the environment should therefore be used effectively. Casualty response teaching would also be beneficial for maritime authorities, classification societies, casualty investigation authorities, insurance companies, Maritime courts etc. that could be served by training institutions and their facilities. Financing the investment through income

from these sources could help Maritime Universities in this development work. Simulations have already been used by some of these institutions in order to evaluate the actions, which have led to the casualty. The next generation simulation environments for casualty management should also be generated to make it possible to train masters and crew to act according to planned scenarios.

## **Conclusions**

When the STCW convention does not mention it specifically, teaching GA rules has been neglected by many Maritime Universities in last decades. Bringing it back to curriculums as a practical skill of a master and crew is possible through developing the simulator environment, which makes the skills practicable instead of just theory. The Maritime Universities should together take steps to make the studies more interesting and lucrative for the students. Young people need to be familiarized with the environment where they will work. They need to be taught the skills they will need in a realistic environment when the possibilities for realistic practice at sea is not any more certain for everybody. In addition, we need to look at the world where the present and future students are living – Using game like practices should be a way to teach the topics, which might otherwise feel boring or frustrating for the students. In every way possible, we should think how to combine the different topics with each other more effectively and how to make also teaching and learning more fun for our students. As Maritime Universities, we should work on this together.

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## ON THE PARALLEL BETWEEN POLITICAL CORRECTNESS AND LEADERSHIP SKILLS DEVELOPMENT

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**Abstract:** The aim of the presented paper is to discuss some directions of the English language teaching intended to meet the requirements of (Manila amended) STCW 78/95, the IMO Model Courses 3.17 and 1.39. The Maritime English teaching is mainly directed to the provision of the Specification of minimum standard of competence for officers in charge of a navigational and engineering watches.

At the same time, it is not of less importance to focus the teaching directions on provision of performance of the officer's duties under requirements of the IMO model course 1.39 "Leadership and Teamwork" (IMO Publishing. Leadership and Teamwork (Model Course 1.39), IMO, 2014.) directly related to knowledge and ability to apply effective resource management through efficient cross-cultural communication on board and ashore; cultural awareness, allocation, assignment and prioritization of resources; decision making reflecting team experience; assertiveness and leadership, including motivation; obtaining and maintaining situational awareness; appraisal of work performance.

Thus, the empirical data of the paper presents a set of case studies (real situations on board merchant ships) giving a possibility to analyze the factors causing the effectiveness of situational awareness and moreover the principles of the possible conflicts prevention.

Taking into account a newly introduced term “a helmsperson” instead of a traditional “a helmsman” and the other terms gradually entering the maritime terminology, we’d like to mention that the future ship officers, provided with such conversational skills, will successfully perform their duties showing ability to apply

effective communication on board and ashore at the same time providing the principles of leadership and team working.

In order to provide the above-mentioned advantages, we propose to introduce politically corrected communicative technologies and cross-cultural communication principles into the Maritime Education and Training.

**Keywords:** cross-cultural communication, standard of competence, multilingual crew

## **Introduction**

The aim of the presented paper is to break the language barriers, possibly caused by political incorrectness between the seafarers. Nowadays, we live in the rapidly changing world and moreover in the society where new values and new ways of thinking are promoted. Since the language is a living phenomenon and ubiquitous, it attracts and mirrors each individual's viewpoint and distinctly is reflected in the language. That is why, new lexical units occur within the scopes of Political Correctness.

Taking into account seafarers work on the so-called "locked space", where they are obliged to be for months, away from their home countries, families etc. being a part of group where representatives are of different culture presenting their values and identities differently forming the group where are united people with diverse race, ethnicity, religion, country of origin, even sometimes gender inequality and etc are acquainted with some stressful condition, which is primarily revealed in the language. In such cases, the sender of the message and the receiver of the message are from different cultural backgrounds. Of course, this introduces a certain amount of uncertainty, making communications even more complex. As it is known, widely spoken on board language is English which is basically the 2<sup>nd</sup> language for them. That is why, there occur problems in spoken English which can be foreseen in their grammar, pronunciation and so on.

When the speakers communicate cross-culturally, one should make particular effort to keep the communication process clear, simple and unambiguous. One communicates the way s/he does because any individual is raised in particular culture. The listener may interpret the speaker's behavior from an opposite standpoint. Sometimes this type of situation leads and creates misunderstanding and can be conflict producing. Whereas, understanding the other's culture facilitates cross-cultural communication. Linguistic realization of political correctness has become one of the burning issues in the modern world. As is known, political correctness implies verbal behavior that excludes any form

of verbal discrimination: racial, gender, religious or political: “The principle of avoiding language and behavior that may offend particular groups of people“ (Oxford Dictionary 2010).

The term political correctness was coined and first used in 1793 when a judge, James Wilson, used it in the decision *Chisholm v. Georgia* (1793) to say it is not politically correct to speak of the United States instead of the people of the United States.

Political Correctness is linked to the face and politeness theories since the study has revealed that the choice of a particular strategy largely depends upon the context a particular term is used in.

### **Gender inequality**

In current English gender inequality used to be conveyed lexico-grammatically. As a result of the feminist movement, certain changes were introduced into the English language in the second half of the 20th c. viz.: The use of the lexical unit man in a generic sense denoting a human being is avoided. The morpheme man as a component of compounds denoting different professions has been replaced by gender-neutral items. Accordingly, the terms related to occupations do not reflect gender. Below presented lexical units ending on “-man” is advised to be replaced “person” where the gender of a person is not indicated.

Politically Correct	Politically Incorrect
helmsperson	helmsman
pump person	pump man
mess person	mess man/boy
Sea person	seaman

If we discuss the lexical unit “seaman” which according to the Cambridge dictionary means the following: “a person skilled in seamanship”, also we meet the following definition which is “a general-purpose for a man or a woman who works anywhere on board a modern ship, including in the engine spaces, which is the very opposite of sailing”. Based on the definitions the term “seaman” is used both for male and female addressing form. But the protest can be raised due to the morpheme “man” because there are women seafarers as well. For instance, a female Georgian graduate from Batumi State Maritime Academy Ms. Natia Labadze is employed in the crewing company Columbia

ship management LTD. She started as a deck cadet, and a novice sea person was promoted as 3rd Officer on board. That is why, the addressing term “seaman” will be derogatory and offensive one since the morpheme “man” excludes women’s rights and does not foresee that women can be sea persons as well. In the case of the term “sea person”, the morpheme “person” has a general meaning, where is not stated a person is a female or a male. Thus, by the recent IMO researches, (<http://www.imo.org/en/OurWork/HumanElement/Pages/Default.aspx>) the safety and security of life at sea, protection of the marine environment and over 90% of the world's trade depends on the professionalism and competence of seafarers. The human element is a compound issue that touches different maritime issues - safety, security and environmental protection involving the whole range of activities performed by crews, shore based management, authorities, etc. Thus, the IMO continually promotes different measures aimed at implementation of such an important issue. One of the modern approaches aimed at the same direction is the introduction of the IMO model course 1.39 Leadership and Teamwork intended to provide a person with the knowledge, skill and understanding of leadership and teamwork at the operational level on board a ship. The course is designed to meet STCW requirements for the application of leadership and teamworking skills, in accordance with the 2010 Manila Amendments, specifically as stated in Table A-II/1, Function: Controlling the operation of the ship and care for persons on board at the operational level.

### **Correlation of leadership and teamwork with language**

On completion of the course the learner/trainee should be able to demonstrate sufficient understanding and knowledge of leadership and teamworking and have the relevant skills to competently carry out the duties of officer in charge of a navigational watch on ships of 500 gross tonnage or more, or officer in charge of an engineering watch in a manned engine-room or designated duty engineer in a periodically unmanned engine-room. The knowledge, understanding, and proficiency should include, but not be limited to, those listed in Column 2 of Table A-II/1 and Table A-III/1:

Working knowledge of shipboard personnel management and training include (IMO Publishing. Leadership and Teamwork (Model Course 1.39), IMO, 2014.) organization of crew, authority structure, responsibilities; cultural awareness, inherent traits, attitudes, behavior, cross-cultural communication; shipboard situation, informal social structures on



board; human error, situation awareness, automation awareness, complacency, boredom; leadership and teamworking.

Knowledge of related international maritime conventions and recommendations: SOLAS, MARPOL, STCW, MLC, as well as national legislation.

Ability, to apply task and workload management (IMO Publishing. Leadership and Teamwork (Model Course 1.39), IMO, 2014.) involve planning and coordination; personnel assignment; human limitations; personal abilities; time and resource constraints; prioritization workloads, rest, and fatigue; management (leadership) styles; challenges and responses. Knowledge and ability to apply decision-making techniques contain situation and risk assessment; identification and consideration generated options; evaluation of outcome effectiveness; decision making and problem-solving techniques; authority and assertiveness; judgment; emergencies and crowd management). Self-awareness, personal and professional development include knowledge of personal abilities and behavioral characteristics; opportunities for personal and professional development. Knowledge and ability to apply effective resource management foresees (IMO Publishing. Leadership and Teamwork (Model Course 1.39), IMO, 2014.) effective communication on board and ashore; allocation, assignment and prioritization of resources; decision making reflecting team experience; assertiveness and leadership, including motivation; obtaining and maintaining situational awareness; appraisal of work performance; short and long term strategies.

The whole set of competences and especially the last extract state new and high standards for the English language competence. Everything noted above should be implemented through the conversational ability of the officers, presenting a new challenge to the Maritime English teaching development. That is why, we want to propose political correctness as a potentially useful Maritime English teaching direction. Linguistic realization of political correctness has become one of the burning issues in the modern world. As it is known, political correctness implies verbal behavior that excludes any form of verbal discrimination: racial, gender, religious or political: <http://www.oxforddictionaries.com/> “The principle of avoiding language and behavior that may offend particular groups of people“. The term political correctness was coined and first used in 1793 when a judge, James Wilson, used it in the decision *Chisholm v. Georgia* (1793) to say it is not politically correct to speak of the United States instead of the people of the United States. There are different domains of political correctness such as gender, that of sexual minorities, racial and disability one.

## **Conclusion**

As the conclusive part of a paper could be proposed a brief politically corrected glossary which may be used within the frames of the English language competency for future seafarers:

- Business person - a person in business or one who works at a commercial institution
- Chairperson - a chairman or chairwoman, someone who presides over a meeting, board, etc.
- Craftsperson - someone who is highly skilled at their trade.
- Differently able - disabled or handicapped.
- Fireperson - A fireman or firewoman. A firefighter
- Flight attendant - a member of the crew (staff) of an airplane who is responsible for the comfort and safety of its passengers.
- Fresh person - a freshman (male or female).
- Handicapable – Physically challenged.
- Helmsperson - a helmsman or helmswoman.
- Native American - an American Indian.
- Nurseryperson - a nurseryman or nurserywoman.
- Police officer – a policeman/policewoman
- Salesperson - a salesman or saleswoman.
- Serviceperson - a serviceman or servicewoman.
- Undocumented immigrant – illegal immigrant.
- Waitperson - a waiter or waitress

Taking into account a newly introduced term “a helmsperson” instead of a traditional “a helmsman” and the other terms gradually entering the maritime terminology, we’d like to mention that the future ship officers provided (within the frames of the English language teaching) with such conversational skills will successfully perform their duties showing ability to apply effective communication on board and ashore.

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# MOTIVATION AND RESTRAINTS OF MAAP MIDSHIPMEN IN CHOOSING A MARITIME PROGRAM AS ASSOCIATED WITH THEIR ACADEMIC PERFORMANCE

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**Abstract.** The role of the Maritime Higher Education institutions (MHEIs) in the Philippines is very vital in producing competent seafarers that will man the international ships. However, the motivations and restraints of the learners are also important in determining the performance of the midshipmen during their stay in the academe and later in their performance as ship officers.

A total of one hundred thirty-five (135) or seventy – five percent (75%) of the students taking Bachelor of Science in Marine Transportation of the Maritime Academy of Asia and the Pacific (MAAP) during the first semester of the Academic Year (AY) 2015 – 2016, participated in the study.

A self-made questionnaire was used to determine the motivations and restraints of the respondents. The questionnaire was divided into six (6) areas of concerns namely: fulfilment of dreams, source of income, expression of myself, challenging work/ workplace, accidentally chosen profession and long term plans.

Among the six (6) areas of concerns, the results showed that the main motivation of the midshipmen in choosing the maritime profession is the source of income while their main restraint is that they find maritime profession as a challenging work or work place.

It also showed that the demographic profile of the respondents and restraints in choosing maritime profession are not significantly associated with their academic performance while motivation is significantly associated with the academic performance.

**Key words:** Motivation, Restraints, Academic Performance, Association

## **I. Introduction**

The motivation of students is always a critical issue in higher education, especially because it may affect the academic performance of the learners and their professional life. This study is focused on determining the motivations and restraints of the MAAP midshipmen in choosing maritime profession. This may help the educational managers and leaders to know the learners' outlooks towards learning, their motivation in learning and the hindrances to their learning progress. Learning sometimes becomes a cause of pressure and intimidation rather than a source of fun during their university life, that's why a significant number of students tend to leave the university prior to their graduation. It shows that learners with repulsive attitude and less motivation towards education tend to quit or cannot perform better in their academics.

The role of the Maritime Higher Education institutions (MHEIs) in the Philippines is very vital in producing competent seafarers that will man the international ships. Graduates that have high motivations in their chosen career and profession may perform better and may be more competent than those with restrictions and restraints in their decisions. Therefore, motivations and restraints of the learners are important in determining the performance of the midshipmen during their stay in the academe and later in their performance as ship officers. These motivations and restraints may greatly affect their academic performance that later may also affect their chosen profession.

Determining the motivations and restraints of the learners are an essential step toward academic success. It involves different factors that arouse the desire and energy of the learners to be constantly interested and committed to pursue, actively participate, or excel in the attainment of their goal.

Therefore, it is deemed necessary to determine the motivations and restraints of the learners in choosing the maritime profession as their lifetime career may help and support the maritime higher education institutions' leaders to predict learners' academic performance and identify the student's weaknesses before their grades begin to fall.

### **1.1 Research Question**

The general problem of the study: How do the motivations and restraints of the midshipmen in choosing seafaring profession associate with their academic performance?

Specifically, the study sought answers to the following questions:

1. How may the profile of the respondents be described in terms of: Age, Gender and Region of origin, Seafaring as their first choice of career, plans in staying in seafaring profession, and their knowledge in seafaring profession?
2. How may the motivations and restraints related factors be described in terms of: Life time Profession, Fulfillment of Dreams, Source of Income, Expression of Myself, Challenging Work/Work Place, Accidentally Chosen Profession, and Long Term Plans?
3. How do the demographic profile, motivation and restraints related factors associate with the academic performance of the respondents?
4. What are the implications of the findings to the Maritime Education and Training?

### ***1.2 Significance of the Study***

The results of this study may help the midshipmen to determine their weaknesses and restraints in choosing the maritime profession. With the results of the study, midshipmen may do some modifications in their learning styles to improve their academic performance. It may help also the instructors on how to deal with their students. Appropriate actions may differ based on the needs of their learners. The results of the study may also serve as a database for the school and its directors in modifying or improving their educational plans and programs to suit the different needs of the learners. Necessary trainings for teachers and academic staff may be developed and executed based on the findings of the study to further improve their teaching methodologies. Lastly, the results of the study may be used by future researchers as a reference in conducting other related studies.

## **II. Methodology**

### ***1.1 Methods and Techniques***

The quantitative type of research was used in the study. One hundred thirty-five (135) or seventy – five percent (75%) of marine transportation student-respondents were given a self – made survey questionnaire to gather information based on their perceptions on the motivations and restraints of midshipmen in choosing the maritime profession. The tool is divided into two (2) parts; part I is the demographic profile of the respondents and part II is the motivations and restraints related factors.

### ***1.2 Hypotheses:***

1. The profile of the respondents has no significant relationship to the motivations and restraints of the midshipmen in choosing seafaring profession.

2. The motivations and restraints of the midshipmen in choosing seafaring profession have no significant relationship to their academic performance.

### **III. Results and discussion**

#### **1. How may the profile of the respondents be described in terms of age, gender, region of origin, seafaring as their first choice of career, plans in staying in seafaring profession and their knowledge in seafaring profession?**

It shows that 57 (42%) of the respondents are 17 years of age while 41 (30%) are 16 years old and the remaining 37 (27%) are in the range of 18 – 21 years old. This means that the majority of the respondents are in the adolescence stage. It is the time of decision-making on what program to take that later will affect their future. According to Kaneshiro (2015), it is necessary for an adolescent to become more strong and independent before he develops good decision making skills. Furthermore, Cherry (2016) said that an adolescent who is exposed to proper inspiration, proper guidance and good environment through personal evaluation and assessment will have the chance to grow with a strong self-confidence and a feeling of individuality and self-control.

In terms of gender, 96% of the respondents are men while the remaining four percent (4%) are women. It only shows that maritime profession is not an attractive program for females. Most of the young professional women are more inclined to business, tourism, hotel programs, education, IT and medicine. In the study of International Maritime Organization (IMO), 225 out of the 230,000 Filipino seafarers registered from 1983 to 1990 were women which shows less than 1 percent of the total population of the maritime officers. From 2006 to 2010, women seafarers account for 2 percent of the total number of sea-based workers deployed (Tangi, 2015).

Furthermore, most women have an anxiety and inferiority feelings in entering a man's world because they might encounter different problems such as sexual and physical harassments, intimidations and discrimination. It has been a noted tradition that the maritime profession is a male dominated environment and that tradition runs for a long time. It also shows that shipping industries are one among other professions with very low number of women workforce (Mukherjee, 2015) and most of the ship owners' associations are hesitant in employing female merchant officers (Zhao, 1998 as cited by Aggrey, 2000).

In terms of whether seafaring is their first choice of career, 80 (59%) said yes that seafaring is their first choice while the remaining 55 (41%) said no. It only shows that majority of the respondents prefer other programs to maritime studies. Out of 55 respondents (41%), 32 said

that they prefer engineering, medicine and law programs; five (4%) said that Information Technology (IT) is their first choice of program; and four (3%) prefer to become part of the military or navy group. According to Kalvaitiene (2013), making a career decision cannot be done in a day. A good planning must be established for the consequences will last for a long-term.

In their plans on how long they are going to stay in the maritime profession, 61 (45%) said that they will stay from 16 to 20 years, while 40 (29%) will stay in the maritime profession from 11 to 15 years. The remaining 34 will stay from 5 to 10 years or no plan at all.

In terms of their knowledge in seafaring profession, 76 (56%) said that their knowledge is probably enough, 27 (20%) have absolutely enough knowledge, 26 (19%) have neutral knowledge, and the remaining population said that their knowledge is not enough or absolutely not enough.

## **2. How may the motivations and restraints related factors be described in terms of life time profession, fulfillment of dreams, source of income, expression of myself, challenging work/ work place, accidentally chosen profession, and long term plans?**

Among the four (4) categories given, the seafaring profession as a source of income came out to be the first motivation of the MAAP midshipmen in taking the maritime program, with an average mean of 4.67 or strongly agree. This is followed by seafaring as a maritime profession (4.55 or strongly agree), expression of oneself (4.20 or agree) and a fulfillment of dreams (3.59 or agree). Overall, the respondents agree with the statements of motivation given.

In the area of lifetime profession, MAAP midshipmen strongly agree that because of their profession, they will be able to travel and see different places, with a mean rating of 4.84. They also strongly agree that they will have a stable job (4.60), and that maritime profession is a prestigious profession (4.56). Midshipmen agree that they will be challenged by the nature of work and they will be able to man different types of vessels.

In the fulfillment of dreams as a motivation, it shows that the respondents strongly agree that they will be able to travel the world for free. They also agree that they like to continue the dreams of their parents to become a seafarer. Further, they agree that they love the sea compared to other environment. However, they neither agree nor disagree that it was their childhood dream. And lastly, they also neither agree nor disagree that maritime profession is a family tradition.



Furthermore, in the area that it will be a good source of income, the respondents strongly agree to all the specific statements, except for buying anything they want. Looking closely, it shows that the respondents put more value for future endeavors with their income than satisfying their present wants like buying whatever they feel like buying. It may also mean that they value their family and hard work that is why they do not indulge in whims.

Moreover, MAAP midshipmen strongly agree that choosing the maritime profession means independence from their family, becoming a part of a team and proving their abilities. They also agree to the regimented training in the academy. Finally, they are neutral at working far from home.

Together with motivations are perceived deterrents that come with the maritime program and profession. Life at sea got the highest mean rating of 4.36 indicating the agreement of the respondents of the problem that this entails. This is followed by the maritime profession as a challenging work (4.26). On the contrary, the respondents disagree with the maritime profession as chosen by accident as a restraint (2.32 or disagree) in choosing seafaring.

In the category 'life at sea,' the midshipmen expressed strong agreement on having no one to take care of them when they get sick, on the possibility of being captured by pirates, and on being confined by routine. They also agree on the possibilities of acquiring diseases and experiencing distress and urgent situations on board.

Another perceived deterrent is the challenge of seafaring job. The midshipmen strongly agree that competition on board is very strong and they need to excel in their work. This is followed by working for months with the same crew on board (4.44), and working with people with different personalities, nationalities and attitudes (4.43). While working on board ship will disconnect them from their families for months got a mean rating of 4.04. Lastly, midshipmen agree that internet at social media connections will be a problem during their shipboard with a mean rating of 3.79.

It only shows that the respondents' greatest deterrent in choosing seafaring profession in terms of challenging work/ work place is the environment on board ship. Although, they will be trained to become competent seafarer, there are still hesitations that once they act as an officer they need to perform well. Otherwise they will be sent home and lost their job. Further, they believed that the competition on board is very strong especially with different nationalities present onboard. Likewise, since they will be working with different nationalities, it cannot deny the fact that discriminations among other nationalities still exist. In the study of Lane et.al. (2003), evidences of discrimination still occur on board. According to the same author, crews appeared to be divided more on the degree of nationality and at

times work-related hierarchies were re-aligned aboard ship to accord with nationality rather than rank.

In the area of accidentally chosen profession, it has a mean rating of 2.32. Among the areas of concerns, midshipmen neither agree nor disagree, that choosing the seafaring profession was a suggestion of family, friends and relatives with a mean rating of 3.25. In the same way, midshipmen cannot manage to study other programs because of high tuition fee and maintenance allowance got a mean rating of 3.11. While they all disagree that most of their friends took seafaring profession, they were able to pass entrance examination for other programs and they were forced by their parents are the reasons of choosing the seafaring profession with a mean rating of 1.87, 1.55 and 1.79 mean respectively.

Parallel to the study of Lau and Ng (2015), choosing maritime profession with the influence of family members and friends does not play any significant role in persuading the decision of the maritime students.

### 3. How do the demographic profile, motivation and restraints factors relate to the academic performance of the respondents?

**Table 1. Profile, Motivation and Restraints and Academic Performance**

Profile	X <sup>2</sup>	Sig.	Remarks	Cramer's V	Remarks (Level of Associations)
Age	1.17	0.88	Not significant	.07	Negligible
Gender	1.96	0.38	Not Significant	.12	Weak
Region of origin	6.35	0.18	Not Significant	.15	Weak
Seafaring as first choice	0.47	0.79	Not Significant	.06	Negligible
Plans in staying in seafaring profession	4.24	0.64	Not Significant	.18	Weak
Knowledge in seafaring profession	2.28	0.68	Not Significant	.13	Weak
Motivation	6.01	0.05	Significant	.21	Moderate
Restraints	5.77	0.22	Not Significant	.15	Weak

[Based from Rea & Parker (2014), Cramer's V coefficient is interpreted such that a value below 0.10 indicates negligible association; 0.10 to 0.19 weak association; 0.20 to 0.39 moderate association; 0.40 to 0.59 relatively strong association; 0.60 to 0.79 strong association, and 0.80 to 1.00 very strong association.

As gleaned from the table, age is not significantly associated with academic performance based on the chi square value of 1.17, not significant at 0.88, and the negligible Cramer's V coefficient of 0.07. Gender is not significantly related to the academic performance with chi square value of 1.96, not significant at 0.38, and weak correlation of Cramer's V coefficient of 0.12. The same way with the region of origin, seafaring as his first choice of career, plans

in staying in the seafaring profession, knowledge in seafaring profession and restraints in choosing seafaring profession show not significant and either weak or negligible level of association to their academic performance.

However, motivation shows significant association with the academic performance of the students as implied by the chi square value of 6.01 significant at 0.05 level. However, the Cramer's V coefficient of 0.21 only suggests a moderate association. It only means that the motivations of the students in choosing the maritime profession have vital role on their academic performance. It reflects student's choices in dealing with the learning chore, in the time and effort they will dedicate and their perseverance in handling different obstacles they encounter during the learning process. When a student enjoys what he is doing, he sees it as an avenue to learn. Student participates in an activity because he is motivated to do so. In the study of Bandalos et. al (2005) as cited by Peklaj and Levpušček (2006), students' success, their interest in chosen courses and their achievement anticipations were positively correlated to their course grade.

#### **4. What are the implications of the findings to the Maritime Education and Training?**

The identification and recognition of motivations and restraints issues of the midshipmen based on self-efficacy, control beliefs, goal direction and value concern, and anxiety may be helpful in developing particular strategies that will lead to a greater success in university and their future maritime career. It is the goal of every institution and educator to help the learners acquire self – motivation that will lead to a continuous desire to learn.

#### **IV. Conclusions**

1. The null hypothesis that the demographic profile of the respondents has no significant effect to the motivations and restraints of the midshipmen in choosing maritime profession is accepted.
2. The null hypothesis that the restraints of the midshipmen in choosing maritime profession have no significant effect to their academic performance is accepted while the null hypothesis that the motivations have no significant effect to their academic performance is rejected.

## V. Recommendations

The management may develop an approach or strategies that will highlight and focus on the motivations of the midshipmen in choosing the maritime profession. Creating methodologies/ techniques that may counteract the restraints of the midshipmen in choosing maritime profession may also be done. These maybe in the forms of continuous dialogues, inspirational talk from a maritime officer and the like. Another study may also be conducted after the shipboard training of the respondents to determine whether their motivations and restraints in choosing maritime profession will change after experiencing the life of a seafarer.

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**AN INVESTIGATION OF THE SKILLS GAP BETWEEN COURSE LEARNING  
OUTCOMES OF MARITIME BUSINESS DEGREES AND ONSHORE  
EMPLOYMENT REQUIREMENTS**

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**Abstract** This paper explores key industry perceptions, through interviews with 27 senior maritime managers in Australia, Canada and the US, on the employability skills required for onshore maritime professionals. Those perceptions are then compared to the skills identified from the collected nine Course Learning Outcomes (CLOs) of nine maritime business degrees. The findings show that CLOs and maritime industry requirements tend to converge in areas such as knowledge, self-management and computer/IT skills. Less alignment was evident in CLOs relating to communication and problem solving. By giving more attention to these two CLOS in terms of specific emphasis and depth of study, students will gain more comprehensive skill sets for these critical areas. This paper also recommends that including adaptability, flexibility and an inquiring mind in CLOs may enable students to better respond to the dynamism and complexity inherent in the maritime industry.

**Keywords:** Employability Skills, Course Learning Outcomes, Maritime Business Degrees, Onshore Maritime Industry

## **1. Introduction**

The onshore maritime industry, including ports, terminals and shipping companies, is a crucial contributor to the viability and sustainability of the maritime sector. Within this industry, there is a diverse array of skilled professional occupations and career pathways. Maritime business degrees are a well-recognised qualification to gain entry to employment in this industry, often undertaken by seafarers for example as a pathway to enable the transition from ship-to-shore by building on their experience at sea. Of interest, in seafaring there are professional standards that apply to the skill sets required, determined by international organisations such as IMO. However, for onshore business-related roles in ports, shipping, freight forwarding and ships agents, the key employability skills are unclear due to the diversity of job roles.

This paper explores key industry perceptions on the employability skills required for onshore maritime professionals and compares those perceptions to the skills identified in the Course Learning Outcomes (CLOs) of maritime business degrees. The focus of this paper is to identify whether a gap exists between the CLOs of maritime business degrees and the required employability skills in the onshore maritime industry. This paper commences with literature reviews on key employability skills in the maritime industry, and evaluates CLOs from seven IAMU and two non-IAMU maritime business degrees. Subsequently, following interviews with 27 senior maritime managers in Australia, Canada and the US, this paper identifies the required knowledge and employability skills for professionals in the onshore maritime industry. Finally, the paper highlights how universities may consider making changes to their CLOs of maritime business degrees to improve graduates preparation for working in the industry.

## **2. Employability skills and learning outcomes**

Employability skills are a set of skills ‘required not only to gain employment, but also to progress within an enterprise so as to achieve one’s potential and contribute successfully to enterprise strategic directions’ (Australian Chamber of Commerce and Industry & Business Council of Australia 2002, p.14). When integrating employability skills into undergraduate programs, universities develop graduate attributes at a university level, which are then made more specific at a faculty, discipline, and unit (subject) level (Precision Consultancy and BIHECC 2007; Australian Technology Network 2000; Sumsion and Goodfellow 2004).

Students undertaking bachelor degree programs expect to acquire not only generic employability skills but also discipline specific skills. Therefore, universities, especially

Australian universities, seek to facilitate graduates in gaining both skill sets by focusing on learning outcomes. Learning outcomes describe the skills and knowledge a student can attain by the end of the subject or course (Australian Qualifications Framework Council 2013). For example, the Australian Government and universities have implemented a series of discipline-related policies and standards that set out minimum learning standards for higher education courses. Both university level and discipline standards focus on addressing learning outcomes at course level. The CLOs refer to graduate outcomes of any university degree programmes specifying what students should achieve after graduate.

### **3. Literature review on employability skills for the onshore maritime workforce**

Academic literature related to workforce studies in the maritime industry mainly focuses on the offshore maritime industry such as seafarer skills, with limited research in onshore maritime workforce skill requirements. One study undertaken by Fernando, Sigera and Cahoon (2013) suggests that, in the Sri Lankan shipping industry, employees could attain greater success with skills in using computers and the internet, intuition and forecasting, analytical thinking, English language, customer service, time management, creative thinking, and the accuracy of work. In relation to the Taiwanese shipping industry, Han and Li (2015) found 11 employability indicators. Of interest, shipping-related firms in this study suggested that graduates from shipping management degrees needed to improve general business English proficiency, morality and virtue, Emotional Intelligence (EQ) management, and language expression in the languages used.

From a broader perspective, the Australian Transport and Logistics Council's annual environmental scan identified that the shipping and port sectors in Australia demand skills such as leadership and management, teaching and training, information technology, financial management, language, literacy and numeracy (LLN), problem-solving, analytical skills, and sophisticated contract management practices (Transport and Logistics Council 2015). However, as noted, a paucity of in-depth investigations of employability skills exists.

### **4. Examining CLOs of maritime business degrees in worldwide universities**

On completion of a comprehensive web search of maritime business bachelor degrees, including the eduMaritime and IAMU member websites, a total of 28 universities offering the degrees was found, of which 24 were IAMU members (10 European, 9 Asia Pacific, and 5 USA). From the 28 universities, only nine CLOs of maritime business bachelor degrees from the following nine universities could be obtained:



- Asia Pacific: Australian Maritime College, University of Tasmania (AMC); Hong Kong Poly University (Hong Kong); Dalian Maritime University (Dalian);
- Europe: Plymouth University (Plymouth); Liverpool John Moores University (Liverpool); Southampton Solent University (Southampton); Dokuz Eylul University, Maritime Faculty (Dokuz); and
- USA: Massachusetts Maritime Academy (MMA); Texas A&M University (Texas).

Of the available CLOs, some are similar to those in general business degrees although indicating a specialised field i.e. maritime and logistics. Few degree programmes clearly identify skills in their CLOs, for example the BSc (Hons) Maritime Business (Southampton) addresses cognitive skills, practical, professional skills and transferrable and key skills in its CLOs. Others such as BSc (Hons) Maritime Business and Logistics (Plymouth) and BSc (Hons) Maritime Business and Management (Liverpool), separately include information on graduates' expected specific employment related skills, including professional practical skills and transferable skills. In this study, information on CLOs and employability skills collected from various universities were used for analysis to find skills expected for graduates of maritime business related degrees. Content analysis was applied in examining the collected CLOs. Consequently, the following 11 categories of skills inherent in the 9 available CLOs are identified in the subheadings below followed by the actual number of CLOs including each skills.

**Knowledge (9).** The CLOs split knowledge into general and specialised. General knowledge in most CLOs tends to expect application of general business knowledge to the maritime industry, whilst some specifically refer to management, financial management, marketing, human resource management, international business and analytical methods. In relation to specialised knowledge, some CLOs simply state it in a general way such as 'systematically and critically review a body of knowledge within the study and practice of maritime business and the maritime industry, including elements of new and specialised knowledge' (Southampton). However, few CLOs of programmes indicate specific maritime related knowledge, such as maritime business, ship finance, logistics, supply chain management, information systems, maritime policy, and transport geography. As each programme's course structure varies, ascertaining common critical knowledge for maritime business degree graduates is challenging.

**Communication (8).** One of the most common CLOs is written and verbal communication, which is an important inclusion to ensure graduates have skills to effectively communicate to

a wide audience. Students should be able to present a clear and coherent exposition of business management knowledge, concepts and empirical evidence relevant to the maritime and logistics related industries. Using modern electronic and multimedia technology for communication is essential for graduates. For programmes not delivered in English, such as from Dalian, graduates are expected to be able to communicate internationally through foreign languages.

**Critical thinking (9).** All programmes' CLOs require students to demonstrate critical thinking, an intellectual skill individually and within teams. Critical thinking is 'the intellectually disciplined processes of actively and skilfully evaluating information and conceptualizing a solution, through tools including observation, experience, reflection, reasoning, or communication, as a guide to belief and action' (Scriven & Paul 1987 in the Critical Thinking Community Skills 2017). Skills used in critical thinking include analysing, synthesising, evaluating, observing, reflecting on possible outcomes and creative and innovative thinking from various sources in the field of maritime business and logistics related areas. By using critical thinking skills, students are able to anticipate and solve problems, enhancing their problem solving skill, which is also one of the important skills embedded in CLOs.

**Problem solving skills (8).** Problem solving is applied in programs to develop solutions to diverse problems in the maritime business world and involves analytical and creative skills. The majority of programmes' CLOs indicate that maritime business students should be able to recognise problems in the maritime and logistics related fields, analyse information, evaluate and appraise solutions, and draw appropriate conclusions and recommendations for maritime business needs. In addition, students should be able to use decision support tools, quantitative techniques and IT skills to analyse complex information and data for solving problems.

**Self-management (7).** CLOs of seven programmes identify expectations that students should be able to be responsible for their learning such as managing time and tasks; demonstrate autonomy and accountability in deterring and achieving personal and group objectives; and reflect their performance feedback to identify and action learning opportunities and self-improvement. These expectations are referred to as self-management skills in which students work and learn independently and take responsibility for personal actions.

**Social responsibility/ethics (5).** Five programmes' CLOs clearly indicate that students should be aware of professional ethical conduct and understand the concept of social responsibility in relation to social, cultural, economic and environmental issues.

**Team work (5).** Five CLOs require students to work collaboratively with others from different disciplines and backgrounds to formulate solutions to complex problems, including leading a team activity, whilst showing responsibility, professional behaviour and mentoring skills.

**Computer/IT skills (5).** Five programmes' CLOs indicate that students should understand the applications of information systems in a variety of contexts related to business and transportation, and utilise computer and information management skills for data analysis and maritime business and management purpose.

**Global perspective (4).** Four CLOs address that maritime business graduates should develop a diverse and global perspective to work in a global society as well as demonstrate a global outlook and understand cultural diversity, globalization and their implications for business.

**Research skills (3).** Three CLOs require students to conduct a research project related to maritime business or logistics issues. Students should demonstrate the skills necessary to plan, conduct and report an original research. Despite some programmes' CLOs not mentioning research skills, they do require students to complete a research project in their programme, for example, the Maritime and Logistics Management degree at AMC.

**Experiential learning (2).** Two programmes including BSc (Hons) Maritime Business (Southampton) and Bachelor of International Maritime Business (MMA) respectively have included experiential learning in their CLOs. Through experiential learning, students have unique opportunities for further integrating, applying and sharpening their shipping and business knowledge and professional skills.

In summary, CLOs in maritime business related degree programmes describe expectations that graduates should have a broad and coherent general business and maritime business related knowledge and be able to apply the knowledge to professional work. Graduates should also have cognitive skills such as critical thinking; practical skills such as problem solving, research skills, application of knowledge; and transferable skills including communication, self-management, teamwork, use of computer and IT skills in maritime business and management. In addition, graduates should be able to demonstrate a global perspective, and conduct themselves in a professional, socially responsible and ethical manner in life and business.

## **5. Employability skills of the onshore maritime industry-interview findings**

In order to explore the employability skills required by employers in the onshore maritime industry, the research team conducted focus group and individual interviews with 27 senior

industry managers in Australia, the US and Canada. In Australia, the team conducted two focus group meetings with six participants in Melbourne and four in Sydney respectively, and five face to face and two telephone individual interviews. The research partner in Texas undertook five individual interviews through face to face and telephone; the partner at Memorial conducted a focus group interview with five industry participants. The participants worked in the sectors of shipping, port and terminal, freight forwarding, trading, logistics, chartering and brokering, ship management and ship agency. Their positions in the workplace included CEO, managing director, director, human resource manager, division manager, and functional managers. The major questions asked in interviews included: (1) key employability skills necessary for graduates to succeed in maritime-related organisations; (2) most important employability skills of a recent graduate from a maritime business degree; (3) skill differences between a business graduate and a maritime business graduate for a graduate position; and (4) key employability skills necessary for graduate success in 10 years' time. This paper uses the findings from questions 1 and 2 to identify current skills required of maritime business graduates to compare with those embedded in the CLOs.

As each participant worked in separate areas of the maritime industry, the identified knowledge and skills varied depending on their sector involvement, although the following 9 skills and knowledge represent those deemed important by interviewees. Each subheading also indicates the number of responses for each skill and knowledge.

**Communication (27).** This was unanimously identified as the most important skill. The maritime industry is global and requires employees to communicate clearly and concisely with customers in other countries that speak different languages and possess different cultural values. Communication includes empathy, active listening, written (email, letter, reports), and verbal skills (face to face; telephone communication). Today's graduates must be able to communicate effectively in all electronic forms including email, formulating spreadsheets, creating presentations, and compiling data in effective and concise manners, in addition to person-to-person effective communication. Communication skill requirements differ between levels and the role of employees in the organisation. For example, in the head office of a port company, significant written skills are required, whereas at the operational level oral communication is the core. Chartering and broking companies for example, also require good negotiating skills.

**Adaptability and flexibility (21).** These are highly required skills when working in onshore maritime organisations. The maritime industry is changing and the business has many moving parts needed to complete one goal, so graduates must be able to handle dynamism and

complexity. Therefore, employees should be adaptable to the ever-changing environment and have a good attitude towards learning to find new skillsets to meet future changes. They also need to be flexible in the work place, eg. being willing to move between jobs and to travel. Graduates who can progress through a broad exposure to a range of work activities and diverse environments, such as working overseas, are able to upgrade their skills. For instance, they can start improving their leadership skills by managing people in various cultures.

**An inquisitive mind (13).** Many respondents indicated they expect their employees to show interest and willingness in learning. Attitude towards learning is the most important strategy for meeting future changes in the industry. Respondents stated their interest in having graduates with the ability to self-motivate, find solutions on their own, and constantly learn. Employers are looking for graduates displaying the ability and initiative to research and find answers quickly and effectively on their own. Employees working in the field for longer periods will garner more knowledge and glean applicable information through on the job training; however, they must desire to learn more through self-motivation and self-reliance. With such a proactive attitude towards learning, employees will be able to experience a wide range of activities across the organisation and further their career.

**Self-management skills (18).** The majority of respondents stated that employees should have skills such as time management, the ability to prioritise tasks effectively, to cope with pressure, to learn on the job, self-reliance, and work ethics. A few interviewees also emphasised the importance of emotional intelligence in the work place. In addition, employees should be able to receive criticism and discern the difference between constructive and employment-jeopardizing criticism. This is particularly important to those new graduate employees, as they may tend to make more mistakes compared with incumbents.

**Analytical and problem-solving skills (22).** These skills are critical for daily operations in the on shore maritime industry. Employees should be able to think critically, holistically, collect data and analyse data to assist themselves or managers in decision-making.

**Interpersonal skills (16).** Interviewees emphasised such skills as being vital in the maritime industry due to the importance of relationship management. The skills required are to engage and build relationships with both stakeholders and staff from other departments.

**Computer skills (12).** Employees are expected to have basic computer literacy, proficiency in using software (in particular Excel), and technology to organise data and disseminate information.

**Team work (14).** Respondents stated that they require potential employees who can work in a team. They should be able to operate as a good teammate through cooperation, communication, and playing multiple roles to achieve the objective of teamwork.

**Knowledge.** Interviewees indicated various knowledge, relative to their specific areas, necessary to work in the onshore maritime related organisation (See Table 1 below). The bracket indicates the number of responses for each knowledge.

**Table 1** Knowledge necessary to work in onshore maritime related organisations

General business knowledge	Specific maritime business related knowledge
<ul style="list-style-type: none"> <li>- Financial accounting (10)</li> <li>- Financial management (4)</li> <li>- Marketing (2)</li> <li>- International trade (7)</li> <li>- Commercial law (5)</li> <li>- Systems concept (2)</li> </ul>	<ul style="list-style-type: none"> <li>- Shipping business operation and management (24)</li> <li>- Port operation and management (11)</li> <li>- Stevedoring operation (2)</li> <li>- Maritime geography (1)</li> <li>- Logistics and supply chain management (10)</li> <li>- Transport systems including intermodal transportation (14)</li> <li>- Maritime law (7)</li> <li>- Project management (12)</li> <li>- Naval architecture (1)</li> <li>- Documentation for exporting and importing (6)</li> <li>- Marine insurance (1)</li> <li>- Overview of the maritime industry (13)</li> <li>- Freight forwarding (5)</li> <li>- Information Communication Technology (ICT) in the maritime industry (11)</li> </ul>

**6. Skills gap between CLOs of maritime business degrees and industry requirements**

Considering the CLOs of the nine programmes studied and the information provided during the face-to-face interviews, it is suggested there are some strong similarities in the skills required by industry and CLOs. An example of this is general business knowledge, such as financial management and marketing being required by the industry, in addition to specific information relating to the maritime industry and logistics. Other similarities were evident in discussions related to the categories of self-management, team work and computer/IT skills. There were three study areas included in CLOs not mentioned by industry interviewees - ethics, a global perspective, and experiential learning. It may be that these skills are taken for granted by industry or are of little importance and therefore not mentioned; or they may not be considered as something that can be taught. Alternatively, it may be that employers consider that these are areas of learning that should be taught on the job, after completion of a study programme.

Some areas appeared to have a different focus when comparing the CLOs and listening to industry viewpoints. Firstly, analytical and problem-solving skills were seen by industry to include critical thinking and research; the impression given was these are a body of skills that need to be integrated and cohesive, not separated. Noticeably, industry was keen on graduates having inquiring minds, being interested and willing to learn. Fostering such skills may sometimes be assumed in universities, with little emphasis given to engaging students in the processes of learning by inquiry in CLOs.

Secondly, communication as a category is far more refined in industry's views than is shown in CLOs. The requirements are far more specific and given greater importance by industry. Unquestionably, industry is keen to have graduates that are skilled in all aspects of communication, not only written and verbal skills but also in active listening, negotiating skills and being proficient across all electronic media. Interpersonal skills are also included by the industry as necessary and can be developed through effective delivery of communication-related studies. More emphasis on broader communication skills in CLOs may benefit industry.

A key skills gap in CLOs is adaptability and flexibility. The maritime industry is dynamic and complex; it is vital that graduates can adapt and be flexible to further their careers in an industry where change is a given. A willingness to change roles or locations, to upgrade skills and see various perspectives is critical. Including adaptability and flexibility as a key CLO may assist universities to better meet industry requirements.

## **7. Conclusion**

In general terms, this paper highlights that there is further work to be undertaken by universities in developing CLOs. In particular, there is an opportunity to clearly articulate how their maritime business related undergraduate programs can prepare graduates for adapting to the rigours of working in the onshore maritime industry and being able to make early contributions to their chosen organisation. The comments in this paper are made tentatively because the CLOs of only 9 of the 28 universities could be found. Further research is required to fully investigate whether CLOs do in fact exist in the other 19 universities, perhaps using a different term to CLOs, or it may be that other universities either do not utilise CLOs to explain outcomes attained by graduates, or simply do not see the benefit in providing CLOs in a public forum such as on their website.

From a more specific perspective, this paper suggests that the available CLOs and maritime industry requirements tend to converge in areas such as knowledge, self-management and

computer/IT skills. However, modifying CLOs relating to communication and problem solving to give more specific emphasis, depth of study and focus may benefit industry as universities will be providing more comprehensive skill sets for these critical areas. Finally, including adaptability, flexibility and an inquiring mind in CLOs may increase the value of maritime business programmes to the dynamism and complexity that are inherent in the maritime industry.

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# THE NEED FOR IMPROVING ASSESSMENT SYSTEM IN MARITIME EDUCATION AND TRAINING

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**Abstract.** STCW is a fine example of communication failed to go beyond its creators' community boundaries. After hearing from the shipping industry about shortcomings of the STCW79 and the fact that it has failed to achieve its objectives, international maritime community virtually created a new convention. Compare to its predecessor, STCW95 based on a contrastive philosophy. The 1995 Convention adopted Competency Based Training (CBT), as a new maritime pedagogical practice. After a decade of its implementation answer to the question of what has fundamentally changed since then was hard to answer. Changes that realized by STCW95 for many training institute did not exceed curriculum modification of already existed ones, whereas, STCW95 aimed to produce a change in concept and worldview of maritime education and training. The case is worse with maritime administrations and competency certification authorities in many countries. The bureaucratic nature of these regulatory organizations prevents many of them from effecting basic change required by the convention. One of the main indicators of this reality is the assessment system. Currently, the final evaluation of competency still heavily relied on written and oral examinations, albeit simulators, in some countries, are small part of their assessment systems. The last revision of STCW Convention in 2010 seems to overlook this problem and it did not affect how the competency of mariners evaluated. This paper discusses how the assessment for certification in practice today not only does not measure the authentic competency of the mariners but also how it shaped the pedagogical practices of the maritime training institutes. The paper recommends *Quasi-community* as a novel framework for teaching and assessment in maritime domain (Emad and Roth, 2016). This method allows the student seafarer not just learn how to be successful in the examinations but how to be authentically competent and perform better on the job.

**Keywords:** Maritime Education and Training, STCW, Assessment, Competency Based Training, evaluation, Seafarers' competency.

## **Introduction**

To develop the knowledge, skills, and competencies that seafarers require to perform their job on board ships they attend Maritime Education and Training (MET). To assure the quality of MET outcome, maritime administrator in each state assess the competency of the graduate from their MET systems and if they are successful they are assigned a certificate of competency. This will assure shipping companies that the holders of certificate of competency who want to work for them meet the requirements of the job and are able to perform their skills competently. This method is not only exercised in maritime domain but it is a common practice in many professions. The employer in those professions require a technical organization (certification body) to re-evaluate the ability and competencies of their prospective employees. These professional certification organizations assess the candidates and if meet the requirements issue them a certificate of competency. These certificates, for many occupations, acts as a permit to work in that profession. Unfortunately, in most cases, including seafaring the evaluation for certification is limited the assessments to a series of written and/or oral examinations. The less than optimal performance of many of the educated and certified seafarers on board ships questioned not only the quality of certification but also the value of education and training in maritime training institutes. My research was designed to study such processes in a system that intended to increase the competency of practitioners in the maritime domain. My intensive case study research on the processes of a post-secondary education and its related certification for maritime vocation confirms that the separation of assessment from education created challenges for the seafaring students and MET institutes.

Study such as mine (Emad and Roth, 2008, 2009, 2016), show how the present certification assessment system has changed the objectives of the MET practices from learning knowledge and competencies needed on board ships to simply learning what is needed to successfully pass the certification examinations. In this system the students, assisted by their instructors, learned to avoid failing the exams for the certificate and not what is required to operate ships.

In this paper after providing a background of maritime education and certification system I explain different elements of this system and discuss how the assessment system affect the change in objectives of seafarers learning and lecturers teaching.

## **Background**

Those who would like to become a seafarer have to attend MET institutions get educated and then get certified to be able to work on board ships. Shipping is an international industry and seafarers may get hired and sail in any part of the world thus there is a need to have a uniform international standard for MET and certification system. The international convention, the *Standard of Training, Certification and Watchkeeping of Seafarers* (STCW) is set out to regulate the maritime education and certification processes. STCW lays out the training standards for the MET institutes and the certification procedures anywhere in the world. The requirement of STCW has to be implemented by maritime administration of each country. In Australia, Australian Maritime Safety Authority (AMSA) is the maritime administrator and the responsible organization for certifying mariners. Any person who would like to be certified has to attend an educational institute, then attend a ship for on-the-job training and undergo the certification assessment conducted by certification authority. The assessment process includes written and oral examinations—the so-called competency certification assessment.

## **Method**

This research paper is based on a qualitative ethnographic case study conducted in the context of training at a MET institution. The study is designed to better understand the challenges in a system of maritime education specifically designed to increase the competencies of prospective seafarers. My database was collected during a series of courses presented for students applying for maritime certificate of competency. The data of the case study presented in this article is collected from a series of courses presented for students who have already acquired their first-level certificate and been employed by shipping companies. In the process of promotion in their job they require to upgrade their certificate thus they re-attend college. Thus, all of the course participants (students) have work experience. The data was collected during interviews and focus group from students and their instructors. The secondary database included student's course notes, teaching syllabus, sample tests and also certification procedures, rules and regulations in addition to the related academic publications.

## **Current practice in MET institutions**

The maritime education and training system is greatly influenced by the requirement of the competency certification system. The prerequisite for attending the certification examination is for the candidate to attend a specific number of courses in a MET institution. The

certification examination itself is comprise of a series of written examination and finally an oral examination. To match those requirements the MET institutes, adjust their program accordingly in two parts, namely *training* which covers mainly practical and hands-on skills and *education* that comprise of teaching theoretical knowledge.

### *Training courses*

My study shows the training in the training institute works relatively successful in reaching its objectives and most of the students and instructors were satisfied with the results. The training courses generally are approved by the maritime administration. It means that in most cases the training institutes have the authority to assess the students for the course and issue the relevant certificate. The main criterion for assessment in these courses is the ability to perform successfully the targeted tasks. These courses are consisted of theoretical and practical parts and include hands-on activities. Students in my study generally were satisfied by what they were able to learn from most of the training courses. Although the marine administrator asks for part of the assessment to be in written examination (generally multiple-choice questions), the students are primarily evaluated while engaged in carrying out the tasks and the instructor have to be convinced that the students are competent in performing that type of tasks. Many of the participants in this study, was satisfied with the result and mentioned that these courses are very useful, very applicable to what they are going to do on board ships. Students stated that the practical nature of these courses and the direct relation that they could make between training and on board practice was a motivating factor. They believed that they would be able to transfer their newly developed skills to their work. My analyses reveal that the students are more satisfied with these courses than by other aspects of their college-based education. They actually felt more confident, prepared, and competent to do the related tasks in their workplace.

### *Theoretical Knowledge*

To attend certification examinations seafarers, have the choice to attend the preparatory courses in the MET institute or to self-study and prepare themselves for those examinations. For most of the theoretical subjects, my study shows that the students generally find it more convenient to prepare themselves on their own. However, for the more challenging exams that demand higher cognitive ability, for example ship stability, they prefer to attend courses in MET colleges. Course attendees' primary concern in the college was to pass the certification

exams rather than learning knowledge and competencies that they need on board ships. Many of the students participated in my study mentioned that when they are not able to get the proper amount of knowledge to pass specific exams on their own they decided to come to college to do those particular courses. They articulated their objective for attending the course is to develop the type of knowledge required for passing the certification exams. I found that in general, students' perception of the certification examinations mediates their approach to learning while attending college. It was evident from the fact that their primary demand from their course lecturer was to prepare them for the exams.

To attract students to their courses, MET institutes have to consider the objectives of students since they are their customers. This was the incentive for MET institutes to concentrate on teaching the students how to pass the examinations, a fact evident from the data collected from the course instructors. For many of the instructors, the examinations constitute an obstacle, as they believe that the students do not even feel the need to understand the tasks while they have been asked a question but to merely provide specific answers. My classroom observations revealed that lecturers put substantial effort into the delivery of information that historically appeared in competency examinations. This was in direct response to students' requests and the lecturers' desire for students to be successful. This shift in objectives from the acquisition of job-relevant knowledge and competence to knowing enough to pass the certification examination is a source of weakness and a drawback in maritime education system.

#### *Assessment for certification*

Assessment is a process by which lecturer and the student themselves evaluate the student's learning quality and process. Thus, it is an important part of every education system. Assessment gives an insight to whether the objectives of the MET system is achieved and the student developed the required skills and knowledge. However, as studies show, assessment may actually contravene attainment of educational objectives (e.g. Emad and Roth, 2008). My observations in the present study show that this is also the case in the current MET system. The current STCW requirement which guides the maritime certification system around the world created a contradiction in those systems. As the result, some aspects of the system become impediments to achieving the goals of STCW.

My study shows that students' perception of assessment shaped their approach to learning. They discussed the assessment from the beginning of the course and wondered about the nature of examinations' questions. They collected most of previous examinations' questions.

Those who had experience of attending these examinations, for their earlier certificate, were aware of the type of assessment they should expect. Students were concerned about specific issues in the exams. One of the issues was the validity of the exam questions. Students considered the questions to be outdated and have no practical implications for their jobs. The instructors also were in agreement as they believed that often the examinations are old and have not been up-dated.

The conventional assessment system in use is not able to achieve its claimed objective; i.e. evaluating the knowledge and understanding an officer needs to be able to act competently on board ship. In the current practice the maritime authorities created a bank of questions. As the examination's questions are drawn from that bank, the questions may appear identically across different examinations.

My findings are consistent with those of other studies that revealed the severely compromised nature of examinations that reused the same questions year after year (e.g. Stutman, 1997). Students' perceptions about assessment significantly influence their approaches to learning and studying (Struyven *et al.*, 2005). This affects the way education and training system performs. Students aim to pass the exams knowing that all they have to do is to get ready for the set of largely known questions. Answering these questions became the primary objective of teaching and learning. As an instructor mentioned that what he is having to do is trying to figure out what marine authorities may want in certification examination and as the result what he ends up to do is wasting lot of students learning time teaching history instead of teaching today. The instructor also oriented toward teaching outdated knowledge, rather than focusing on teaching useful, present-day knowledge, because he wants the students to be successful in the certification examinations.

Continuous demand of students from teachers resulted in final sessions of the courses to be assigned for reviewing the sample questions from the available previous competency examinations' question bank. When the students are under pressures for the score they have to give up or beat the system teaching the test questions and corresponding answers is one response (Bloor, Sampson and Gekara, 2014). Some of the maritime authorities tried to solve the problem by creating a new set of questions for their question bank. They may not be aware that the renewed question bank can only be a temporary solution, as some years down the road students and lecturers are going to have those questions. This solution may not solve the flaw but at best may postpone the problem. Inappropriate assessment procedures encourage superficial learning and varying the examination questions may not be enough to fully evoke deep approaches to learning. It seems that the action might not change the

perception of students about the examination and as a result it most probably not affects the way that the students approach learning.

### **Discussion and conclusion**

My study shows that the assessment system as enacted today does not allow an authentic evaluation of the competency of the candidates. The students thereby may engage in defensive learning, acquiring what they need to be successful on the examinations irrespective of whether what they learn is actually useful on-the-job. There is no indication that a graduate is competent for the targeted job. This causes the education and training system to perform in a way that make the students better in taking test rather than to be competent in performing the required tasks on ships. Likewise, my analysis suggests that the assessment system needs to be redesigned. Thus, the students may be able to engage in authentic learning where they may learn a wide range of practices they have available for addressing problematic situations on board ship.

My research resulted in development of a novel framework for teaching and assessment in maritime domain namely *Quasi-community* (Emad and Roth, 2016). The quasi-communities design to identify and improve learning in maritime education and training system. It will allow the pedagogy to co-develop through the lecturer's practice and students' participation in their teaching and learning. This method may allow the student seafarer not just learn how to be successful in the examinations but how to be authentically competent and perform better on the job.

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# MATURING THE INTERNATIONAL ASSOCIATION OF MARITIME UNIVERSITIES (IAMU) USING BENCHMARKING

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**Abstract:** From the perspective of organizational theory, groups within the nonprofit/NGO sector have a unique and distinct form, but structure is key to their strategy nonetheless [1]. Furthermore, methods of collaboration and communication often form the vehicle by which the strategy is implemented. In its second decade of existence, the International Association of Maritime Universities (IAMU) is an example of a nonprofit/NGO that is seeking more mature practices to advance from stage 3 (competent) to stage 4 (proficient) [2]. Performance measurement system design principles developed for the private and public sectors are applicable to the nonprofit/NGO sector [3]. This paper will outline a standard benchmarking analysis methodology to evaluate IAMU against comparative and aspirant organizations [4]. By examining the practices of other organizations using this standard benchmark process, a set of performance levels and targets will eventually be established for structure, collaboration, and communication. This work may form the foundation for noteworthy improvements to the global MET enterprise.

**Keywords:** MET, Benchmark, NGO, Nonprofit, Communication, Collaboration, Organization

## **Introduction**

Benchmarking has played a prominent role in management as a tool for continuous improvement [5], [6], [7]. There are many definitions of benchmarking [4], [8], [9], but the key concepts include: measurement, comparison, identification of best practices, implementation, and improvement. All organizations, including and especially non-profits or NGOs, constantly seek improvement, and therefore engage in benchmarking. Many organizations use maturity models to evaluate the effectiveness and efficiency of their processes and practices. For example, one such framework specific to non-profits and NGO's [2] uses the following five stages of development: novice, advanced beginner, competent, proficient, and expert – each with increasing levels of sophistication and detail. In its second decade of existence, the International Association of Maritime Universities (IAMU) is an example of a nonprofit/NGO that is seeking more mature practices to advance from stage 3 (competent) to stage 4 (proficient) [2]. Therefore, IAMU would benefit from a benchmarking study.

## **Materials and Methods (Benchmarking Process)**

In order to properly benchmark, organizations should consider the internal aspects of their organization to be benchmarked as well as the external comparisons to be made [10]. Given the basic agreement of the IAMU and its goals, a *process* or *functional* benchmarking model would be of most benefit. Upon evaluating a comprehensive review of hundreds of benchmarking models [11], it was determined that the “traditional, most widely used” Xerox benchmarking model was most appropriate for the IAMU proposes based upon its longevity, ubiquity, and practicality.

The so-called Xerox model [4], includes four principle phases: planning (of benchmark study), analysis (of comparison organizations to identify gaps), integration (where

results are prioritized and communicated), and finally action (where results are implemented). The Xerox model for benchmarking is included as Figure 1. These phases correspond to traditional quality management four-step processes and would be easily understandable by a wide audience.



Figure 1: Xerox Model of Benchmarking [4]

### Proposed Case Study (IAMU Benchmark Study)

According to the IAMU Tasmanian Statement [12], communication, collaboration, and structure would seem to be prime candidate areas for benchmarking analysis. Specifically, objective 4 calls for functional and regional cooperation within the IAMU organization and sets out two actions to accomplish this. However, it is unclear if these two actions would accomplish the desired objective. As such, a benchmarking study that focused on a few process or functional areas and identified competitive gaps by comparing outwardly

to other similar, segment-leading non-profit organizations would likely yield actionable information that would have a higher probability of achieving success.

Using such a benchmarking orientation, a development project could be undertaken to achieve specific objectives, such as:

- Identify which organizational structure is most appropriate (e.g., regional, functional, or mirror of IMO subcommittees)
- Identify the best means of collaborating within this structure is necessary to achieve organizational goals
- Identify the best means of communicating within this structure to enable the collaboration drivers.

The following is a general process by which the Xerox benchmarking model could be applied to IAMU as a development project in an effort to enhance collaboration and relevance.

***Planning:***

1. The study will benchmark organizational structure, collaboration methods, and means of communication.
2. In consultation with members of the IEB, the project team will identify several global organizations (including several aspirant organizations). One key organization for comparison would be the IMO; it is imagined that one form of organizational collaboration would be functional rather than regional and might mirror parts of the IMO subcommittee structure (e.g., SSE, HTW, NCSR, PPR, etc.).
3. A standard and common method of data collection would be used.

***Analysis:***

4. Using the data collected, the team would compare IAMU to the comparison organizations and identify the gaps between the current state and a desired future state

as identified by best practices in the comparison organizations: for organizational structure, for collaborative methods, for means of communication and flow of information.

5. Performance levels will then be identified.

***Integration:***

6. The team will compile the results of the analysis and recommend a set of practices around organizational structure, collaboration methods, and means of communications. The study will also include a communications plan for IAMU to share the results with its membership.
7. In addition to the communications plan, the study will provide a timeline for implementation and functional goals.

***Action:***

- 8-10. The action necessary to implement the recommendations proposed in such a study would not be within the scope of the study. Action plans would be recommended, but the IAMU leadership and membership would be responsible for enacting the results of the development project. Alternatively, this could be considered phase 2 of this development project and could be submitted for approval next year.

As may be evident from the benchmarking process, a systematic method for goal achievement can be obtained in efforts to maintain and sustain competitive advantage. Additionally, other process improvements (e.g., fund raising) could be endeavored using a similar benchmarking process. As the process of comparison became used repeatedly to adopt and incorporate segment best-practices, IAMU would continue to become more proficient (stage 4) and mature as an organization.

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# DEVELOPING AN ASSESSMENT METHODOLOGY FOR A UNIVERSAL MARITIME ENGLISH PROFICIENCY TEST FOR DECK OFFICERS

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**Abstract** The paper presents the adopted approach to develop a methodology for assessing the language proficiency of Deck officers in Maritime English. The methodology design is a collaborative effort involving partners from six countries and is a core outcome of the EU-funded Erasmus + MariLANG Project.

The current context of teaching and assessing Maritime English has been determined by the latest amendments (Manila, 2010) to the original International Convention on Training, Certification and Watchkeeping for Seafarers (IMO STCW-78 Convention). In the recently revised (2015) *IMO Model Course 3.17 Maritime English* the IMO recommends the assessment of communicative competence without clearly defining language proficiency levels recognised by international MET institutions. Therefore, there is a need for a standardized instrument to measure the language proficiency in Maritime English. Such a proficiency test can be used as a benchmark test against which MET institutions can compare their students.

This paper will discuss the aspects to be considered during the development of test specifications and why these are useful to guide the entire process of test development to ensure a balance between different aspects of test usefulness, e.g. reliability, construct validity, authenticity, etc.

**Keywords:** Maritime English testing, test design, construct validity, reliability, test tasks, assessment criteria, piloting

## Introduction

The purpose of this paper is to introduce the MariLANG methodology for the development of a universal proficiency test of Maritime English to measure the English language ability of Deck officers around the world. It reflects extensive research work in the field of language testing and experience in teaching and assessing Maritime English as collaborative effort involving six European partners in the framework of the EU-funded Erasmus + MariLANG Project. The partners consist of not only language testing specialists, but also maritime subject experts and Maritime English and English for Specific Purposes teachers from Belgium, Bulgaria, Germany, Greece, Slovenia and the United Kingdom.

As the language domain of Maritime English is considered English for Specific Purposes (ESP), the MariLANG Project team has conceptualised the design of the proficiency test in terms of the key concepts of a special purpose language test as defined by Douglas (2000, p. 19):

*“A special purpose language test is one in which **test content and methods** are derived from an analysis of a specific purpose **target language use** situation, so that test tasks and content are authentically representative of **tasks** in the target situation, allowing for an **interaction** between the test taker’s **language ability** and **specific purpose content knowledge**, on the one hand, and the test tasks on the other. Such a test allows us to make inferences about a test taker’s capacity to use language in the specific purpose domain”.*

The *target language use* (TLU) situation in this definition refers to specific real life professional context which can be related to the scope of deck officers’ duties and requires successful communication using Maritime English. These duties have already been established in terms of competencies in previous EU-funded projects such as MarENG, MarTEL and SeaTALK, in particular with reference to documents edited by the International Maritime Organization (IMO).

## **Background**

The current context of teaching and assessing Maritime English has been determined by the latest amendments (Manila, 2010) to the original *International Convention on Training, Certification and Watchkeeping for Seafarers*, known within the Maritime community as the *STCW-78 Convention, as amended*. These amendments were made in response to the need of international standards in training seafarers towards acquiring practical skills and competences in addition to professional knowledge.

The shift to a competency-based approach to teaching and learning Maritime English implies that the goal of the assessment should be communicative competence. The International



Maritime Organization (IMO) recommends in the recently revised IMO Model Course 3.17 Maritime English that “*Tests of English language competence should aim to assess the trainee’s communicative competence. This will involve assessing the ability to combine knowledge areas of English language with the various language communication skills involved in order to carry out a range of specific tasks. Assessment should not test the trainee’s knowledge of separate language areas alone*” (2015, p. 208).

In recent years, assessing linguistic competence in Maritime English adequately and reliably at internationally recognised levels has been brought to the attention of the International Maritime English Conference (IMLA-IMEC) audience. Research in Maritime English Training (MET) studies suggests that numerous attempts and efforts to address the complexity of the issue and explore the process of developing assessment instruments have been made throughout the years. Research into existing tests of Maritime English (both teacher-made and commercial) suggests that many training institutions or companies and Maritime Administrations uses their own resources, experience and understanding of how and when the Maritime English competence should be measured and how results should be interpreted. This, in turn, shows that despite the major breakthrough of the Maritime English competence *Yardstick* (Cole and Trenkner 1994, p. 11) as a standard it has not been applied properly and consistently yet.

Furthermore, little is known about the extent to which the assessment literacy of Maritime English teachers and providers has been the focus of any specific training and monitoring. The main focus of teacher training seems to be the methodology of teaching English for Specific Purposes (ESP) and acquiring the specific subject matter knowledge from the maritime professional work environment. An ESP teacher is often a course and task designer, a teacher, a researcher and evaluator and his/her role “... *becomes more pronounced as the teaching becomes more specific*” (Dudley-Evans and St.John 1998, p. 13). It is generally assumed that as teaching and testing go together and are inherent parts of the educational process in any content area, ESP teachers have the necessary knowledge and skills to produce valid and reliable tests. However, the development of a universal Maritime English proficiency test requires sufficient knowledge and experience in test development as there are many important decisions to be made about what should be considered in the process of test design.

## **Main considerations**

### **1. Adopting a model of language ability**

Following the IMO Model Course 3.17 recommendations for the assessment of competence in English with the freedom given to interpret what stands behind “*effective communication*” implies that it is necessary to clearly identify the kind of language ability/competence to be assessed, i.e. what communication means in the context of Maritime English referring to a model of communicative language ability with its components and communicative functions. Recent models of language competence have identified several components of communicative language ability, e.g. organizational and pragmatic competence (Bachman 1990, p. 87). Deciding which competences are relevant to the seafarer’s use of English would be the best guidance to identify the participants, means, context, purpose, etc. of communication in the particular target language use (TLU) situation. Keeping in mind that “...*communicative language teaching is directed at use, i.e. the ability to use language meaningfully and appropriately in the construction of discourse*” (Ellis 2004, p. 28), and giving due consideration to the variety of Maritime discourse with its many genres and registers, will clearly make teachers and instructors rely on professional competences which find linguistic expression through the current *Lingua Franca* of the sea, namely the English language.

## **2. Selecting the type of assessment**

Researchers have categorized several types of tests (e.g. placement, achievement, proficiency, progress, etc.) based on what each test is intended to measure. One of the most important decisions to be made by the MariLANG project team is to define clearly the specific language aspects or abilities that constitute the construct validity to be measured. One distinguishing feature of ESP testing to bear in mind is the interaction between subject matter knowledge and language knowledge (Douglas 2000). As each test is only a sample from a content domain, in defining the aspects which the test is supposed to measure test writers should make sure that the test is as representative of the specific maritime domain as possible.

## **3. Selecting the test methods/tasks**

Research findings show that it is difficult to find suitable and novel tasks that test communicative ability alone and not intellectual capacity, educational and general knowledge or maturity and experience of life. The results offered by a recent SeaTALK Survey (available at <http://www.seatalk.pro/>) conducted at 24 maritime institutions show that the use of multiple choice questions (MCQ) is a popular and widespread means of assessment. In many countries MCQ are used in examinations aiming at STCW certification. However, the validity of MCQ assessment of linguistic competence towards STCW Competency certification has been studied and questioned recently by Maritime English teachers. The conclusions drawn are that “*MCQ use is driven by economics and convenience, rather than effectiveness: that assessment is*

*subject to random (unpredictable) factors, and that there is a lack of formal training in question construction and evaluation”* (Drown, Mercer, Jeffery & Cross 2014, p. 60). In order to minimize the effect of guessing, more candidate-supplied response task types should be used (short answer questions, sentence completion, gap-fill, etc.) A good balance of different task types will enable test-takers to demonstrate a wider variety of language abilities.

Selecting the test tasks is of primary concern as the flexibility of the task frame may guide or limit the response of the test-taker. According to studies in ESP assessment a major characteristic of tests tasks is authenticity, i.e. how closely they reflect what test-takers will do in a real-life professional situation. In this way, the task will achieve situational authenticity within the domain.

Furthermore, the choice of test methods is directly linked to what is often ignored – the “washback” (or “backwash” as used in the general education field) effect. The notion of washback refers to the influence that tests have on teaching and learning (Alderson and Wall 1993). Different aspects of influence have been discussed in different educational settings at different times in history due to the fact, that testing is not an isolated event (Shohamy 1993a). Washback studies investigate the impact of different types of tests on the content of teaching, teachers’ approaches to methodology and the reasons for their decisions to do what they do. According to Madaus (1988), ‘high-stakes tests’, i.e. tests the scores of which are used to make important decisions about the test-takers would have more impact than low-stakes tests. We should be aware of the complex interaction between tests on the one hand and language teachers, material writers and syllabus designers on the other hand, as test tasks have influence the decisions made in planning a communicative curriculum.

Bachman and Palmer (1996, pp. 85-86) argue that making decisions about the test content and task types, identifying the linguistic competences to be tested and describing the test-taker and the purpose of the test should be the starting point in the process of test development. They refer to these activities as *Stage 1 Design*. The authors see the test development process consisting of three stages: *design, operationalisation and administration*.

Stage 2 involves producing the test specifications document.

#### **4. Test specifications or the ‘blueprint’ of the test**

In general, this document provides information about the purpose of the test, the profile of the test-takers, the test structure including the number of tasks and items in each section/version, the duration of the test and its components, the grading system as well as a definition of the construct. According to McNamara, the initial draft will be “*subject for revision as experience*

*with the test and investigation of its strengths and weaknesses proceeds*” (2010, p. 25) with the aim to improve test quality.

A number of researchers in the field of testing have contributed to the structure and purpose of test specifications (Alderson et al., 1995; Bachman & Palmer, 1996; Davidson and Lynch, 2003). They view the structure from different standpoints; however, they agree that different versions should be produced for different audiences.

For example, the most detailed version of the test specifications, which is often confidential will be used by test writers to develop new versions of the test to ensure sustainability. As it will include the task specifications, this version will be used during item moderation to consult and review the work done.

Another version of the document may be produced for public use to familiarize test-takers and everybody interested in the test with the test content. For example, managers of shipping companies may need information in order to select a valid test for their needs. This version should include sample test tasks.

The MariLANG team has already drawn up the first draft of a set of test specifications for the skills of listening, reading, speaking and writing and for the Standard Marine Communication Phrases (SMCP). As Maritime English encompasses a standardised language (IMO 2001), specifically designed for use on board a ship, the SMCP require independent attention and, ultimately, testing. Task specifications for each type of test task have been developed and included in the structure of the test specifications. One of the purposes of the task specifications according to Bachman and Palmer (1996, p. 177) is to enable the creation of an item bank for producing more versions of the test.

Once the test items for each section of the test have been written in accordance with the test specifications, they should be tried out to find out potential problems with the test.

### **5. Pretesting and analysis**

You may have written very good items but *“it’s impossible to predict whether items will work without trying them out”* (Alderson et al. 1995, p. 74). The purpose of piloting (in research and testing literature the terms *“pre-testing”*, *“try-out”*, *“trial”* are used) is to identify problems with test content, test rubrics, rating procedures (assessment criteria, rating scales, marking), etc. The sample of test-takers should be large enough and as representative of the intended audience as possible (ibid. pp. 75-76). For example, if it is supposed to measure Maritime English language proficiency of deck officers, the piloting group should consist of the same or similar people. Depending on the purpose of the test, people from different cultures should be

involved in pretesting in order to minimize the effect of cultural background on test performance.

After the trial statistical analysis will be carried out to establish item difficulty and item discrimination values as well as inter- and intra-rater reliability. To do this successfully, the team has undergone training in Language test item analysis.

#### **6. Training of test writers and raters**

In order to write good test items it is not enough to have excellent English and be knowledgeable in the content area. It is not enough to be familiar with the test specifications, either. If you are not a professional item writer or have no experience in writing test items, you might produce test items which do not match the test specifications and will pose a threat to the content and construct validity of a test. In a study on writing items for an academic reading test Green and Hawkey (2012) provide evidence about how training and guidance help inexperienced item writers pay greater attention to the construct, evaluate texts and items better as part of the review process, identify skills easier and select appropriate task types.

Training can be beneficial for item writers in many ways. For example, it will help them gain some insights into the specific elements of each test task in terms of how well it can elicit certain language abilities. In addition, it will make test writers aware of the advantages and disadvantages of each test method which, in turn will develop abilities to select the best task type for a particular context and construct. This will increase the confidence of the test writer in his /her own skills and enhance their abilities to look critically at the work of other item writers during the reviewing process known as *item moderation* (Alderson et al. 1995, p. 40). Having another member of the team look closely at and/or try out a test question they did not produce themselves helps identify some problems with the original intention of the test writer, the expected response, the approach to reaching the correct answer, etc.

Another aspect of training is related to assessing writing and speaking as it is very difficult to achieve consistency in measurement due to a number of issues (examiner characteristics, task appropriateness, interpretation of assessment criteria, etc.). Training will help raters minimize the variations in the grading of writing and speaking performances. It will also ensure internal consistency in interpreting and using a proficiency scale (*intra-rater reliability*) and the level of agreement between two or more independent raters (*inter-rater reliability*).

To ensure sufficient level of expertise the MariLANG project provides four different training modules to its partners at different stages of the test development process. However, the training itself combined with knowledge about the theory of developing a language proficiency test will not automatically guarantee a good quality test ready to be used.

There is one more step to consider in the methodology design. It would require the professional judgement of experts on test *usefulness* based on evidence (Bachman & Palmer 1996, p. 133).

### **7. Evaluation of test qualities**

Bachman and Palmer (ibid. p. 17) argue that before any test is put into practice, its quality and sustainability should be examined carefully to provide evidence that the test can be used as a valid and reliable measurement instrument. The authors consider *validity* and *reliability* the most important specific qualities of a test as they “*provide the major justification for using test scores – numbers – as a basis for making inferences or decisions*” (ibid. p. 19).

For the purposes of this paper, the complexity of the nature of validity and the process of test validation will not be discussed here. It is generally considered that a test is valid when it measures what it is supposed to measure. Alderson et al (1995, p. 171) emphasise that “*it is best to validate a tests in as many ways as possible*” in order to collect more evidence about different factors pertaining to validity. Mesick (1989) identifies two aspects related to test construct and having serious impact on validity. *Construct under-representation* is observed when important aspects of the defined construct are not included in the test. *Construct-irrelevance* refers to testing something that is not included in the construct. The other crucial test feature - *reliability* is often defined as a consistency of measurement and is reported in the form of a *reliability coefficient*.

Although test validation is the final stage of test development, Weir (2005) argues that evidence of validity need to be collected from the very beginning of the test design process. Weir’s Socio-Cognitive Framework for Test Validation identifies a priori (before the test is administered) and a posteriori (after the test is administered) validation evidence. The MariLANG team has based the validation of its test on this framework as it clearly indicates the types of validity evidence that one should look for at each stage.

### **8. Ethics**

An important consideration in the methodology design is to make sure that the general principles of good practice set in the EALTA Guidelines for Good Practice in Language Testing and Assessment (2006) are followed. Being fair to all test-takers is a major concern to everybody involved in the development of language tests and their implementation. It means following all steps in test preparation professionally to build a firm theoretical foundation of the new measurement tool as decisions about real people will be made based on the test scores.

### **Conclusion**

The aim of the MariLANG project to develop a universal Maritime English language proficiency test for Deck officers is ambitious and requires a huge amount of responsibility and commitment by all partners involved in all stages of the project.

By adopting a highly systematic test development approach, a valid and reliable assessment of Maritime English proficiency for deck officers will be available to the international community. This will assist maritime teachers and facilitators in reaching an internationally accepted language proficiency standard.

However, it would be impossible to achieve the desired aim without the support of the Maritime English teaching community in the reviewing and trialling process.

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# **SEARCHING THE MET HIDDEN CURRICULUM THRU THE ALUMNI'S BELIEFS LEARNED OUTSIDE THE STCW REQUIREMENTS: MAAP-CMU JOINT STUDY**

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**Abstract** This paper is an exploratory study on MET hidden curriculum that made use of the following methods of data collection namely: observation, a questionnaire, structured interview and documentary analysis from internet and library research. The respondents are Alumni and holders of Certificate of Competencies. They are currently employed in either at MAAP or CMU. This study involved an analysis of the various concepts and existing research works on the hidden or covert curriculum. This study was limited to the hidden curriculum which is just one of the eleven types of curriculum (overt/explicit or written, societal, null, phantom, concomitant, rhetorical, curriculum-in-use, received, internal and electronic curriculum). Various theories of the hidden curriculum are investigated, analyzed and interpreted. The MET hidden curriculum as it relates to the alumni seafarers' beliefs they have learned outside the STCW requirements, was examined using some methods of data collection namely documentary analysis, observations, questionnaires, and interviews. Empirical findings were compared to the hidden curriculum theories, and the same were analyzed and explained in detail.

**Keywords:** Hidden MET curriculum, covert curriculum, alumni beliefs

## **Introduction**

This paper is a joint study made by Maritime Academy of Asia and the Pacific (MAAP) from Philippines and by Constanta Maritime University (CMU) from Romania. The study was

planned when MAAP and CMU, represented by Dr. Angelica M. Baylon and Dr. Cristina Dragomir respectively, had met for the first time at CMU Romania, on May 9-16, 2017. The meeting was due to the kick off meeting for the project “Gender Equality and Cultural Awareness on Maritime Education and Training” or GECAMET, funded by the International Association of Maritime Universities (IAMU) and the Nippon Foundation. After several discussions and exchange of issues on MET, they both opined that problems in MET curriculum might have two natures: the “public nature” or the “personal nature.” A study on beliefs may be more of a “public nature” that is linked with pressures that people feel about various changes in MET curriculum or policies for the implementation of the curriculum. The school talks a lot about objectives, subjects, timetables, syllabuses, quality standards and technologies. These are all important issues, but they are similar to a donut with icing on top. What ones see or hear or talk about is the “overt” part of a curriculum or the icing above the donut. On the other hand, what one does not see, hear or say, is equally important as well. That refers to the hidden or “covert” curriculum which is like the fillings inside the donut.

The hidden curriculum is made up of the beliefs, attitudes, expectations and motivations of various people - teachers, students and administrators. They are the ones that are mostly unknown, rarely spoken, and very often underestimated. If only they are uncovered, it will provide a lot of insights for the improvement of the MET curriculum. A study on beliefs and attitudes may also be more of a “personal” nature.

Belief may be defined as the feeling that something is true or an idea which is considered correct, but that does not necessarily imply that the idea is right. In other words, the thoughts we hold about language, about teaching and about learning range from conventionally accepted facts to things we receive on a very personal basis. Hidden curriculum refers to messages communicated by the organization and operation of schooling apart from the official or public statements of school mission, policies and subject area curriculum guidelines. The messages of hidden curriculum usually deal with attitudes, values, beliefs, and behavior. There are obvious examples when hidden curriculum has pronounced undesirable effects. An institution with a strong focus on academics may fail to value students who are academically excellent. Honors to deserving students may have been denied for reasons not within the student’s control, namely: lack shipboard training days as these depend on the sponsor’s schedule of the vessel; mistakes in the computer grading system or wrong judgment of school authorities. This scenario would

demoralize and devalue the student achievers because of the unfairness and injustice experienced. A student's ability to be optimistic, to trust authorities, or to build self-esteem can strongly be affected when his experiences in school are contrary to the school's manual that students are important and well-taken care.

The messages of the hidden curriculum may complement or contradict each other, as well as the official curriculum. Hidden curriculum can support or undermine official curriculum. It is likely that hidden curriculum has the most impact when there is an aggregate or a pattern of consistent messages. When hidden and explicit curricula conflict, it may be that hidden curriculum, as nonverbal communication, that carries more weight. Structural or organizational aspects of hidden curriculum may include: time scheduling of classes and other school activities; facilities provided; materials, such as textbooks and computer software; examinations; required courses; special programs, such as advanced placement; extracurricular activities and services; and grading and grouping policies whereas cultural aspects of hidden curriculum may include school norms or ethos; décor and wall decorations; roles and relationships, including intergroup relations (within and between teachers and students); student cliques, rituals, and celebrations; and teacher expectations of various groups of students (Wren 1999). This paper examines the alumni's beliefs on their learning outside the STCW requirements to uncover the MET hidden curriculum.

### **Literature Survey**

A MET curriculum is an organized framework that guides MET teachers and students in the required education. It is similar to a "contract between society and educational professional about the educational experiences that learners should undergo during a definite phase of their lives" (Braslavsky 1999). Both the school and the community have a say in the development of the written and unwritten or hidden school curriculum. There are differences between written and hidden curriculums. Teachers teach, and students learn implicit concepts and patterns. Some of these are written in the curriculum while others are not. Teachers may not be as aware that they are transmitting unwritten or hidden curriculum ideas. Students may sense it much faster because some of these ideas force them to behave in ways they do not always like. Quickly, they learn that they have to conform to the rules of the school if they want approval.

T. Anderson described three historical ways of viewing an unwritten or hidden curriculum (Anderson 2001). Curriculum sometimes determines limitations to student behavior in the classroom and in the school which may be a hindrance to learning (Marsh 1997). Other notable researchers have studied the hidden curriculum (Longstreet and Shane 1993), the role of the backward design in curriculum establishment (Wiggins and McTighe 2004) and other types of curriculum used in school: societal curriculum (Cortes 1981, p. 240), the null curriculum (Eisner 1994) or the Electronic curriculum (Wilson 2004).

### **Methodology**

There are two ways to explore the beliefs of people - by asking and by observing. By just asking people, or rather, let them talk, give them the time to write or say things, listen to them will provide insights into their thoughts and feelings. Another interesting way of eliciting beliefs is by asking people to complete statements as they wish. The same event can be viewed in entirely different terms by different people holding different sets of beliefs.

This paper presents an exploratory study that made use of the following methods of data collection: observation, a questionnaire, documentary analysis from internet and library research and the structured interview with the 10 MAAP alumni who are currently on vacation and are teaching at MAAP and 10 CMU alumni who are currently employed at CMU. The documentary analysis from the internet and the library analysis contributed to understanding the scientific mainstream on hidden curriculum and in establishing the objectives of the study, the questionnaire, and the interview questions.

The topic guide for the interview was drawn up based on the review of literature and studies and by pilot interviews to four alumni seafarers (two from MAAP and two from CMU). Topics covered included their perceptions about themselves both as former students and as Mariners; their beliefs on what they have learned in the Academy/University outside of the STCW requirements; their sources of learning; the primary way of assessment in their training experience; and the reasons on why they consider their lecturers as role model or not.

The structured interviews were held in May-June 2017. Each interview was approximately 45 minutes-1 hour long. The interview had 19 questions divided into two parts: part A for gathering background information (e.g. nationality, age, sea experience, program/degree etc.) and part B

for collecting more insight (core information). A sample of the core interview questions (part B) can be found in Table 1 below.

**Table 1.** Sample of questions for structured interview on MET hidden curriculum

<b>PART B. Core Information</b>	
<b>No.</b>	<b>Question</b>
1	What is your perception of yourself as a former MET student? Describe yourself in few words.
2	What is your understanding of yourself as a Mariner? Describe yourself in few words.
3	What were your sources of learning as a student?
4	What were your sources of learning as a mariner?
5	Which skills, gained during the educational program, were useful in your current work as Mariner?
6	Did the beliefs, attitudes, expectations, and motivations of the teachers, students, and administrators contribute to your development? If yes, how?
7	What was the primary way of assessment in your training experience?
8	Do you consider your lecturers as a role model? Why?
9	How did your previous education in the Academy/University outside of the STCW requirements help you evolve as a seafarer?
10	How did your previous training in the Academy/University outside of the STCW requirements help you develop as an individual?
19	Did the MET program help you overcome seafarer career challenges? If yes, please give some examples

An interview method was used as it provides: “The opportunity for the researchers to probe deeply to uncover new clues, to open up new dimensions of a problem and to secure vivid, accurate, inclusive accounts that are based on personal experience.” (Burgess 1982, p. 107).

The interview was conducted face to face with respondents. The interviews were tape recorded and later transcribed before analysis. The respondents were aware that their participation is voluntary. All of the interviewees were positive during the interview and felt the importance of the study.

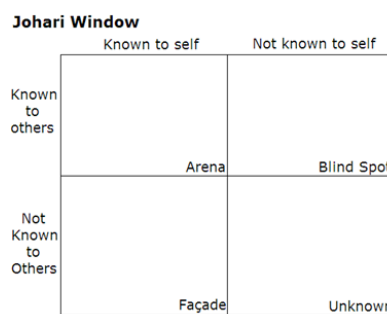
Demographic (Age: Nationality: Sea experience: Last rank: Certificate of Competency, Institutions of training) details of respondents, were collated using a questionnaire and verbatim quotes are also included from the interviews, providing a vivid account of how respondents think, talk and behave. The interview method resulted in a total of 20 interviews composed of 10 Filipinos and 10 Romanians with age range from 32 to 57 years old. They all possess a

Certificate of Competencies, having a rank of an operational level of seafaring experience of at least five years long.

## Results and Discussion

### 1. Personal Perceptions of Respondents as Students and as Mariners

The majority of the respondents perceived themselves both as an excellent mariner and an average student. Just like the Johari window, this is the first way to discover beliefs in oneself and others. The Johari window is a communication model that can be used to improve understanding between individuals (Luft and Ingham 1955), represented in Figure 1.



**Figure 1.** Johari window. Source: Wikipedia.org

However, not all beliefs are available for inspection. There is a secret self, things that a person is aware but do not want to disclose; there is a blind self, things that one is aware but others are not; and also the hidden self, things both the person and others are not aware. So to search into own or other person's belief, one cannot just rely on what a person says or inferences - a person also need to observe to confirm or reject those assumptions. So the second way to explore beliefs is observation and self-observation and, of course, comparison and discussion of what a person observed. By looking at one's actions, at what one does, a lot of things can be inferred, once can go back to his decisions, then to his attitudes, and finally get at his beliefs - and maybe decide to challenge or change them.

### 2. Learning Outside the STCW Requirements

The study showed that things learned in the formal curriculum often evaporated after the licensure or competency exams and sometimes even earlier.

Regarding the skills which have been useful in their current work as a mariner, the following skills have been cited: theoretical, technical, practical, communication, critical thinking, managerial leadership, human relations and problem-solving. Hence, further study may be conducted to determine the degree of usefulness of each skill as a mariner.

As to the study provisions and study conditions experienced, the following have been cited with both negative and positive feedbacks for improvements: the teaching quality of teachers; the design and structure of the program; the course content of primary subject; the trust and grading system; the length of study in the academy; the contact with fellow students; the chances to participate in research and extension projects; the provision of work placements and other work experience; the opportunities for students to have an impact on the school's policies and overall skills. Hence, further study may be conducted for the respondents to rate their satisfaction as regards their experience.

### **3. Sources of Learning**

The respondents cited the following as their sources of learning namely: fellow students, a special lecturer, some teachers, the actions of the Institution, the inactions of the Institution and experience. It must be noted that majority of the respondents cited actions of the institution which may connote positive or negative. It may pertain to the enacted /endorsed/ratified curriculum or policies approved by the school for implementation by the teachers and officials that have a tremendous effect on students.

### **4. Assessment forms**

The following are the listed primary way of evaluation in their training experience: oral exam, simulator work, written test, class quizzes, class discussions and field trips. Various MET activities of schools may be better funded than others, sending the message that some MET activities are more important, which may create caste or clique structures within schools. Even in the very organization of an academic day, the schedule may say much about hidden curriculum emphasis on particular subjects. The subjects given the most time or scheduled at the most prominent parts of the day could be a means of referencing them, or the topics provided more assessments is more preferred than the others.

## **5. Lecturers as Role Models**

The majorities of the respondents said that their lecturers are their role models and cited the following reasons: “I have learned theoretically and practically”; “ I felt that why he says is true and he is doing what he says”; “ The lecturer shared experiences on board”; “The teacher used various case studies to exemplify the theory, including his case”; “The professor acknowledged the values system of the student and communicated with the student accordingly”.

Three of the respondents had mainly the same beliefs or philosophy: “Yes my lecturers are my role models because there are two kinds of role models - the BAD lecturers and the GOOD lecturers.” One alumnus mentioned: “I had enjoyed most the classes when the lecturer was able to identify my interests and system of values and used a collective and appropriate language to keep up my interest to his class subjects.” Another one said that: “I can still remember today, after many years, the case studies presented by an excellent lecturer and master mariner, from his experience.”

## **Conclusions**

In essence, a hidden curriculum is what the students are taught to exist in the world as a whole. The various beliefs that the alumni seafarers cited as regards on what they have learned outside the STCW requirements include respect for authority; proper behavior in society; how to follow directions; tolerance; and emotional stability. These are components of the hidden curriculum which are based on each teacher, at least to the extent of how the teachers are perceived by their students as role models or not. The hidden curriculum is an extension of the coach.

Whatever the teachers hold in the highest regard is what is transferred to the students. Many of these beliefs and views are universal (such as the respect for authority and proper societal behavior), but some of them seem unique. This could include ideas and views such as: to accept things even if you do not like the idea and to hide ones true thoughts to cite a few. These views were obviously stated by a statement of beliefs made or were stated more subtly through sarcasm and body language, that provided clues to a wide variety of other views and opinions of the students to their teachers who taught them and are therefore part of the hidden curriculum.

The result of this study is not to generalize but rather, this was an exploratory study of an under-researched area of MET hidden curriculum that attempts to explore the beliefs of the alumni seafarers (Filipinos and Romanian combined) which somehow had provided valuable insights.



The alumni seafarers' views are important because they lie at the heart of what people think, feel and do. The more the MET instructors are aware of the student's beliefs, the better they will be able to manage any process of change in the curriculum. MET teachers also need to be aware and do whatever they can to lessen the impact, possibly through oral disclaimers when they venture out about their personal beliefs, and to just simply do their best. This may mean developing multiple teaching strategies and methods based on individual differences for each student in the class. Doing so would mean more work for MET teachers, but it would help keep them and the students on their toes and would reduce the impact of the hidden curriculum upon the other categories of the curriculum.

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# MOVING THE BOUNDARIES OF MET WITH HIGH FIDELITY ERS TRAINING

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**Abstract:** Engine Room Simulators (ERSs) have become an attractive and valuable tool in maritime education and training (MET) mainly due to the associated cost, risk and convenience in providing training on-board ships. In addition, simulators enable training to replicate scenarios that are not otherwise possible for students to experience and interact. For these reasons, the international convention on the Standard of Training, Certification and Watchkeeping (STCW) has recognised the importance of the use of simulators in MET. With this recognition, the investment and innovation in simulation systems have evolved ERSs from a preparatory tool to a full mission engine room simulator over the last three decades. As a result, ERSs of varying capabilities and configurations are currently widely employed in MET institutes around the world. This paper explores the role of ERS and the opportunities it may present in the future to MET. It is identified that ERS has the potential to play a vital role in preparing the workforce for autonomous ships in the future.

**Keywords:** Autonomous ships, Engine Simulator Training, Maritime Education and Training, Marine engineer training.

## Introduction

Engine Room Simulators (ERS) have been used in maritime education and training (MET) for over 30 years. Figure 1 shows an example of an early hardware based simulator system that was installed at the Australian Maritime College (AMC) in 1985, which had a number of limitations. Their training capability was mainly focused as a demonstration tool for marine engineering trainees, with limited ability to provide operational and diagnostic training, further exacerbated by the lack of realism in the presentation and interaction. With the rapid development of computer technologies, software based simulators have gradually replaced the hardware systems. Nevertheless, they yet consisted of many simplifications, abbreviations and schematic representations of the machinery and their associated systems. As a result, even if trainees excelled in their simulator training, they may not be able to respond with confidence and the required competence when faced with actual problems while operating the machinery on board a ship. In addition, the cost of software based simulators were a major concern with many MET institutions resorting to purchasing systems with significantly reduced capabilities, while others were compelled to stay with hardware based ERS systems.



Figure 1. (a) Hardware based Engine Simulator installed at AMC in 1985, showing the entire engine room and the machinery space analogue mimic panel, (b) Engine Control Room console.

For the above reasons, many software based ERSs were used as a preparatory tool in MET focused on to familiarising students with the machinery and associated systems. With recent advancements in computer technology, high fidelity full mission engine room simulators are becoming more affordable to MET institutions. Modern ERS systems use the concept of virtual reality to mimic the actual engine room environment in an attempt to provide the user

with realism. Figure 2 shows the big-view screens and engine room console of the current ERS installation at AMC.

There are a number of advantages of ERS in MET such as:

- active learning which provides better interaction and interest;
- authentic assessment to evaluate student competence;
- building confidence by providing an environment where students can make mistakes and learn from their mistakes;
- risk free environment where faults and hazardous can be simulated with no danger to personnel or infrastructure;
- realism, connecting learnings to real-life scenarios;
- understanding the consequences, with the ability to provide immediate feedback on the actions taken and decisions made;
- ability to develop teamwork and leadership;
- ability to supplement lectures through relevant applications; and
- repeatability and consistency.



(a)



(b)

Figure 2. (a) Current AMC Engine Room Big-view touch screen panels showing the virtual reality machinery space, (b) control room console

Therefore, the use of ERSs has now become a norm within the MET, with institutions investing in the required infrastructure, and embedding ERS training and assessments as a key aspect within their engineering training programmes.

Currently there are a number of initiatives being investigated by practitioners, researchers, and authorities to explore the possibility of replacing part of the sea time requirements in MET with ERS sessions. The first step in this approach has been taken by the United States Coast Guard (USCG) to acknowledge a 6 to 1 ratio, where one hour of simulation training is considered equivalent to six hours of on-board training (Barsan 2009). A study conducted by the Marine Safety International Rotterdam and TNO Human Factors Research Institute has revealed that a ratio of 7.25 to 1 could also be considered as pertinent (Marine Safety International 1994). Other studies (Committee On Ship-Bridge Simulation Training 1996) have revealed that this ratio could be increased further to a ratio of 12:1.

Amidst the increasing interest and acceptance, ERS based education and training has several shortcomings and challenges. The lack of situational awareness is a major shortcoming where students may face difficulties in perceiving the present situation and anticipating what will happen next. Modern ERS tools come with various features such as audio-visual effects to help solve this issue. Nevertheless, many physical aspects such as change in the engine vibration due to a change in the operating condition, smoke and smell coming from hot or burning equipment, and changes in temperature would be hard to simulate and thus the prediction that could be made by the operator by sensing these changes is not easily

achievable with simulators. This further leads to the improper understanding of the risk of making mistakes, as simulator trainings can be viewed by students as being closer to video games than a real ship at sea, thus not fully appreciating the effect of making wrong decisions. Therefore, it is a challenge for trainers to create the environmental awareness and proper understanding of the risk involved in the actions taken by the students.

The abovementioned shortcomings are relevant to current ships where the engines are operated and maintained by seafarers on-board the ship. However, as ships move towards fully autonomous operation, the lack situational awareness will not be as significant as it is for manned ships. With the emergence of autonomous ships, the role of a marine engineer will gradually change to a shore-based operator role, eliminating the repair and maintenance from their duties. As a result, the gap between the ERSs and real world applications become narrower, enabling MET institutions to use ERS as the main tool of training for the future marine engineer.

This paper explores the use of ERS in future MET programmes to meet the requirements of the changing industry and technology. It presents options to expand the boundaries, outreach and relevancy of MET through the planned increased use of simulators. Potential challenges and opportunities are also discussed, together with the results of a case study conducted at AMC.

### **Motivations for expanding the boundaries in MET through ERS**

A century ago, the replacement of steam reciprocating engines by diesel engines created a revolution in the shipping industry. Subsequently, towards the end of the last century, the development in control and automation technologies created another significant change in the shipping industry, paving the way to unmanned machinery spaces (UMS). Currently, fully automated vessels are in operation, requiring no repairs or maintenance at sea, indicating the emergence of fully autonomous vessels that will not require engineers on-board the vessel (Levander 2017).

This exponential change in technology has had a significant impact on shipping in general and marine engineering in particular. However, MET has not always adapted, or indeed been proactive, to keep up with the pace at which technology has changed. Changes to the regulations and competency standards provided by the International Maritime Organization's (IMO) Standard of Training, Certification and Watchkeeping (STCW) and the relevant marine authorities, have for many reasons not been keeping pace with changes within the industry and in technology. Therefore, many administrations and MET institutions follow the

minimum standard required by STCW and be guided within its provisions rather than following industry needs and developing innovative training solutions. Hence, MET has mainly evolved around the STCW model courses, thus not addressing future and impending changes, such as the introduction of automated shipping, which is already a reality in the industry. This will require drastic changes to how MET programmes are developed and implemented to address the competencies required by seafarers and related personnel in the near future.

The current MET is focussed upon STCW functions and the competence tables prepared to address the following functions for marine engineers (International Maritime Organization 2010):

1. Marine Engineering
2. Electrical, Electronics and Control Engineering
3. Repair and Maintenance
4. Controlling the ship and care for the persons on-board.

With the emergence of fully autonomous ships, the role of the marine engineer will gradually change from on-board operation, repair and maintenance personnel to the remote operators, involved in fault diagnosis and rectification. This warrants a complete overhaul of competence requirements and probably a complete removal of the last two functions. Thus, the first two functions and the competence within them will remain the core curriculum for MET. In addition, inclusion of new competencies reflecting the needs of future ships are inevitable. Furthermore, the tasks that seafarers perform in an automated ship could accurately be replicated within a modern simulator environment. This provides a major opportunity for the training systems. It also may provide possible reduction in sea time requirements with the judicious use of simulators. As a result of this rapidly changing climate, ERS have the potential to play a major role in training of future engineers.

Over the past four decades the IMO's STCW guided MET systems around the world. Although it has been successful in many aspects, one of the main shortcomings is its passive nature. This need addressing to make seafarer education more proactive to meet future needs. Autonomous ships is one major driving force to initiate change in the STCW guidelines for MET in order to keep pace with the developments within the shipping industry.

The importance of making a change to the current MET system is further corroborated in the Marine Professional Journal, which states, "...we should see remotely operated autonomous vessels by 2020. Although there are strong predictions that the autonomous ships will be



sailing in 3 to 5 years' time, the question arises that, are we training future marine engineers to operate those ships when they are around?" (Nadkarani 2017).

Therefore, as all the evidence suggest, shipping industry is about to go through another revolution with autonomous ships and thus changes and expansion to the STCW guidelines and regulations pertaining to the use of ERS in MET is inevitable in order to meet the associated training requirements.

### **Advantage of current software based simulators**

There are two very important features when training simulators are software based.

- The affordability and flexibility of use for MET Institution, as they provide training on any type of ship and engine by simply 'loading' the appropriate software to the simulator.
- Most 'high fidelity' simulators use the same software that is used on the actual ships. This enables the simulator-trained personnel to transition smoothly into their roles when they join their ship. This means the trainees who undergo simulator training in fact operate their future ships during their training in the MET Institution.

The design of modern simulators enable 'real-time' simulation models providing a knock-on effect on adjacent sub-systems. Faults and alarms will have cascading effects throughout the system if not acknowledge and attended to in a proper manner. In addition to an extremely high level of realism, these simulators offers user friendliness and flexibility, key features of providing high levels of instructor control and greater variety of course offerings – capabilities demanded by ship owners and MET Institutions worldwide (Kongsberg Maritime 2013).

The modern state of the art 'Full Mission' simulators offer a wide variety of training opportunities in the operation of machinery in the engine room using ICT. This is exactly what is required in future autonomous ships where shore based engineers remotely control and service the machinery and the associated systems of the ships that are out at sea.

### **A case study conducted at AMC to show the effectiveness of ERS in seafarer training**

A survey conducted during the past four years at AMC revealed that school leavers who are commencing seafaring programmes find the ERS an exciting experience and an effective tool to grasp and consolidate upon the theories taught in class. This is clearly shown by the feedback obtained from students in the "Engine Resource Management" (ERM) unit. This unit enables the students to learn a comprehensive range of operational functions related to

marine engineering; for example how they can systematically start a Very Large Crude Carrier (VLCC) from cold ship status to finally being underway at full ahead. It is an elaborate process, which requires significant analytical thinking and problem solving skills.

For the purpose of this survey, students were provided with introductory sessions and videos explaining how to start up emergency and main generators to power up the ship. They then follow a critical path to start all the machinery in order to get the ship underway. An assessment was carried out at the end to evaluate the level of competence achieved by the students. The assessment rubric ensured that the students will not score 70% unless they managed to start the Main Engine and proceed to sea from the port.

A summary of the number of students who achieved more than 70% of this assessment is given in Figure 3. As the results indicate, 46% of the students did not have any prior sailing experience. This indicates that even without seeing the actual system, they were able to identify issues and take correct and timely decisions. Moreover, 89% of the students were below the age of 35 years, possibly indicating that simulators are more effective with the younger student population.

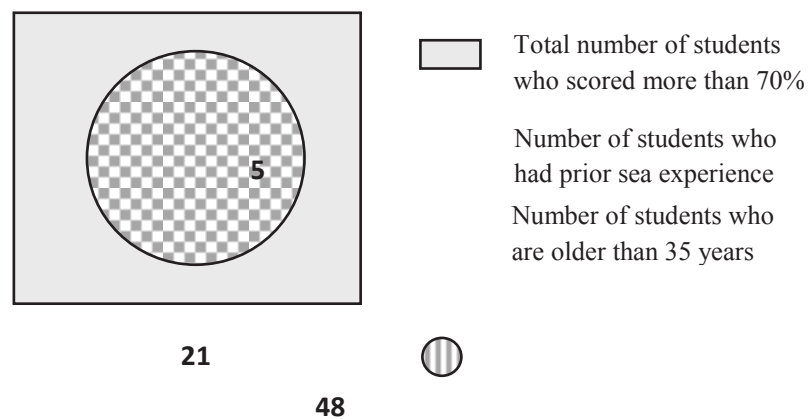


Figure 3. Venn diagram representation of the student distribution for the ERS assessment on machinery start up procedure.

Further observations revealed that, compared to the younger compatriots, the mature students struggled with the simulator training and ICT in general. The younger students come from a generation tuned to accepting ICT as the norm, whereas the mature students were moderately reluctant to give-up the old values of learning through traditional methods. A group of international students undertaking this unit stated that, “The simulator experience is like a real experience in an engine room. The subject has helped greater understanding on how the engine room operates and the learnings will surely impact our careers,” (Australian Maritime College 2017). Furthermore, students expressed that the technology was positively

influencing what was being learned and were supportive of the changes to their way of learning. The move from content-centred curricula to competency-based curricula in this exercise is associated with the move away from teacher-centred to student-centred learning. Through technology-facilitated approaches, contemporary learning settings now encourage students to take responsibility for their own learning. In the past, many students become comfortable learning through transmissive modes. Students had become used to, and indeed expected, others to present them with the information for learning. The growing use of ICT as an instructional medium is changing, and will likely continue to change, many of the strategies employed by both teachers and students in the learning process (Oliver 2002). Therefore, as evident from these results and the aforementioned trends, ERSs are not just an instructional medium, but also a key tool in the development of required competencies and attributes of marine engineers for future autonomous ships.

### **Summary and concluding remarks on moving boundaries in MET through ERSs**

The increased reliance and dependence on ICT is unavoidable in the marine industry, and this must be reflected in the modern training systems. In this respect, simulation can provide educators with a capable and flexible tool to train future marine engineers to meet the technological competencies required on-board sophisticated future ships, as they can provide a realistic training environment and assist in authentic assessments (Wallace 2017).

From the current STCW content, for future autonomous unmanned ships only the following STCW functions will be applicable:

1. Marine Engineering
2. Electrical, Electronic and Control Systems

This is because the role of the marine engineer in the autonomous ship era will transform into a remote operator. Although ships of the future will still need repair and maintenance, this will be scheduled when the ship arrives in port, which is somewhat different to the current practice. The design of these future ships is such that "...almost every bit of equipment is encased in a standard container, including fuel tanks, batteries and gensets. The propulsion itself is fixed, but everything else is modular, and the vessel can even be operated on battery packs alone if required. The maintenance on the vessel would be almost non-existent, with majority of work being carried out on shore." (Kongsberg Maritime 2015).

As stated by Kongsberg, "Simulator training has over the last few years proved to be an effective training method when training engineers, especially where an error of judgment can endanger life, environment and property. A dynamic real-time computerized simulator can

compress years of experience into a few weeks, and give knowledge of the dynamic and interactive processes typical for a real engine room. Proper simulator training will reduce accidents and improve efficiency, and give the engineers the necessary experience and confidence in their job-situation. It is important that the trainees experience life-like conditions on the simulator and that the tasks they are asked to carry out are recognized as important and relevant in their job-situation. The trainees should be challenged at all levels of experience in order to achieve further experience and confidence” (Kongsberg Maritime 2015).

Once the autonomous ship *Yara Birkeland* is in operation in less than two years (Nastali 2017) the reality of such vessels and the required competencies of the marine engineers to remotely operate such vessels will be clearer. In this context, current competencies, such as workshop competence, will not be required for future marine engineers working or operating autonomous ships. The industry may choose to have both ship operating marine engineers specialised in operation and ship repair and maintenance personnel competent in handling the STCW Code Function ‘Repair and Maintenance’. Thus, the functions ‘controlling the ship’ and ‘Care of the persons’ will cease to exist. It is thus prudent for the industry stakeholders to prepare for the future, changing current regulations, competency standards and MET practices to meet future challenges.

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# THE ACCREDITATION PROCESS: ANALYSIS OF THE RESULTS AND CREATING IMPACT ON THE EYES OF THE STAKEHOLDERS

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**Abstract.** The study aimed to analyze the results of the accreditations by Commission of Higher Education (CHED), The Philippine Association of Colleges and Universities Commission on Accreditation (PACUCOA), and International Organization for Standardization (ISO) 9001 vis-a-vis its impact to the institution as perceived by the stakeholders.

Sixty – eight (68) faculty members, forty – three (43) alumni members and one hundred sixty – four (164) students participated in the study as research respondents. The data analyzed is from AY 2010 – 2015 including the admission, enrolment, graduation, and board passing rate. The present study utilized quantitative and qualitative research design.

The results of the study showed that the Maritime Academy of Asia and the Pacific (MAAP) successfully passed the accreditation process by CHED, PACUCOA, and ISO with some areas or opportunities for improvement. It also shows that the quality of education is the most benefited aspect by the accreditation process as perceived by the stakeholders.

**Keywords:** MAAP, CHED, PACUCOA, ISO

## **1. Statement of the problem and its background**

### **Introduction**

The accreditation process is one way to ensure the quality education in an academic institution as seen in their outputs such an increase in the passing rate of board passers, success in employment and the higher level of competence of the graduates (Abesamis, 2008). According to Adelman as cited by Ching (2013), accreditation is a method of quality control and policy whereby, as an outcome of deliberation or examination, whether the institution or its programs are granted based on the qualification set by the accrediting agency as complying with the required mandatory standards. However, in the Philippines, it is noticeable that the quality of education in several higher education institutions (HEI's) have worsened over time as cited by Conchada and Tiongco (2015) as showed in low passing rate in the national board exams. Improving the quality of higher education institutions is thus one of the concerns and driving force on why some of the government agencies such as CHED are continuously discovering different ways to address the issue. In the Maritime Higher Education Institutions (MHEIs), there are some issues on the quality of education earned by the students. It is the vision of all MHEI's to be globally competitive by producing skilled and proficient human resources. However, the task is demanding as these institutions need to constantly verify and check their existing policies against the international standards. To address the demand of the competitive world market, the CHED issued policies in relation to compliance of all MHEI's in the country. Thus, there is a need to determine the impact of accreditation at the Maritime Academy of Asia and the Pacific so that other maritime higher education institutions in the Philippines who will undergo voluntary accreditation will have the foundations and basis in modifying their policies, procedures, and systems in education.

### **Statement of the Problem**

The general problem of the study is: What are the results of accreditation to the Maritime Academy of Asia and the Pacific vis – a – vis its impact to the institution as perceived by the stakeholders during the academic year 2010 – 2015?

Specifically, this study sought answers to the following questions: (1) How may the profile of the Bachelor of Science in Marine Transportation and Bachelor of Science in Marine Engineering be described in terms of years of offering, years of accreditation and admission rate? (2) How may the results of accreditation by CHED requirements on the two programs? (3) How may the results of accreditation by PACUCOA requirements on the two programs? (4) How may the results of ISO for the Management System Certification be described in terms of Quality management system, management responsibility, resource

management, product realization, measurement, analysis and improvement, performance evaluation and improvement? (5) Is there significant difference on the perceptions of faculty, MAAP alumni, and students on the effects of accreditations? (6) How may the respondents have perceived being the most beneficial aspect of accreditation? (7) How may the results of CHED assessments, PACUCOA accreditation and ISO certification affect the institution in terms of admission rate, graduation rate and board passing rate?

### **Significance of the Study**

The findings are deemed important to the maritime industry, administration, faculty members and future researchers.

## **2. Review of related literature**

### ***Quality Assurance Framework in the Philippines***

As mandated CMO-No. 46-s2012, it explains the QA framework used in the Philippines: (1) the fitness for purpose in terms of quality was used by the international organization for assessment and accreditation. This standpoint expects the institution to convert into learning outcomes, programs, and systems their vision, mission and goal. (2) Exceptional for quality should be used for being distinctive, meaning above very high standards, or conformance to norms based on a system of comparability using conditions and standards.

### ***Resistance to Quality Assurance and Accreditation***

In the study of Wang (2014), he emphasized the significance of teacher's and student's participation in QA and accreditation to help define quality in higher education in China. Jarvis (2014) opposes that there is an increasing global popularity of using QA in managing higher educational institutions as regulatory tool. Lucas (2014), argue the existence of the academic resistance to Quality Assurance practices.

### ***What is the Importance of QA and Accreditation and its Relationship?***

Quality Assurance is a state of conditions that may spearhead to the attainment of comprehensibility and transparency among areas of concerns. The transparency should be visible, it only means that the quality assurance and accreditation should make institutions evident of performance, it also letting the required outcomes to be experienced and felt by the faculty, staff and students.

## **3. Conceptual framework**



The study presents a theoretical framework based on the independent and dependent variables. The independent variables considered are the components of CHED assessment, the criteria of PACUCOA and the International Organization for Standardization (ISO) 9001 by DNV – GL criteria.

The dependent variable used in the study is the impact on the effectiveness of accreditation in terms of admission, graduation, and board passing rate and the evaluation of MAAP faculty, alumni and students on the accreditation of CHED, PACUCOA, and ISO. The perceptions of the respondents were used to validate the results of the accreditation.

#### **4. Methodology**

##### **Methods and Techniques of the Study**

The study utilized the quantitative and qualitative type of research. Descriptive type of research was utilized to explain and interpret conditions or relationship that exists, the perceptions of the respondents, the present conditions of processes and the effects that are evident or trends that are developing (Best and Kahn, 1998).

##### **Population of the Study**

Sixty-eight (68) MAAP faculty members, forty-three (43) alumni and one hundred sixty four (164) students of the Maritime Academy of Asia and the Pacific (MAAP) were used as the respondents of the study in the survey.

##### **Research Instrument**

The research instruments used in conducting this study were self-made questionnaire intended for the faculty members, alumni and students of MAAP. Several procedures in validating the instruments were repeatedly done to obtain accurate results. Likewise, the study used secondary data for the documentary analysis of CHED assessment, PACUCOA accreditation and ISO assessment results from 2010 – 2015 for the two (2) programs offered by MAAP. The research questionnaire focused on the areas evaluated by CHED and PACUCOA. This is followed by unstructured interviews to supplement the original information from the survey.

#### **5. Findings**

##### **Part 1. Profile of the Bachelor of Science in Marine Transportation and Bachelor of Science in Marine Engineering.**

From the time of establishment, MAAP is committed to continuously improve its system in producing qualified and competent graduates by submitting to different types of

accreditations. From the statutory and regulatory requirements to various third party accreditations that will check the existing quality policy of MAAP. The ISO started its verification from 2000 up to present, while PACUCOA started in 2012.

**Part 2. Accreditation Ratings of the Two (2) Programs by CHED**

In the area of faculty, based on the assessment made of CHED in the two (2) programs offered by MAAP, it showed that the area of faculty is not compliant with the requirements. They found out that one (1) faculty member is not a BSMT degree holder. The said faculty member was given a chance to take BSMT program in a maritime institution using the Expanded Tertiary Education Equivalency and Accreditation Program (ETEEAP).

**Part 3. Accreditation Ratings of the Two (2) Programs by PACUCOA**

**Table 1.** Results of PACUCOA Accreditations for the 2 Programs offered in MAAP

Areas of Evaluation	Program	
	BSMT	BSMarE
Philosophy and Objectives	4.13	4.13
Faculty	4.22	4.22
Instructions	4.53	4.53
Laboratories	4.83	4.83
Research	3.32	3.32
Library	4.03	4.03
Students Services,	4.17	4.17
Social Orientation and Community Involvement	4.05	4.05
Physical Plant and Facilities	4.58	4.58
Organization and Administration	4.21	4.21

Based on the report made by PACUCOA on the area of laboratories, “Latest model and impressive state – of – the – art simulators and computer – based training equipment approximating those used in the industry were provided” was found out to be one of the strengths of MAAP.

On the other hand, Research Area though it has the lowest score, the PACUCOA accreditors found it to have a strong management commitment for research activities as gleaned from the provisions of the MAAP Research Manual.

**Part 4. Accreditation Ratings of MAAP on ISO 9001**

Based on the results of certification, it showed that MAAP is compliant with the certification standards of ISO 9001:2015. It is also stated in the report that the facilities are well maintained all throughout the campus including renovation of cadet’s dormitories, efforts to improve the system of grades submission to Registrar through the On-line Grading

System (OGS), very strong and effective leadership by top management in driving the risk-based thinking.

### Part 5. The Effects of Accreditations as Perceived by Internal Stakeholders

It can be gleaned from table 2 that among areas of evaluation, MAAP faculty members rated the organization as the highest area with 4.98 mean score while the area of library got the lowest score with 4.66. MAAP alumni rated the facilities as the highest with 4.98 mean score while the area of research scored the lowest with 4.16. MAAP students gave 4.92 mean score to the faculty while extension services has the lowest with 4.60.

**Table 2.** Perceptions of the Stakeholders on Accreditations

Areas of Evaluation	Faculty		Alumni		Students		Total	
	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
Philosophy	4.90	0.27	4.76	0.35	4.63	0.50	4.71	0.44
Faculty	4.77	0.37	4.49	0.77	4.83	0.32	4.92	0.25
Instructions	4.75	0.38	4.62	0.46	4.89	0.25	4.81	0.34
Laboratories	4.85	0.40	4.66	0.40	4.84	0.31	4.81	0.35
Research	4.72	0.54	4.16	0.50	4.71	0.47	4.68	0.54
Library	4.66	0.44	4.81	0.36	4.75	0.41	4.74	0.41
Extension Services	4.77	0.36	4.21	0.48	4.63	0.45	4.60	0.47
Facilities	4.84	0.30	4.98	0.11	4.87	0.25	4.88	0.25
Organization	4.98	0.10	4.76	0.40	4.94	0.23	4.71	0.43
OVERALL	4.78	0.19	4.60	0.22	4.78	0.17	4.75	0.19

Scale of Mean	Descriptive Equivalent
4.50 – 5.00	Strongly Agree
3.50 – 4.49	Agree
2.50 – 3.49	Neither Agree nor Disagree
1.50 – 2.49	Disagree
1.00 – 1.49	Strongly Disagree

On the findings, the process led the administration to be supportive in trainings and personal development of the faculty and students and in practicing fair and reasonable judgement to the concerns of faculty and students. On the part of alumni, accreditation led MAAP to an environment that is conducive to educational activity and relaxation. Lastly, students strongly agree that this has led in producing sufficient and competent faculty members.

### Part 6. Comparison of Perceptions towards Accreditation between Faculty and Students

Among the areas of evaluations, the perceptions of the respondents when grouped according to faculty/ alumni and students is significant on Philosophy, Faculty, and Instructions, therefore the null hypothesis that there is no significant difference on their perceptions is rejected. In the areas of laboratories, research, library, extension services, facilities and organization, the perceptions of the respondents are not significantly different,

therefore the null hypothesis is accepted. In overall, the perceptions of the respondents when grouped according to faculty/ alumni and students are significantly different therefore the hypothesis is rejected.

### Part 7. The Perceptions of the Respondents on the Benefits of Accreditation Process.

**Table 3.** Ranking of Benefits of the Accreditation Process as Perceived by Stakeholders

Benefits	Faculty		Alumni		Students		Total		Rank
	Freq.	%	Freq.	%	Freq.	%	Freq.	%	
Welfare of Faculty and Students	6	8.8	17	39.5	30	18.3	53	19.3	2
Personal Development	1	1.5	8	18.6	14	8.5	23	8.4	3
Quality of Education	59	86.8	18	41.9	102	62.2	179	65.1	1
Improvement of the classroom or work environment	0	0.0	0	0.0	6	3.7	6	2.2	5
Improvement of the Quality System	0	0.0	0	0.0	4	2.4	4	1.5	6
Improvement of Physical Facilities	2	2.9	0	0.0	8	4.9	10	3.6	4
Total	68	100.0	43	100.0	164	100.0	275	100.0	

In the interview made with the stakeholders on the perceived effects of accreditation, one (1) faculty member said, *“Accreditation helps the management to determine its strengths and weaknesses’ when it comes to quality of education. Accreditation process guides the management towards different approach in education. They also make suggestions on how to improve the existing policies and procedures that will cater the needs of the learners”*.

Another faculty member said, *“With the help of accreditation, I was able to push myself to finish my master’s degree”*. In addition, one faculty member also said, *“Because of the accreditation, I was able to push myself to study and take my BS degree even at my age. I believed that it is indeed a great help for me. It will help not only for myself but also to my students. I can be able to transfer my experiences and ideas to them”*. *“It is just that we have that kind of checking and accreditation”*.

Furthermore, one (1) alumnus said, *“I experienced the transformation of MAAP from an ordinary Academy to a world class maritime institution. Let’s continue in improving our system and commitment to produce world class seafarer. The quality of education here in MAAP is incomparable to other maritime institutions”*.

On the other hand, students of MAAP viewed accreditation as, *“It is one way to improve the performance of the Academy for the benefit and welfare of the students”*.

*“Accreditation helps the management to determine what is best for the institution, faculty, staff and to the students”.*

Faculty members on the benefits of the accreditation process, 86.8% said that the quality of education had been beneficial followed by the welfare of faculty and students with 8.8%, and improvement of physical facilities with 2.9%.

On the perceptions of alumni, quality of education ranked first with 41.9% followed by the welfare of faculty and students with 39.5% and personal development with 18.6%.

While the majority of the students with 62.2% believed that quality of education has been beneficial with the accreditation process followed by the welfare of faculty and students with 18.3% and personal development with 8.5%.

**Quality of Education.** It shows that the faculty members, the alumni, and the students believed that quality of education is the most beneficial aspect of the accreditation process. Accreditation helped the management to determine its strengths and weaknesses’ when it comes to quality of education

**Improvement of Physical Facilities.** The respondents are well appreciated with the efforts of MAAP to give the state-of-the-art facilities to be used by faculty and students.

**Improvement of Quality System.** The respondents believed that MAAP quality system has improved because of the accreditation process.

**Part 8. The Effects of Accreditation to the Admission, Enrolment, Graduation and Board Passing Rate of MAAP.**

Table 4 shows the applicants for admission in MAAP the enrollment sizes, and reflects the number of graduates, while table 5 demonstrates the board passing rate of MAAP from AY 2010 – 2015.

**Table 4** The Number of Applicants Who Took the Entrance Examination, Enrollment sizes, and Number of Graduates

Class	Number of Applicants for Admission	Percentage Increase of Applicants (compared to class 2010)	Total Enrollment	Percentage Increase in Enrollment (compared to class 2010)	Total Graduates	Percentage Increase in the Number of Graduates (compared to Class 2010)
2015	3218	-67.46	478	132.04	406	126.82
2014	8671	-12.31	496	140.78	495	176.54
2013	10044	1.58	478	132.04	369	106.15
2012	12441	25.82	249	20.87	202	12.85
2011	9533	-3.59	244	18.45	218	21.79
2010	9888	0	206	0	179	0

**Table 5** The Board Exam Passing Rate

Class	Program	National Passing Rate	Program	National Passing Rate
	BSMT		BSMarE	
2015				
2014	87.76	54.42	85.00	59.11
2013	50.00	55.09	83.34	63.05
2012	79.34	54.37	93.94	61.05
2011	83.33	48.3	89.33	54.56
2010	43.33	48.73	92.27	52.97

It only shows that accreditations may have an impact on the performance of MAAP in terms of admission, enrollment, graduation and board passing rate. MAAP management was able determine the appropriate actions on how to run the institution properly based on the demands set by the local and international standards. Accreditation process helps the institution to determine the weaknesses and areas that need improvement. Suggestions from the external reviewing bodies are important to make sure that the existing policies implemented in the institution is working and implemented properly.

In the study of Abesamis (2008), she found out that accreditations contribute significantly to the level of effectiveness of BSMT and BSMarE programs in terms of admission, enrollment, graduation and board passing rate.

## **6. Conclusions**

The Maritime Academy of Asia and the Pacific started in 1999 with two (2) programs offered – the BSMT and BSMarE. In the year 2000, MAAP instituted the accreditation process with ISO 9001 and with CHED inspections. In 2012, MAAP received its Level 1 accreditation under PACUCOA. MAAP voluntarily submits the institution for accreditation from local and international agencies for continuous improvement and ensure that the institution is compliant with national and international standards. MAAP passed the CHED inspections, the ISO certification and PACUCOA accreditation with some areas for improvements. As perceived by the faculty members and students, the area of organization got the highest mean while the alumni members gave the highest mean to the facilities. As perceived by stakeholders, the quality of education is the most benefited from the accreditation process. Accreditations may have an impact on the performance of MAAP in terms of admission, enrollment, graduation and board passing rate. The perceptions of the stakeholders have significant differences in the areas of concerns. MAAP may consider to focus and give importance on the opportunities for improvement as suggested by the accrediting agencies for the benefit of the institution, faculty, staff and students. External

stakeholders that include sponsoring companies, parents, non-teaching personnel and the community may be included in the study for they may have other perceptions on the impact of accreditations in MAAP. MAAP may continue submitting voluntarily to accrediting agencies that will check and monitor the performance of MAAP.

## 7. Acknowledgment

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# THE LABOUR MARKET NEEDS BASED MARITIME EDUCATION – ESTONIAN MARITIME EDUCATION CONCEPT

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**Abstract** Referring to the latest studies Europe's maritime sector employs over 5 million employees generating almost EUR 500 billion a year, with a potential to create many more job places [1]. Moreover, almost 90 % of the EU's external freight trade is seaborne. Short sea shipping represents 40 % of intra-EU exchanges. Ensuring a good quality of life on Europe's islands and in peripheral maritime regions depends on good maritime transport services. Each year, more than 400 million passengers embark and disembark at European ports. [2]

Above-mentioned highlights the importance of the maritime sector and the fact that the maritime sector can be internationally competitive if there are working specialists educated according to the labour market needs. Maritime education is facing several challenges. From one side it is required to educate sufficient number of specialist to fill the needs of labour market. On the other hand, maritime education has to tackle at the same time with the existing demographic downturn and with the future development needs of maritime sector, for instance technological developments in the shipping and ports as well as in supply chain systems.

The paper presents integration of maritime labour market needs with the supply of maritime education market based on Maritime Education Concept (*MEC*). The objectives, methodology, and main results of MEC are described. The paper is focusing on labour market needs for the ship officers' professions. General conclusions and recommendations are given.

**Keywords:** maritime education concept, labour market needs, maritime education and training.

## 1. Introduction

The Estonian Marine Policy 2012-2020 (EMP) states that the maritime education and training (MET) should meet the follow condition: the maritime education in Estonia must ensure high-

level education to all specialities in balanced capacity and in all fields of maritime sector based on the labour market needs [3]. According to EMP, the concept of Estonian MET (MEC) is developed for achieving this goal.

The concept is based on previous studies' findings: i) the survey of labour market needs in Estonian maritime sector, 2015 [4], and iii) the study amongst alumni of Estonian MET institutions, 2016 [5]. The analysis of the all MET areas studied in MEC is not within the scope of this paper, the authors focus on the education and training of ship officers as an internationally regulated and most specific area of maritime education.

## **2. Estonian maritime education concept – ship officers' case**

### **2.1. Methodological approach**

The main starting point of the MEC development methodology is the assumption that there are two main factors in the formation and operation of maritime education system. The first of them is **an objective educational demand** for maritime education that comes from employers due to need of them for specialists with different levels of professional education. The source for determination of the objective educational demand were the results of abovementioned survey of labour market needs in Estonian maritime sector for years 2015-2025 [5]. This demand must be satisfied by the **supply of the education market** in the field.

Another key factor is **the subjective educational demand**, which is reflected in the number of people who want in the reviewed period to acquire one or another specialty of a certain level of maritime education [6]. It is important to note that subjective educational demand does not equal to supply of the education market, because the number of students inevitably decreases during study time, so the number of graduates is lower as compared to the number of those who have entered. Moreover, some part of graduates proceeds to work outside the maritime sector immediately after the graduating or does it later during observation period. These types of losses should be taken into account by correlation of the supply of the education market by corresponding coefficients. The result would be a **real supply** of the maritime education market.

### **2.2. The needs of Estonian shipping labour market**

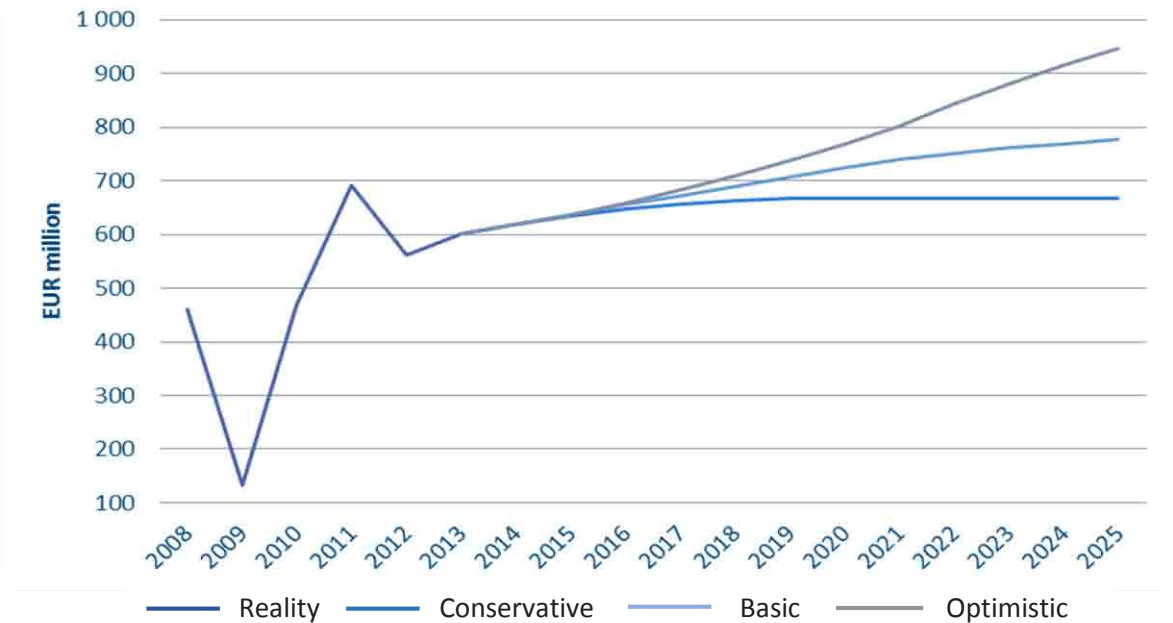
In course of investigation of maritime labour market needs the investigated activities were redundant to three operating subgroups: **shipping**, which in addition to the carriage of the goods and passengers contains ships towing, bunkering and crewing, **shipbuilding and ship repair** (including small boats building and repair), and **ports** (including stevedoring, ships agency

services and goods forwarding) [4]. For the purpose of present work, the target of the investigations has been shipping only, moreover, only the situation of the ship officers has been examined.

For drawing up the prognoses of labour market needs three development scenarios until 2025 were composed on the base of statistical analysis, interviews and experts' assessments. They were conservative, basic and optimistic scenarios what has been prepared in accordance with the following principles [4], [6]:

- the conservative scenario - relatively moderate scenario that takes into account some negative businesses estimations;
- the basic scenario - the continued development of the sector in accordance with the current development projection;
- the optimistic scenario - the most positive development opportunities are selected, i.e. the challenges facing the sector will realized in full.

Three development scenarios for subgroup of shipping are shown in Figure 1.



**Figure 1.** The development scenarios for shipping subgroup until 2025 (EUR million) [5]

The needs for additional labour forces in seafaring until year 2025 are shown in Table 1. Under additional labour forces, we understand in this case the people who will come to labour market in period of observation and who have to have maritime education for being employed on the vessels.

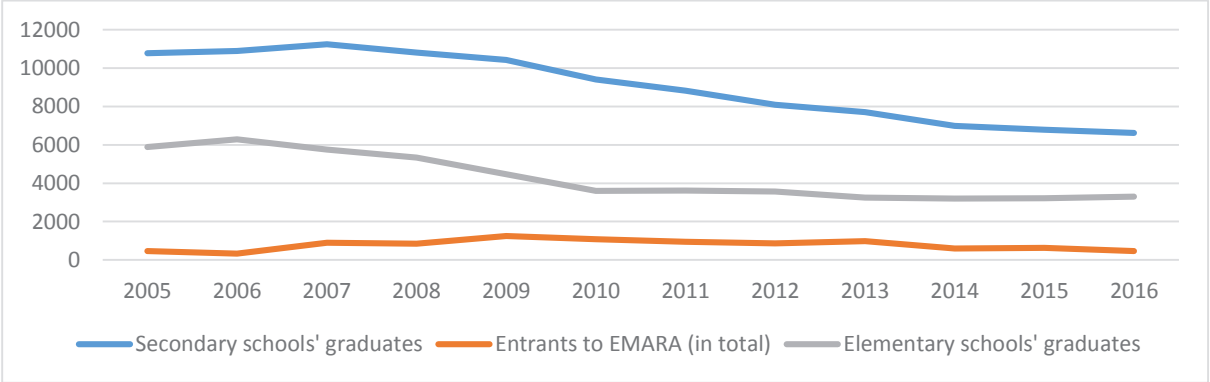
Table 1 shows that the greatest demand in Estonian shipping is for the captains and the chief engineers that correlates with the situation in the European Union and worldwide as a whole.

**Table 1.** The needs for additional ship officers in Estonian maritime sector until 2025 [4]

Job position	Scenario		
	Conservative	Basic	Optimistic
Captain	42	59	71
Chief Mate	14	18	25
Second Mate	8	12	17
Third Mate	21	24	29
Pilot	10	12	15
Chief Engineer	57	66	79
Second Engineer	13	15	20
Third and Forth Engineers	64	73	89
Refrigerating Engineer	8	10	13
Electro-Technical Officer	21	25	30
Radio-Electronic Officer	11	13	15
<b>Total</b>	<b>269</b>	<b>327</b>	<b>482</b>

**2.3. The subjective educational demand**

The subjective maritime education market demand is analysed on the base of the entrance to ship officers’ specialities in Estonian Maritime Academy (EMARA) in period 2000... 2016. Statistical data show that the weighted average competition for one student place for this period was 2.6 applicants for the navigation speciality and 2.7 respectively for the marine engineering speciality. True, those numbers annually have shown a downward trend in the last 8-10 years, primarily due to the deteriorating demographic situation in Estonia, which leads to a continuous decrease in the number of secondary and elementary schools’ graduates (see Figure 2).



**Figure 2.** The number of schools’ graduates in 2005...2016; the number of entrants to EMARA

For instance, for the period 2007... 2016 number of graduates completed their secondary education decreased by 1.7 times and, for the period 2006... 2014 number of elementary schools' graduates decreased by 1.9 times (see Figure 2).

Based on the Estonian Statistical Office forecasts can be argued that the number of graduates of secondary schools continues to decline in a few years and reached its lowest state in 2018. Next, however, the process returns since 2019, and begins a slow but consistent growth, so the number of secondary education graduates will increased about 1.2 times by 2025 compared to 2018. It means that by the year 2025 the entrance to ship officers' specialties may be increased, if necessary, by 20% to 30%.

## 2.4. The real supply of the maritime education market

The subjective demand affects the number of people wanting to come for learning every year but for identification of the real maritime education market supply the number of graduates is very important as well as the number of people who move after graduating to jobs, corresponding to the acquired education.

**Table 2.** The ratio of entrees and graduates in the years 2000 ... 2011

Curriculum		Years of entry												Completion percentage in average
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	
Navigation	Entrees	62	86	54	54	54	60	54	62	70	70	70	70	63
	Graduates (5 years later)	29	46	59	56	37	44	29	43	38	42	35	26	
Ship engineering	Entrees	38	30	36	36	36	37	34	40	32	45	45	46	70
	Graduates (5 years later)	19	40	33	27	28	20	22	26	27	33	14	28	

It is clear that, as a rule, for different reasons the number of graduates would be lower than the number of entrees to curriculum 5 years ago (nominal study period for ship officers' specialties). In Table 2 the number of entrees in 2000... 2011 is compared to the number of graduates 5 years later and the average completion percentage has been calculated on the base of it.

**Table 3.** The forecast of the graduates for the period 2017 ... 2025

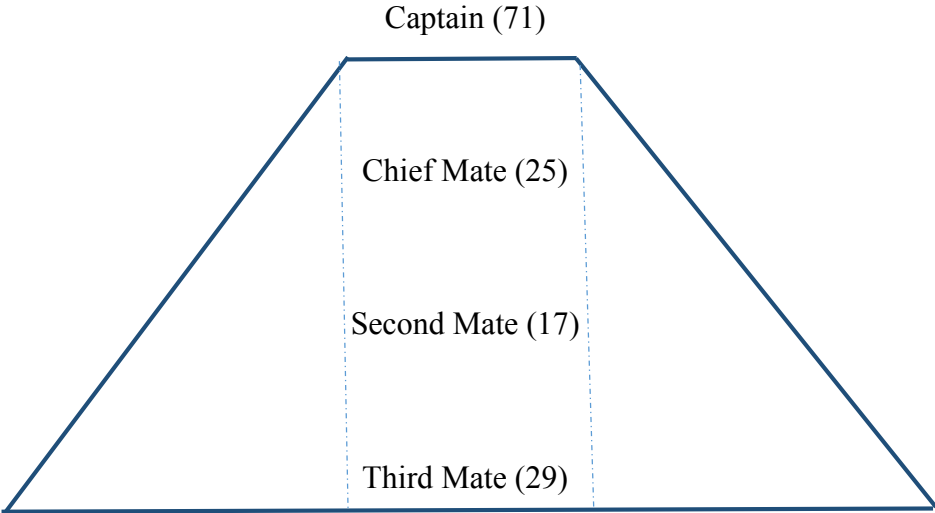
Curriculum	Graduating years									Total
	2017 (real number)	2018	2019	2020	2021	2022	2023	2024	2025	
Navigation	30	42	37	43	40	39	42	45	48	366
Ship engineering	20	32	23	32	32	35	35	39	39	287

Based on this analysis and the results of the subjective educational demand forecasts, it is possible to predict how many people would annually graduate both curriculum for the period until 2025. The predicted numbers of graduates are given in Table 3.

**2.5. Maritime career dynamics**

In sections 2.3 and 2.4 analysis conducted allows to prepare forecasts for so to say initial output of maritime education and training curricula. Based on for relatively long period collected statistical data and taking into account the demographic situation of Estonian education market and its possible developments in the next 10 years, it is possible with a certain probability to determine how much people could come to the labour market each year from maritime training institutions.

For ship officers should be taken into account the specifics of their professions and career. Both mates and engineers can move by “career ladder” only following certain rules. As a rule, they can start after graduation their seafaring career from the lower ship officers’ steps, and to move to higher position not earlier than the requirements of the respective practical experience and the other qualification requirements are met. Life has shown that not all will reach the top of the career ladder as the post of captain or chief engineer (actually not all want to do it). This is probably one of the main reasons, why both the European and the world's fleet have in recent decades a constant shortage of labour on leading staff positions (captain, chief mate, chief engineer, second engineer). Hence, in determining the market offering for the lower-tier ship officers' level it is necessary to have in mind that only part of these officers can come later to higher positions on vessels. It may be illustrated by so-called “career pyramid” (see Figure 3).



**Figure 3.** “Career pyramid” for deck officers

Numbers in brackets indicate how many ship officers of the respective stage should additionally come to the Estonian labour market in next nine years according to optimistic scenario (see Table 1). Looking at the Figure 3 it turns out that all the mates in "pyramid" must to become in 2025 the captains, because the total need for all ranks of mates (71 people) are the same as need of captains. However, this is unrealistic, because, firstly, as stated above, by far not all the officers can and want to become captains, and secondly, reaching the captain' position takes a certain number of years. From this perspective it is clear that for the satisfaction of labour demand in entire extent of the pyramid, watchkeeping qualified people (the third, fourth mate) should come to the labour market in times more than shown in the Figure 3. Similar approach can also be used for the ship engineers.

The Research and Development Centre of EMARA conducted from November 2015 to June 2016 a survey among the graduates of maritime education institutions. In a questionnaire, the respondents answered *inter alia* to work-related questions: on what job position they started after graduation; which their job position now and how much time was taken to reach this post etc. [5] Among those whose first job was at sea, began to work not in the maritime sector only 9% of the graduates.

#### **2.5.1. Deck officers**

From graduates of the navigation speciality 97 people answered the question about his first post. Of these 83 people or 86% were located in his professional work after graduation, 11 people or 11% were recruited maritime sector, but not exactly according to profession acquired, and 3 people (3%) did not have after school graduation worked in the maritime industry. The actual number of graduates should be to adjust by a career transition coefficient  $K_{ESN} = 0.85$ .

The question of the current (in the response moment) job answered 90 people. Among them 72 people or 80% worked at the sea, of which, in turn, 14 or 19% occupied the captain position. The longest time for becoming captain was 21 years and the shortest was 4 years. The weighted average time for reaching of this position is 9.4 years. Figuratively speaking, that one person could obtain in the year  $x$  the captain certificate of competence, 9 years earlier at least 5 people must completed the navigation speciality in maritime education institution.

#### **2.5.2. Ship engineers**

From graduates of the ship engineering speciality 50 people responded to the questionnaire, of whom answered the question about his first post 36 people. Of these 33 people or 94% were located in his professional work after graduation, 1 person or 3% were recruited maritime sector, but not exactly according to profession acquired, and 1 person (3%) did not have after

school graduation worked in the maritime industry. Extrapolating the results the actual number of graduates should be to adjust by a career transition coefficient  $K_{ESE} = 0.94$ .

The question of the current (in the response moment) job answered 34 people, or 97% of all respondents to the questionnaire. Among them 31 people or 91% worked at the sea, of which, in turn, 16 or 50% occupied the chief engineer position. The longest time for becoming chief engineer was 10 years and the shortest one was 3 years. The weighted average time for reaching of this position is 7 years. It can be concluded that about 50% of graduates reach the chief engineer position by approximately 7 years.

## 2.6. The European Union's labour market impact on the real MET supply

Since maritime is by its nature an international activity, it is clear that the EU maritime sector, especially in the labour market of shipping has a significant impact on the labour movement in the Member States, including Estonia, and it also greatly influences the Estonian maritime education market supply. [7] A significant part in Estonia marine-trained seafarers going to work for foreign shipping companies and other foreign flags.

**Table 4.** Ships division between flag states [5]

Flag state	Estonia	Finland	Netherlands	Man Islands	Liberia	Cyprus	Others	Total
Ship officers in total	37	18	11	7	5	4	20	102
%	36	18	11	7	5	4	19	100
Deck officers	25	7	8	6	3	4	17	70
%	36	10	11	9	5	6	23	100
Ship engineers	12	11	3	1	2	-	3	32
%	38	34	10	3	6	-	9	100

Responding to the questionnaire at sea working people answered, inter alia, to the following questions: "Is there a company in which you are currently working, registered in Estonia?", "Under which flag sail the ship on which you work?", and "Where do you permanently live in (country)?" [5]. The survey results showed that from 102 currently working on ships officers 40 people, or 39% of the respondents work in companies registered in Estonia; almost the same number of respondents, or 37 people (36%) are sailing on ships flying the Estonian flag [5]. Respondents' ships division between flag states is shown in Table 4.



The same may be said about division between Estonian and foreign shipping companies. In Estonian companies working 28 deck officers of 70, or 40%, to the engineers this number is 12 people of 32, or 38% [5].

The situation of seafarers' residence is quite different. The answers reveal that from 102 respondents, only 3 people (3%) named some other country than Estonia as the country of their habitual residence (one captain, one chief mate, one third mate) [6]. This confirms the long-time known fact that, in spite to the international character of their work seaman is generally devoted to his homeland, and selects it almost exclusively for himself and his family's residence. This means not only the seafarers' contribution to the Estonian economy by spending their income here, but, given the context of the MEC, more importantly, the potential willingness to go to work in companies in Estonia and under Estonian flag as soon as possible.

### **3. Conclusions**

A detailed description of results of survey would go beyond the scope of this paper even if confined only to the ship officers' specialities, so authors bring out only some general conclusions and findings leaving a deeper and more detailed presentation of the subject for future publications purposes.

1. Analysing labour market demand and the education market supply for the highest positions (captain, chief engineer) it should be taken into account that reaching these position requires time. Average time for acquiring of the captain position is 9 years; accordingly, and for the chief engineer it is 7 years (see p. 2.5).
2. Taking into account statistically calculated coefficient of the achievement of the captain position  $K_{ACP} = 0.2$ , and the EU labour market transition coefficient  $K_{LMT} = 0.6$  it can be concluded that the existing maritime education market offering will cover only about 50% of the shipping labour market needs.
3. At least half of in foreign companies currently employed mates and captains should move to companies registered in Estonia. To do this, however, firstly, should be sufficient numbers of job places for all steps mates in Estonian companies, and secondly, employment in Estonian shipping companies should be for all stages of deck officers and captains more attractive than working in foreign companies or under foreign flags. It does not seem to be real, at least now.
4. Needs for chief engineers can be satisfied to the extent of 85%, and annually entrance should be increased by 1.2 times.

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## **RESHAPING MARITIME UNIVERSITY**

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### **Abstract**

This study aims to investigate actions to reshape maritime universities from existing forms to more effective structure to meet full spectrum needs of the maritime sector in particular the research activities in support of the maritime economy and society. The meta-synthesis method is used to understand new and future requirements of the maritime industry and to develop course of actions to assume new missions for maritime universities.

The maritime transportation and related industry is a vital element of the global economy, in that it services world trade by connecting markets in different parts of the world, moving 90 percent of goods and commodities throughout the world. It is also back bone of the industry transporting feedstock and oil for producing all type of manufactured goods as well as it is comparatively low cost when compared with the other modes of transportation. Maritime universities play a crucial role to support the maritime industry not only providing seafaring officers but also manpower for other sectors of this very wide industry, as well as supporting research and development activities. As the maritime sector is changing rapidly, maritime universities should review their role, vision, mission, objectives and tasks and subsequently they need to reshape themselves to fulfil their responsibilities to meet large spectrum expectations of the respective sector.

**Key Words:** Maritime University; Requirements of Maritime Industry; Maritime Education and Training; Innovation.

### **Introduction**

The maritime universities/faculties/schools are generally known as the education and training institutes which schools seafarers. Following the significant change in the business and industry after 1970s this approach has changed and they added computer science, maritime management, maritime economics, port and terminal management, naval architecture, oceanography and hydrography, computer science subjects in their programmes which are closely relevant to the new requirements of industry. Maritime schools transformed to maritime faculties and adopted traditional engineering and management programmes. Improved simulators in these institutes facilitated many research activities in maritime field

and provided full support for naval architects, mechanical and marine engineers as well as construction works at ports and off-shore facilities. But technology rapidly improves and full automated ships and ports requires the crew not only an act an operator but enable to understand automation theory, capabilities and limitation of automated systems.

The traditional approach absorbed by Maritime Education and Training (MET) institutes to admit students who are trained to become seafarers is increasingly becoming deficient to meet growing requirements of the global shipping industry. Further pressure is being placed on MET institutes to revise the *modus operandi* used to enrol students due to the dynamic nature of the seafaring labour landscape. Nowadays it is very hard to enrol qualified young people for maritime schools due to unwillingness of young generations to go to sea duties which have hard living conditions. Livingstone & Cahoon (2015) states that “Due to the limited knowledge, MET institutes have about the students they admit, their expectations and career ambitions; it is difficult to effectively retain them on board ships.

Also the employment areas of the seafarers are in a large spectrum such as at shipyards, shipping and logistics companies, ports and terminals, marinas etc. Additionally the deployment period of seafaring is shortened due to hard working conditions at sea in particular at developed countries. BIMCO/ISF Manpower Report 2016 estimates the shortage of Seafaring officers is 97,000 at 2020 and 147,500 at 2025. This situation enforces the revision of the programmes and their contents to prepare the seafaring officers also for their future roles and encourage the young people to attract maritime schools. The Germanischer Lloyd and Fraunhofer CML (2014) study with 100 ship management companies reveal the fact that most sensitive area is found to be the crewing with 88 percent of the companies. Although education is the primary mission of universities, application of science and technology in support of business and industry has also become quite important. The innovation which is the driving element of the economy also shapes the structure of the universities. The number of the research centres and institutes is now more than academic units on the organization charts of the most universities. Universities are now playing a major role to support technological improvement of society (Demirel 2015). The main aim of the contemporary education is not to school the students only for their occupation but also being pro-active and open minded people capable creative thinking to respond new requirements and suitable to create innovation. The digital era facilitated our life but it has also introduce new problems which require people equipped with knowledge of digital technology. The invention becomes highly important in challenging world economy and this leads all to improve their research and development capabilities, subsequently the scientific research

activities in the universities increased significantly. Additionally improved IT technology facilitated to reach the information and expedited cooperation, collaboration and coordination between different professions and scientific fields. All technologic improvements reflect the shipping industry quickly. Thus maritime schools should closely track the improvements in industry. McComb (2014) famous CEO of Fifth & Pacific Companies states that “The reinvent-or-die challenges that used to be rare catastrophes in business have practically become the new normal-but without much direction about how to meet them. So we started compiling what we found to be the *truths of transformation*”. He defines the real factor which drives the contemporary business as “Transformation is an era, not an event.”

In order to survive in today’s competitive environment of the economy, the business and industry need more support from universities. The cooperation between university and industry is a vital issue for both parties and they need to reorganize themselves for future.

### **Research Method**

The aim of this study is to do a research on the transformation of the maritime schools to a full spectrum maritime university with particular stress on existing and future requirement of maritime sector in particular the research activities in support of the maritime economy and society. The research is a meta-synthesis which is based on a comparative study on the generally assumed principles, applications and best practises in different institutions and, existing situation, possible course of actions to improve the situation. In the first step it is intended to understand the new role and missions for the maritime universities in the light of the needs of maritime sector taking into account the related improvements in the world. The eligibility of the existing role, structure and composition of the maritime schools to meet expectations of the related sector is overviewed in the second phase. Finally the categorised, grouped and associated findings of the second steps are for discussion and subsequently results will be evaluated to formulate possible/probable solutions to be proposed.

### **Research**

#### ***The requirements of the Maritime Sector***

The Maritime Transportation System is global in nature, in that it services world trade by connecting markets in different parts of the world, moving 90 per cent of cargoes and commodities to all corners of the world. Yet international Maritime transport employs over 1.5 million seafarers and many more ports and logistics personnel, who are responsible for the safe and reliable delivery of food, raw materials, energy and consumer goods to the world’s seven billion people every day (IMO 2013)

The shipping industry covers a large spectrum of professions are introduced in the Figure 1.



Figure 1: Actor s of the Shipping Sector

Practically, the movement of seafarers from vessels to landside jobs in ports and ship management establishments has been identified as a primary contributing factor to the global shortage of ship officers. Thus the need to focus on ship officer retention has been informed by the findings of the existing literature (such as recurring wastage and reduction in the number of years spent at sea by officers) that the shortage of ship officers is not necessarily influenced by low recruitment figures but rather by the early movement of ship officers to shore based jobs [1]. The seafaring officers are deployed at most of the job areas of shipping sector considering they are more suitable to accomplish the missions directly related to shipboard duties. Considering the seafaring officer back grounded personnel requirement of the maritime sector, maritime schools should consider diversified programmes which prepare their graduates not only for sea duties also for shore duties are; Various Operations and Technical positions at the Shipping companies; Marine Surveyors at Classification Societies, Port Authorities, Insurance Companies; Advisers/Consultants endowed with Maritime Law; Desk/Project and Action Officers in the Shipyards; Desk/Project and Action Officers at Maritime Administration; Stevedore and Lashing Captain/Manager, Cargo Surveyor, Average Adjuster; Managerial and technical positions at Ports and Marinas; Technical positions at machinery and supply providing companies; Pilot at Ports, Test Captain and Engineer at Shipyards; Managerial and technical positions at marine infrastructure and off-shore facilities; Lecturer/trainer and researcher at maritime institutions/schools

The new ships are equipped with digital technology and fully automated. Unmanned ship projects are in the horizon. The next generation seafaring officers are expected to be attired with IT and automation background to operate ships of the future.

***The suitable jobs at shore for seafaring officers***

The European Union SAIL AHEAD project aims at providing an on-line guidance tool for a second career for captains. The outcomes of this project cover mapping of competencies and profiles required for at least 10 alternative career paths ashore. The project aims to meet expectations of the maritime sector from seafaring officers at shore duties and defines jobs which require strictly employment of seafaring officers. As a result of SAIL AHEAD Project the following job profiles are found suitable for deck officer at shore: Coast Guard Officer, Chief Executive Officer (CEO), Operations manager, Designated Person Ashore (DPA), Quality Manager, Occupational Health and Safety Manager, Maritime Lecturer, Maritime Auditor, Maritime Surveyor (Inspector – Auditor), Marine Advisor/Consultant, Port Authority officer, Pilot, Arbitrators. Additionally Stevedore/Lashing Captain, Cargo Handling Manager, Port Facility Security Officer (PFSO) can be included in the above mentioned job profiles. Many shipping companies also started to operate as a logistic company and/or have a logistics component. So seafaring officers should be equipped with logistics knowledge to be more efficient in the shipping companies. Ketchum and Pourzanjani (2014) made a study considering the development of a European Masters programme for former seafarers. The possible job opportunities are introduced as Surveyor, Ship and Port Operations/Management, Maritime Science, Coastal Management, Trade and Finance, Maritime Administration, PSC, Engineering, Maritime Law, Naval Architecture, Logistics Management, Environmental Protection. Actually both results Sail Ahead and this study support each other. These job areas are also in line with professions introduced in Figure-1. Depending on the requirements of the job the mariner is pursuing, they should take additional education and training. This could be a short or mid-term specialization course or a post graduate study. An advanced degree is an essential element for those seeking employment in the Maritime Law, Logistics, Naval Architecture or Trade and Finance sectors.

### ***Existing Organization and Management System of the Maritime Schools***

The following issues are considered essential elements to identify the existing organization and management systems of the universities;

*The mission, aim and objectives:* The main mission of any university is education and training with the objective of providing qualified manpower for the industry Research is the second mission of university which also covers relations with the community. The aim is now to deliver the upper level knowledge to the community and provide research in support of technology.

*Governance and administration:* The existing organizations of the universities are based on functions such as academic units, research and innovation centres and administrative support

units. The academic units are mainly organized as faculties or postgraduate institutes. The research units are named as research, innovation, technology transfer centres or institutes.

*Learning and teaching:* Learning and teaching methods have drastically changed. The new system is based on satisfaction of learning outcomes which force both students and lecturers spend more time for independent studies based on researching different sources rather than classical course books. The laboratory and simulator hours are increased. On-the-job training becomes an important element of learning and teaching under the control of academician.

*Research:* Today it becomes an essential role competing with the education. The research and education are now inseparable functions in particular for postgraduate studies. The number of the research units in university is increasing. The lecturers are spending more time for research and their involvement in research also increases the quality of the lectures delivered.

*Student administration and support services:* The lifelong learning and new teaching methods have changed the demography of the students. The young and older students are taught in the same classrooms. The teaching hours enhanced out of the working hours.

*Financial planning and management:* The number of the private universities is significantly increasing against the state universities. These universities need a perfect financial system to enhance their capabilities and more importantly to survive. The state universities also look for additional financial support by enhancing their cooperation with business and industry.

*Management of quality assurance:* All universities are looking for accreditation by an internationally reputable accreditation and rewarding bodies to facilitate the employment of their graduates in the sector. The accreditation facilitates cooperation and student/lecturer exchange among the universities and provides transfer of innovations and best practices.

*Institutional relation with the community:* Universities need close cooperation with community to get benefit from the acquis and experiment of the government, business and industry. Most universities are assuming a critical role in the techno parks established by the industry and companies are establishing permanent liaison offices in the universities to ensure best coordination and cooperation. On-the-job training has become a significant part of the academic education and many studies are initiated to match vocational and academic studies.

## **Discussion**

### ***Latest Improvements in the Higher Education:***

As far as concerning the Higher Education system in the Western Hemisphere, the Bologna Declaration of (1999) is the commonly recognized and respected document which establishes a common policy and main principles on higher education to meet the requirements of the modern community. The objectives aimed by the declaration may be resumed as; Adoption



of common system for graduate and undergraduate studies which is easily readable and comparable; Establishment of a compatible crediting system which facilitates the free movement and exchange of students, teachers, researchers and administrative staff, Establishment of European-wide co-operation in quality assurance to promote higher education. The importance of ‘dynamic knowledge-based economy in the world’ became a strategy after declaration of European Council’s Lisbon Strategy (2000) and specific importance was given for research activities for “economic growth and employment the EU”. A European Commission communique (2005) clearly stated that ‘European universities employ one-third of European researchers and produce 80% of fundamental research in Europe.

OECD CERi (Centre for Educational Research Institute) (2008) has organized an Experts Meeting on “University futures and new technologies” and a Discussion Paper based on six different scenarios has been submitted at the end of these meeting which mentions below issues:

- Reshaping their organization and management system adopting strategic management concept
- Establishment of flexible structure to respond continuously changing requirements
- An improved financial system and coordination units to secure cooperation with business and industry supported with a strengthen PR activity to establish a strong link with society
- Powerful Learning Centre serves for all types of education models and also organization cooperated.

Stakeholder concept become important as a part of the Strategic management. Freeman (2011) states that “The stakeholder concept can be useful in integrating some of these issues (plans and systems of the plans for business level entities, role of the corporation in the social systems, social responsibility of the business, behaviour of the large group of the populations of the organizations and their environments) around the concept of organization strategy, that is around the issues of how organizations can configure themselves and take actions to align themselves with the environment. The university may adopt this concept in the following areas:

*Economic:* To handle a university with only student fees and government financial aids is not sufficient today. The research activities need more financial support and this can be achieved by close cooperation with other parties which require research and innovation for improving their business.

*Technological:* To handle research projects are generally costly. The universities needs to find partners which may support the research activities. So they may follow the technological improvements and match their research activities with the expectations of the industry.-

*Political:* The acquisition of the universities is sufficient to adopt themselves to new rules, regulations and political improvements but they need to be organized for that.

*Social:* The NGOs have a great influence on the society to shape a new social order. Any institution should be very sensitive to understand the new social approaches introduced by NGOs to be able to redefine their new roles and responsibilities.

*Managerial:* The new role of the manager is to keep an eye on society and the economy in addition to existing functions. A manager cannot estimate new course of actions without taking into account the new expectations of the people and economic developments.

To operate a university is now very similar to handle a business company. So, the presidents, rectors, deans cannot act only as a manager to direct their academic units but also act like a businessman or CEO to provide better opportunities for their universities. Technological developments have led to significant changes in the posture of the business life and workforce. These developments have also emerged new occupations and changed structure of existing professions. Furthermore, as new professions appeared to meet the new posture of business, some professions have disappeared accordingly. The rapid change of technology required update of occupational knowledge permanently. New professional competency requirements made education as a continuing lifelong learning activity.

### ***The Role and Mission of Universities***

The main aims of the education is to provide qualified human element for the society not only equipped with vocational knowledge but also dressed up with culture. To achieve that close cooperation between educational institutions and the business world is required. A World Bank (2007) survey proved that it is still insufficient. The survey showed that of a large segment of the business sector (55%) were not satisfied with the education given in the universities and only half (48%) of the universities is reported to be willing to cooperate with the business sector. The cooperation between the business sector and research organizations are recognized as less than 10%. To provide collaboration, cooperation and coordination between universities and industry both parties require to create suitable tools and systems.

### ***General Considerations for Seafarers' Educational Requirements***

The educated young generation in the developed countries have no intentions to work at sea due to heavy working conditions at sea and this attitude also spreads in the developing countries. The average working at sea time reduced to 5-6 years in many countries and trend goes down. This situation increases shortage of the seafaring officers worldwide. The officer shortage is estimated to be 92,000 for 2020 and 147,500 for 2025 (BIMCO/ISF 2016). IMO

has started a 'Go to Sea' initiative to call the young people to become a seafarer and also advised additional education opportunities enable seafarers also working at shore duties.

Another reason for shortage of seafaring officers is deployment of these persons at shore facilities. The people with seafaring officer experience are found rather suitable in many jobs at maritime industry such as at ports, shipyards, logistics centres. Actually we should associate these two situations; seafaring officers who look for a job opportunity at shore and maritime industry's requirement to deploy seafaring officers at shore. This leads us to conceive a combined and complete education institute which responds education requirements for all parts of the maritime sector, may be called as 'maritime university'.

The post graduate programmes delivered by many different institutions are closely related for the professions at shore and in support of maritime industry. Nowadays more over 50 master programmes related to the maritime industry are delivered by distance learning.

### ***Grouping the Education Functions in a Maritime University***

Conventionally, the core element of a MET institute is composed of Maritime Operations (Navigation) and the Marine Engineering departments which are generally called as *Maritime Faculty*. In order to stand apart the same name it may be called as 'Maritime Operations Faculty'. Port and Terminal Management, Maritime Business Management, Shipping and Logistics Management, Safety and Security Studies, Risk Management, Maritime Economy and Finance may be collected under the 'Maritime Economy and Management Faculty'.

Naval Architecture is an inseparable part of the shipping industry and has close relations with Mechanical and Marine Engineering. The naval architecture and mechanical engineering departments specialized on marine engines may establish a 'Maritime Engineering Faculty' having special purpose laboratories, testing facilities and a training ship shared with other faculties is required. The marine engineering department may also be a part of this faculty. Off-shore facilities, huge sea infrastructures, energy production from sea-based wind-mills give a special importance to the hydrography, oceanography, energy, environment protection. The maritime technology will be likely a rising area in the next decade. A Maritime Technology Faculty is required to catch highly profitable opportunities of future.

Suitable postgraduate schools are inevitable for master, doctorate and post-doctoral studies as well as conjunction with research activities. A continuous education centre (CES) is essential to meet the additional training requirements of the maritime sector. There are many jobs that require technician-level personnel ranging from mechatronics to hospitality services for maritime sector. Associated Degree Schools are best institutes to train this kind of personnel.

As mentioned before research is an inevitable function for a modern university. A maritime university is required to establish incubators to support small size research activities; research

centres for dedicated research activity, even a Maritime Excellency Centre to provide full support for national, regional or international maritime industry. It may also participate to techno-parks as required basis. The training ship should not be considered as a tool to provide practical sea training for cadets but creates a good opportunity for scientific research. The different size and type training ship and boats may serve as a research platform and real laboratory for all department of the university.

### **Conclusion**

The maritime sector is a driving element of the world economy composed a lot of function which are closely related and supporting each other. The improvement of world economy and maritime transport created new job areas which require qualified human elements for shipping companies, shipyards, ports and terminals, marinas etc. The task of the maritime schools is now not only education and training for seafaring officers for sea duties but also deployable at for different field of the maritime sector. Rapidly developing maritime sector now requires a composite education and training institute capabilities to educate qualified personnel for diversified jobs and support scientific research requirements of the sector. A Management Board should be formed in accordance with stakeholder concept. The president or rector should be capable of assuming the role of a CEO in a company.

The faculties, community colleges, postgraduate schools will be the key academic units. The delivery of professional and personal development programmes is now an important function of the academic units. A “common planning unit” responsible for improvement of contemporary graduate and undergraduate programmes as well as open and distance learning and personal development programmes is required. A maritime university should focus on economy, management, maritime and commercial law as well as finance which is the driving force of all commercial activities. The structure of the university should embrace all these fields to provide better knowledge for all elements of the institute. The main faculties are considered as; Maritime Operations Faculty (ex- Maritime Faculty), Maritime Economy and Management Faculty, Maritime Engineering Faculty, Maritime Technology and Environment Faculty (Marine Science).Postgraduate Schools for Economic, Management and Human Science Natural Sciences and Engineering, Associated Degree Schools and Continues Education Centre for Life-long Learning is required.

A maritime university is required to establish incubators to support small size research activities; research centres for dedicated research activities, even a Maritime Excellency Centre to provide full support for national, regional or international maritime industry. They may also participate to techno-parks as required basis. Each research units should be manned with core permanent staff and augmentees under the matrix organization concept.

The universities produce and sell “goods” like a commercial company. That requires establishment of a commercial system including “marketing, pricing, public relations,

advertisement, budgeting, financing, procurement, purchasing” etc. A department led by an collecting all these functions under an umbrella is vital for the survival of the university. Total Quality Management is vital to ensure the quality of the production of university.

Finally, the maritime universities should have a dynamic and flexible structure to respond not only the existing but future requirements of maritime sector in today’s challenging World.

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# STUDY ON BUILDING PROCESS OF ACADEMIC INTEGRITY AT VIETNAM MARITIME UNIVERSITY

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**Abstract** Plagiarism, one of popular and complicated problems, needs to be treated in Vietnam's universities. Quality assurance for education and scientific research activities plays an important role in the development of Vietnam Maritime University (VMU). Therefore, the university has decided to subscribe and use Turnitin program to control the quality of education and research since 2015. The paper analyses plagiarism situation at VMU using the database composed of theses and dissertations from 2015 to 2017. The results shows that the similarity index between the original report and the Turnitin database lies in a range from 1% to 79%. Particularly, 40% of dissertations have high similarity index in excess of 25% whereas the internet source occupies more than 50% of copying sources. Besides, the statistics shows that the similarity index of economic major is higher than that of engineering major. One of the reasons is that students do not know about academic integrity and how to make the correct citation. Based on this analysis, authors propose the building procedures for the Academic Integrity at VMU as a case study for the Vietnam's education network.

**Keywords:** anti-plagiarism, academic integrity, copying, Turnitin, similarity index.

## 1. Introduction

Copy and paste actions in education training in Vietnam are more and more popular and serious. Recent surveys held at some Vietnam's universities such as Hoa Sen University, National Economic University etc. show that students popularly reused each other at either the same universities or other ones. Particularly, there are serveral websites arbitrarily offering dissertations and materials such as [www.luanvan.net](http://www.luanvan.net), <http://thuvienluanvan.net/>, <http://zbook.com...> This makes a large number of students become lazy, reduces their creativity. This also leads to a decline in Academic Integrity of Vietnam's universities.

In addition, scientific research works such as articles and scientific research papers have also been copied both ideas and text contents. When checking originality of some papers sending to Marine Science and Technology Journal, we realize that 100% of the contents have been translated from oversea research papers. This problem leads to a waste of both finance and time in scientific research.

In order to control the above-mentioned situation in education training and scientific research, VMU has decided to use Turnitin software for anti-plagiarism in education training and scientific research. The application of checking originality in the University has been started since June 2015. In this paper, the authors will present the building process of Academic Integrity at VMU, the results achieved, as well as the conclusions and recommendations to improve Academic Integrity in education training and in scientific research (Pham 2016, p.148).

## **2. Building process of Academic Integrity at VMU**

To facilitate management and monitoring of the process of Academic Integrity in education and scientific research at VMU, the authors have proposed the process including eight steps as follows:

### ***Step 1: Survey of copying status in education training and scientific research at VMU***

In order to survey of copying status in education and scientific research at VMU, the following works have required:

- Selecting objects of the survey;
- Classifying objects by specialized;
- Designing the form of survey questionnaires for appreciating the level of copying;
- Collecting and statistical of survey data;
- Commenting and appreciating survey results for building process of academic integrity.

### ***Step 2. Proposing objects of checking copying***

The objects of originality checking at VMU as follows:

- Originality checking of undergraduate student thesis, graduate thesis, doctoral dissertations;
- Originality checking of articles published in the Marine Science and Technology Journal, books published at Marine Publishing House.
- Originality checking of scientific research works.

### ***Step 3: Application of Turnitin software to enhance the quality and Academic Integrity of education training and scientific research at VMU***

To check the similarity index in education training and scientific research at VMU, after a long time using several anti-plagiarism program and verify the exaction of the result. We have proposed to use Turnitin because of this software have been widely used by famous foreign as well as Vietnamese universities and publishers with high precision and reliability.

### ***Step 4: Proposing similarity index for anti-plagiarism for VMU***

Turnitin software has four levels of warning about plagiarism. They are:

0%-25% is normal level (Green)

26%-49% is warning level (Yellow)

50%-75% is high warning level (Orange)

Above 75% is alarm level (Red)

To fit the situation of education training and scientific research in Vietnam, to refer experiences of other universities such as Hoa Sen University, National economic University... The authors have proposed the allowable Similarity Index in originality checking of VMU as follows:

- All assignments, dissertations, articles, scientific research works must have the similarity index below 30%;
- In cases, the similarity index of works over 30%, the special committee on Academic Integrity will conclude to accept for revising or refuse the thesis, articles, textbooks or scientific research works.

### ***Step 5: Building the model combining of originality checking and online reviewing papers published on Maritime Scientific and Technology Journal***

At the present time, similarity checking and reviewing of papers published on Marine Science and Technology Journal have been carried out separately by two divisions, this makes the process complicated and last for a long time. From this situation, the authors have proposed the combination of checking similarity with online reviewing of papers by using of Turnitin software, the model has been applied for the VMU's Marine Science and Technology Journal No.48. The reviewer guidelines have been published on the Discussion menu of Turnitin software (Figure 1). The software also allows the reviewer comments directly to editor and authors (Figure 2) and the authors can reply directly to editor and reviewer by choosing Reply menu in Turnitin software (Figure 3).



- Criteria for review of the paper:
1. The content of the paper (The necessary of the topic, precision...);
  2. The new approach in the paper;
  3. The structure of the paper;
  4. The appropriation of illustrations, figures, and tables;
  5. The citation of the relevant work;
  6. Conclusion (Accept, Minor revision, Major revision, Reject);
  7. Comments.

**Figure 1.** The criteria for paper reviewing

- Comments from reviewer
1. This is not something new in the paper.
  2. The paper not well structured.
  3. The paper should have brought something new, useful for all member universities.
  4. The English language is poor.
  5. Author may be approached for major revision to make it more comprehensive with some new ideas
  6. Edit the formatting of the reference list and referring in the text according to the instructions.

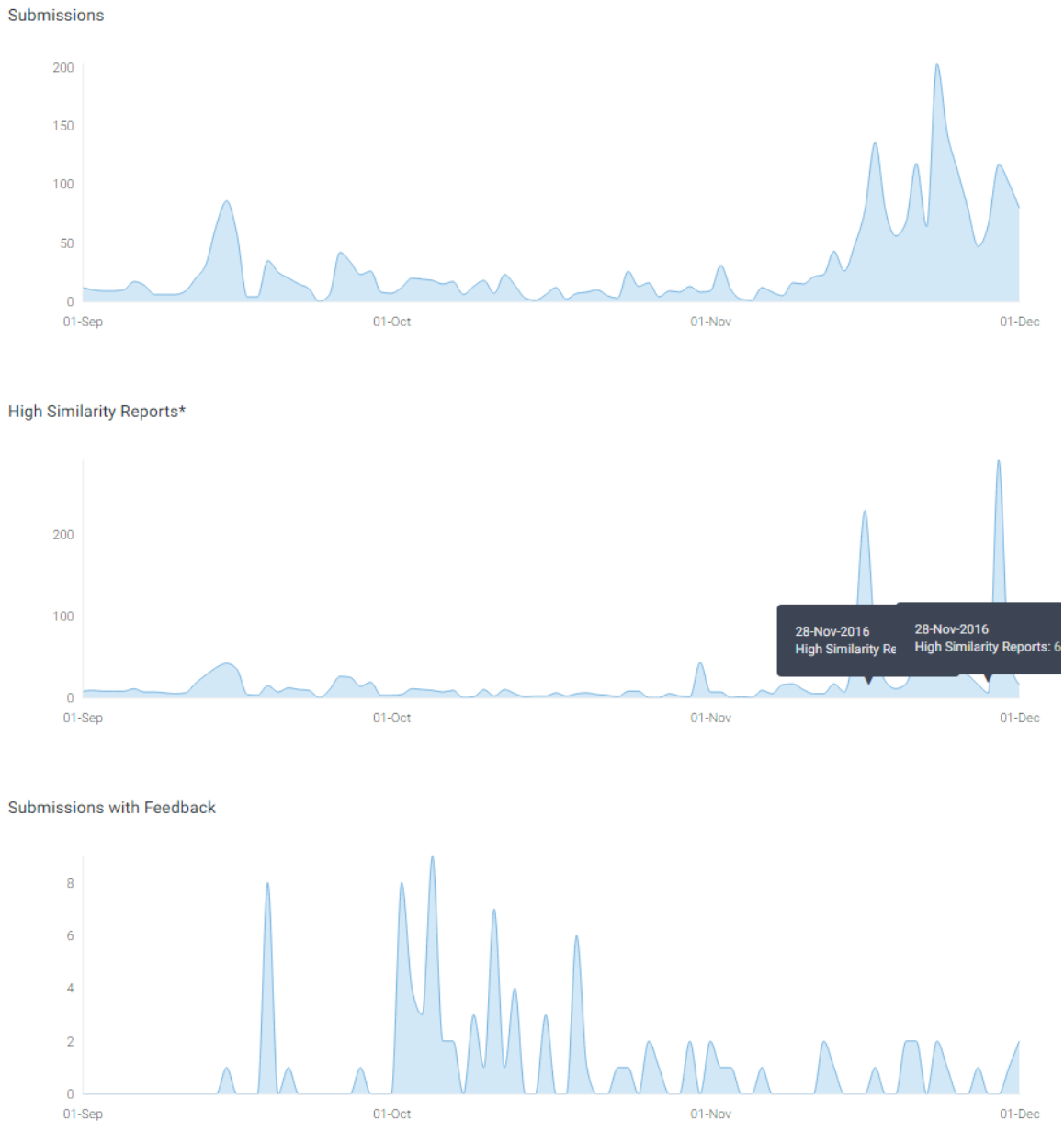
**Figure 2.** Comments from reviewer for authors on Turnitin software

Thanks for the comments. Authors fully agree with the comments of the reviewer.  
Authors will correct the paper to the comments.

**Figure 3.** The reply of the authors to reviewer on Turnitin

### ***Step 6: Building the model combining originality checking with distance education training of the University***

At the present time, there are several distance training courses at the university, almost of students are working in the provinces and cities, that far from the university. Therefore, the process of study, exam and providing certificate for students have taken a lot of time. From the above situation, the authors have proposed the combination of originality checking with distance education training by using of Turnitin software. The model has been applied for six distance training courses in Quang Ninh Province and Binh Phuoc Province from September 1, 2016 to November 1, 2016. The Figure 4 has described the submissions of assignments of students, high similarity reports and submissions with feedback. The use of this model helps to correctly and effectively control both progress and quality of assignments of students in six distance training courses.



**Figure 4.** The overview of statistics data by Turnitin for six distance training courses at VMU  
**Step 7. Analysis, appreciate the results of originality checking at VMU**

The analysis of changing the quality and Academic Integrity in education and training of VMU have been carried out by making the comparison between the Similarity Index of the thesis of students of the Faculty of Hydraulic Engineering in the year 2015 and those of 2016 and 2017 (Tran 2016, p.123). The static has been described in the Table 1.

From this survey, we can see that at the beginning of carrying originality checking, most of the students have similarity index in excess of 40% (87,5%). However, after two years almost students have similarity index under 30% (81,8%), only 3% have similarity index in excess of 40%.

**Table 1.** Similarity Index for the thesis of students in the hydraulic engineering department from the year 2015 to 2017.

Similarity Index	The Year 2015	The Year 2016	The Year 2017
Under 30%	2/40	14/30	27/33
From 30% to 40%	3/40	10/30	5/33
Over 40%	35/40	6/30	1/33

Besides that, the authors also utilizes the dissertations of 768 post graduate students of VMU in the year 2016. Analysis of the results shows that the similarity index between the original report and the Turnitin database lies in a range from 1% to 79%. Particularly, 40% of dissertations with similarity index in excess of 25%. The internet source account for over 50% of copying sources. The statistics show that the similarity index for economic major is higher than that of engineering major. One of the reasons is that students do not know about academic integrity and how to make the correct citation.

***Step 8. Modifying and completing procedures of originality checking at VMU***

After one and a half year application of Turnitin software for originality checking at VMU, the University has summarized building process of Academic Integrity and organized successfully The Second National Academic Integrity Workshop in 2016 (Figure 5). Through this workshop, the university has passed our experienced to other universities as well as getting experiences from other universities in Vietnam and foreign universities such as National Economic University, RMIT University, British University..., the University has been modified and completed procedures for Academic Integrity corresponding to our real conditions.



**Figure 5.** The second national Academic Integrity workshop organized at VMU

### **3. Conclusions**

In this study, authors have described the progress of building procedure for Academic Integrity at Vietnam Maritime University over two years as well as the achievement in improving the quality of education, training and scientific research, as shown in the Table 1.

The procedure of quality control by using this program is simple and accurate. The comments and marks of lecturers in assignments is easy for students to understand and significantly reduce time for scoring and commenting. In our research, authors have also proposed the model combining of originality checking and online reviewing papers published on Marine Science and Technology Journal; the model combining originality checking with distance education training of the University.

With excellent experience from over two years of implementing anti-plagiarism checking, Vietnam Maritime University will expand this model to other activities in education and scientific research in the coming years to equip our students, lecturers and researchers with 21<sup>st</sup> century skills, and also support our university's goal of education and scientific research.

### **Acknowledgements**

We would like to thank Vietnam Maritime University for their assistance with the collection of the data for this study.

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# AN INVESTIGATION OF THE FLOW BEHAVIOR OVER A VERTICAL AXIAL WIND TURBINE (VAWT) APPLYING THE CONCEPT OF A MOVING FRAME OF REFERENCE

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**Abstract:** The purpose of the study is to present a design, investigation and modeling of flow behavior of vertical axial wind turbine blades (VAWT). It has been developed a suitable numerical model using ANSYS software. The made numerical experiment clarified the steady state picture of the flow around VAWT with the help of function-Moving Frame of Reference that is available at ANSYS Fluent software. The main value of that study is that here the task like modeling of the behavior of any kind of complex geometry like VAWT caused by the flow which is extremely difficult is overcome by clarifying first of the steady flow field around VAWT.

**Keywords:** Dynamics, ANSYS, Fluent, VAWT, Moving Frame of Reference

## 1. Introduction

Wind power is considered as a plentiful renewable energy whose technology and capacity is increasing over the years, allowing a breakthrough for harnessing energy from the wind [1].

A lot of innovative solutions are made by the researches over the topic during last years in order to improve the efficiency of wind turbines, [2, 3, 4]

Still unknown, Darrieus vertical axis wind turbines, Fig. 1 appears more suitable than the "classic" ones in different fields such as building integration, the extreme zones (observatories, mountain refuge), [5].

Although less efficient compared with three-bladed wind turbines, this kind of wind turbine can overcome the limits due to the size of the blades and their rotation speed.

The total size is smaller, and in some cases, when the motor is located at its base, this type of wind turbine can be cheaper.

The Darrieus wind turbine can run with a wind speed up to 220 km/h and in any direction.

The main shortcoming of this type of wind turbine is their difficult start, because the weight of the rotor on its base generates frictions.

*Advantages:*

- The generator can be placed on the ground (depending on model)
- Easily integrated into buildings

*Disadvantages*

- Difficult start unlike the *Savonius wind turbine*
- Low efficient

[3],[5].

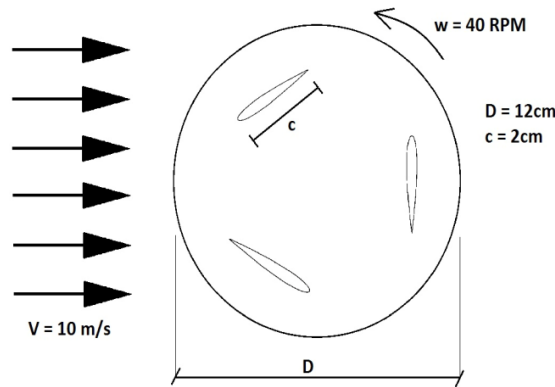


**Fig. 1** Darrieus Wind Turbine, [5]

It is made an important simplification at the presented study using the tutorial of Cornell University Web, [2]. Here it is been considering that the turbine is already spinning independently of the flow, which is clearly not true, since the flow is responsible for spinning the turbine. Combining the incoming flow velocity and RPM, and the given geometry and mass of the turbine is the only one stable combination. Although, modelling the movement of a geometry caused by the flow is considerably difficult. This study presents the simpler analysis by clarifying the steady state picture of the flow behaviour over VAWT [2].

## 2. VAWT –Problem Specification

Figure 2 shows Darrieus VAWT in details, it has been consider a uniform flow of  $V = 10\text{m/s}$  passing through a Vertical Axis Wind Turbine (VAWT) as sketched above, [2]. The VAWT has a diameter of  $12\text{cm}$  and 3 equally spaced blades, each one with a chord length of  $2\text{cm}$ , [2].



**Fig. 2** Darrieus VAWT – details, [2]

For simplification, it has been considered that it spins with constant angular velocity of  $40 \text{ rpm}$ . The center of each blade is located  $0.04\text{m}$  from the center of the hub. Note that this is a *Darrieus* VAWT, which is Lift based; in contrast to the *Savonius* VAWT, which is Drag based. This is an intensive field of research [2].

## 3. Numerical Model of VAWT

The developed numerical model of VAWT under study is based on the relevant models of the Cornell University web [2].

### 3.1. Mathematical Model:

The governing equations solved here are conservation of mass and the Navier-Stokes equations, taken in a frame of reference moving with the turbine:

- **Conservation Mass:**

$$(1) \quad \frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \vec{V}_r) = 0$$

- **Navie-Stokes equations**, simplified for constant angular velocity:

$$(2) \quad \frac{\partial}{\partial x} (\rho \vec{V}_r) + \nabla \cdot (\rho \vec{V}_r \vec{V}_r) + \rho (\vec{a}_{\text{coriolis}} + \vec{a}_{\text{centripetal}}) = -\nabla p + \nabla \cdot \vec{\tau}_r$$

Where:

$$\vec{a}_{\text{Coriolis}} = 2\vec{\omega} \times \vec{V}_r - \text{Coriolis acceleration}$$

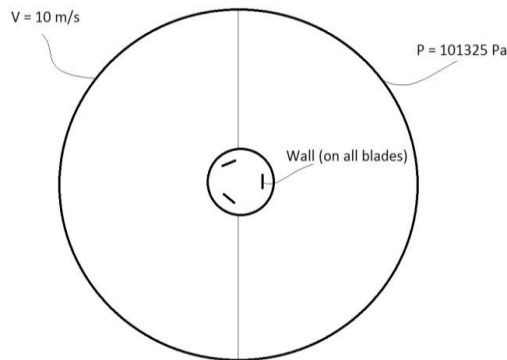
$$\vec{a}_{\text{centripetal}} = \omega^2 r \vec{r} - \text{Centripetal acceleration}$$

Simplifying Navier-Stokes's equation using constant angular velocity is good, because Fluent solver can easily calculate this in a moving frame of reference without dealing with sliding mesh.

The problem that has been solved is turbulent, so that numerical solution procedure is made in ANSYS Fluent using the Finite-Volume Method (FVM).

### 3.2. Boundary Conditions

First, it is needed to create a region a few times larger than the main geometry of the turbine. This region is where the presence of the turbine disturbs the flow. This can be seen in Fig. 3 as the outer circle in the following figure. Note that we could have made any geometry for this "far-field" zone, but to simplify the boundaries a circle was chosen.



**Fig. 3** Boundary Conditions, [2]

The next boundary conditions are shown in Fig. 3:

- Inlet (far-field): constant velocity in the x-direction of 10m/s, with a turbulent intensity of 5% and a turbulent viscosity ratio of 1.
- Outlet (far-field): an absolute pressure of 101325 Pa, or 1 atm.
- Blades: wall, so no velocity. (No-slip condition).

### 3.3. Validation of Numerical Results by Hand-Calculation.

The expression for calculating Tip Speed Ration (TSR), [2]:

$$(3) \quad \text{TSR} = \frac{r\omega}{U} = \frac{\text{Velocity at the blade tip}}{\text{Incoming wind velocity}}$$

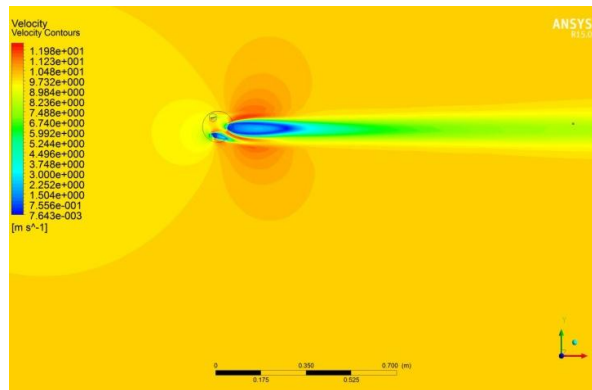


Meaning  $r$  as the distance from the center to the mid point of a blade:  $r=0.04m$ . The angular velocity is  $40rpm$  which corresponds to  $4.1888rad/s$ . Therefore, the expected velocity at the center of the blades is  $0.1676m/s$  and therefore the TSR is  $0.01676$ .

The problem is solved numerically with the additional assumption that the airfoils are flat plates of dimensions  $0.1 \times 2$  cm, the plates are placed such that when they are at the upper-most part of its trajectory, they form an angle of  $20deg$  with the horizontal axis.

## 4. Results and Analysis

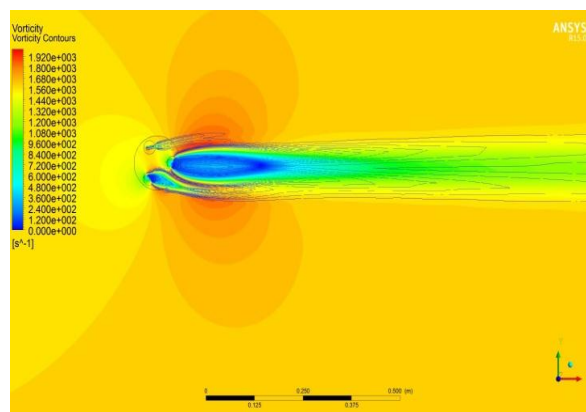
### 4.1. Velocity Contours



**Fig. 4** Velocity Contours

Note that Fig. 4 illustrates very clearly the effect of when the blade is perpendicular to the flow: a huge recirculation bubble is made. This will negatively affect other turbines placed downstream of this one. This is a very important thing to consider when designing an array of VAWTs. Fig. 4 is a single snapshot of the spinning of the turbine or a particular position. A transient analysis with a complete animation will be created in the future.

### 4.2. Vortices Contours



**Fig. 5** Vortices Contours

Fluent has an ability to show also the vortices contours. It's important to analyze the vortices distribution downstream of the VAWT.

Observing Fig. 5 it can be seen the vortices from the emitted from the tips of turbine's blades. If we recall the flow over a plate perpendicular to the direction of the flow, can be concluded that the vortices being generated at the tips of the plate. Also it can be note from Fig. 5 that vortices separations is not so intense on the turbine's blade, it is less.

**5. Verification and Validation of obtained Results.**

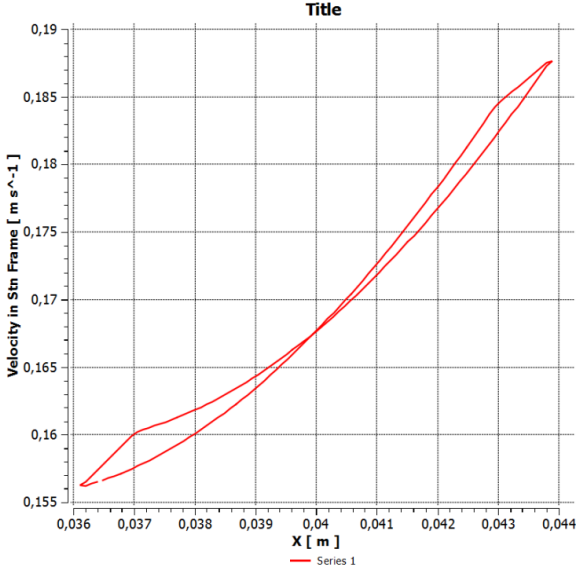
**5.1. Check Mass Flow**

Taking into account the value of mass flow rate 73.50 kg/s get into out the domain, and then virtually everything works. The obtained imbalance of 7.58e-9 kg/s is negligible considering the total amount of flux in the system which is good related to the obtained results.

**5.2. Tip Speed Ratio (TSR)**

According to reference, [2] TSR can be extracted directly from the boundary conditions, because realizing the numerical model this is essentially checked, than the velocity at the wall is zero. Hence, the purpose of this check is more to verify if the mathematical model that is exposed above is correctly inputted at Fluent solver.

Citing a source [2], to calculate the TSR it is need to extract the velocity from CFD-Post. The only way to extract the velocity of fluid particles in touch with the turbine's blades is to extract it at particular location. Here it is made by plotting the velocity distribution along the X coordinate for the whole surface of the right turbine's blade, and then extract the value at x = 0.04 (because our reference is the velocity's value at r=0.04 m), see Fig. 6.



**Fig. 6** Chart - velocity distribution along the X coordinate

The point of interest is the place where two red curves are coinciding and from Fig. 6, the Chart it can be read the coordinates of that point. Looking Fig. 6 it can be noticed that at the edge of the plot there is an abrupt change in velocity, as it was expected. The “closed loop” plot expect is in fact happening, but the curve collapse into a single line. The point where two curves are coinciding is slightly above the half between 0.165 and 0.170. Looking above into the made hand calculation, the expected value is about 0.1676 m/s. The obtained numerical value is the same, indicating that there might to have inputted the right mathematical model into the tool. Using the formula (3) given above for calculating the TSR is the obtained value divided to 10 m/s, the wind speed. So the obtained value of TSR is 0.01676.

### **5.3. Angular Velocity**

Citing [2], the obtained numerical results showed that the moment coefficient  $C_m$  is not zero, and this means that there is some extra torque applied on VAWT. Using [2], that is true, and it could even be used the  $C_m$  to calculated the power coefficient  $C_p$ .

## **6. Conclusion**

The study is performed for steady flow field around VAWT using the help of Moving Frame of Reference. Here it is determined the flow behavior over VAWT by using the simplification that the turbine is already spinning independently of the flow, of course that is not true, since the flow is responsible for spinning the turbine. But, modeling the movement of complex geometry as VAWT is extremely difficult and complex task, that’s why into this study it is made a simple analysis of the flow picture into steady state.

The next stage into this study will be applying the concept of Sliding Mesh in ANSYS Fluent so that to can simplify the transient problem, which is the complex flow behavior around VAWT into a steady state situation.

Also as recommendation to improve the quality of the obtained results and flow picture it should be considered the possibility to make a mesh refinement i.e. to increase the number of cells for generated mesh around the object.

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# AN INVESTIGATION OF THE FLOW BEHAVIOUR OVER A VERTICAL AXIAL WIND TURBINE (VAWT) USING SLIDING MESH FEATURE

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**Abstract.** The purpose of the study is to present a design, investigation, and modeling of the flow behavior of vertical axial wind turbine blades (VAWT). It has been developed a suitable numerical model using ANSYS software. The made numerical experiment clarified the steady state picture of the flow around VAWT using the Sliding Mesh feature that is available at ANSYS Fluent software. The main value of that study is that here the task like modeling of the behavior of any kind of complex geometry like VAWT caused by the flow which is extremely difficult is overcome by simplifying the transient problem into steady state situation, [2].

**Keywords:** Dynamics, ANSYS, Fluent, VAWT, Sliding Mesh

## 1. Introduction

Wind power is considered as a plentiful renewable energy whose technology and capacity is increasing over the years, allowing a breakthrough for harnessing energy from the wind [1].

A lot of innovative solutions are made by the researches over the topic during last years in order to improve the efficiency of wind turbines, [2, 4, 5].

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The main shortcoming of this type of wind turbine is their difficult start, because the weight of the rotor on its base generates frictions.

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- Low efficient

[6].

This study is a next stage of conducted already numerical experiment of the complex flow behavior around VAWT using the concept of Moving Frame of Reference (MFR), [3]. Cited [2] and using the developed approach it is made an important simplification, here it is considered that the turbine is already spinning independently of the flow, which is not correct, since the flow is responsible for spinning the turbine. Quoting [2], modeling the movement of a geometry caused by the flow is considerably difficult, and requires use of a method called “6DOF solver”, (DOF- degree of freedom). This is a trend for the development of this study in a future. In the current stage of that study a simpler analysis is made, first a steady state picture of a problem, [3], and here it is using Sliding Mesh feature available in ANSYS Fluent so that to can simplify the transient problem, which is the complex flow behavior around VAWT into a steady state one, [2].



**Fig.1** Darrieus VAWT, [6]

## 2. VAWT –Problem Specification

Figure 2 shows Darrieus VAWT in details, it has been consider a uniform flow of  $V = 10\text{m/s}$  passing through a Vertical Axis Wind Turbine (VAWT) as sketched above. The VAWT has a diameter of  $12\text{cm}$  and 3 equally spaced blades, each one with a chord length of  $2\text{cm}$ .

For simplification, consider that it spins with a constant angular velocity of  $40\text{ rpm}$ . The center of each blade is located  $0.04\text{m}$  from the center of the hub.

Note that this is a *Darrieus* VAWT, which is Lift based; in contrast to the *Savonius* VAWT, which is Drag based. This is an intensive field of research [2].

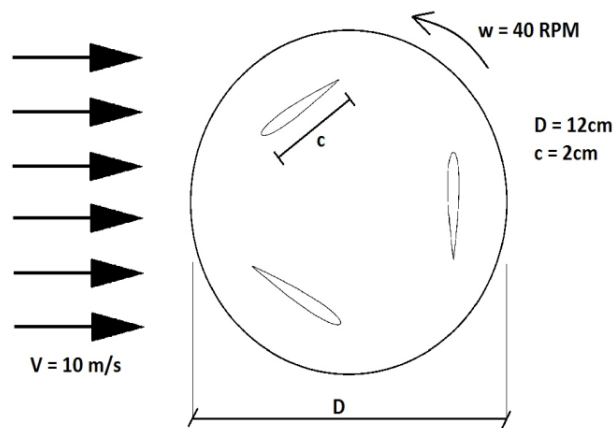


Fig. 2 Darrieus VAWT – details, [2]

## 3. Numerical Model of VAWT

The developed numerical model of VAWT under study is based on the relevant models of the Cornell University web [2].

### 3.1. Mathematical Model:

The governing equations solved here are conservation of mass and the Navier-Stokes equations, taken in a frame of reference moving with the turbine:

- **Conservation Mass:**

$$(1) \quad \frac{\partial p}{\partial t} + \nabla \rho \vec{V}_r = 0$$

- **Navier-Stokes equations**, simplified for constant angular velocity:

$$(2) \quad \frac{\partial}{\partial x} (\rho \vec{V}_r) + \nabla (\rho \vec{V}_r \vec{V}_r) + \rho (\vec{a}_{\text{coriolis}} + \vec{a}_{\text{centripetal}}) = -\nabla p + \nabla \bar{\tau}_r$$

Where:

$$\overrightarrow{a_{coriolis}} = 2\omega x \overrightarrow{V}_r - \text{Coriolis acceleration}$$

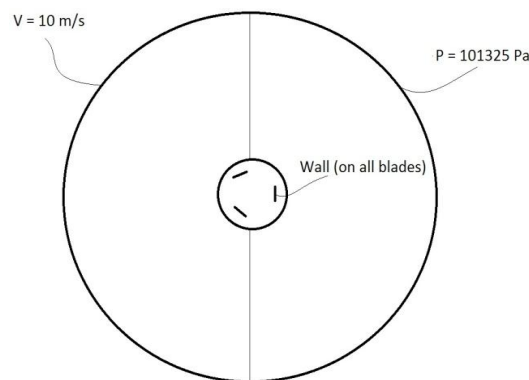
$$\overrightarrow{a_{centripetal}} = \omega^2 x \overrightarrow{r} - \text{Centripetal acceleration}$$

Simplifying Navier-Stokes's equation using constant angular velocity is good, because Fluent solver can easily calculate this with Sliding Mesh features.

The problem that has been solved is turbulent, so that numerical solution procedure is made in ANSYS Fluent using the Finite-Volume Method (FVM).

### 3.2. Boundary Conditions

To solve this in Fluent, it is need to create a region a few times larger than the main geometry of the turbine. This region is where the presence of the turbine disturbs the flow. This can be seen in Fig. 3 as the outer circle in the following figure. Note that it could have made any geometry for this "far-field" zone, but to simplify the boundaries a circle was chosen.



**Fig. 3** Boundary Conditions, [2]

The next boundary conditions are shown in Fig. 3:

- Inlet (far-field): constant velocity in the x-direction of 10m/s, with a turbulent intensity of 5% and a turbulent viscosity ratio of 1.
- Outlet (far-field): absolute pressure of 101325 Pa, or 1 atm.
- Blades: wall, so no velocity. (No-slip condition).

## 4. Results and Analysis

### 4.1. Moment monitor

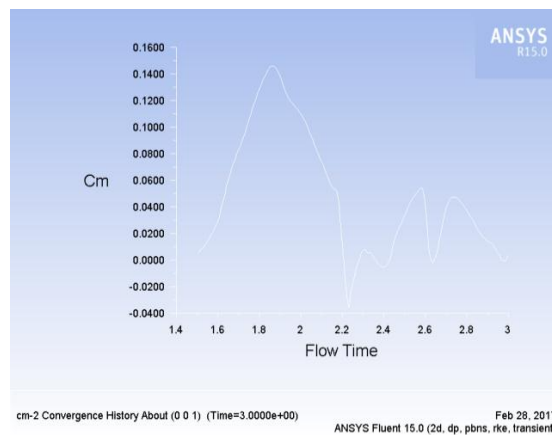
After about reaching 6000 iterations is obtained solution convergence and the calculation is ok. First let's review moment monitor – Cm.

Observing Fig. 4 it can be noticed that when Cm is above zero that means that the flow is exerting a positive moment on the VAWT's rotor but when it's negative it's on the negative



direction. The positive value for  $C_m$  is the one that will generate power, the one that will accelerate the VAWT.

On the other hand the negative value of  $C_m$  is the one that is contrary to the movement of VAWT in terms. Fig.4 shows that our average value for  $C_m$  will be slightly above zero. So that means that the VAWT's rotor in fact has some extra moment so the angular velocity could be increased the little bit in the cell zone and then the VAWT will still spinning. It is possible to account for that moment and let the turbine find its own steady angular velocity the last based on the flow.



**Fig. 4** Moment Monitor

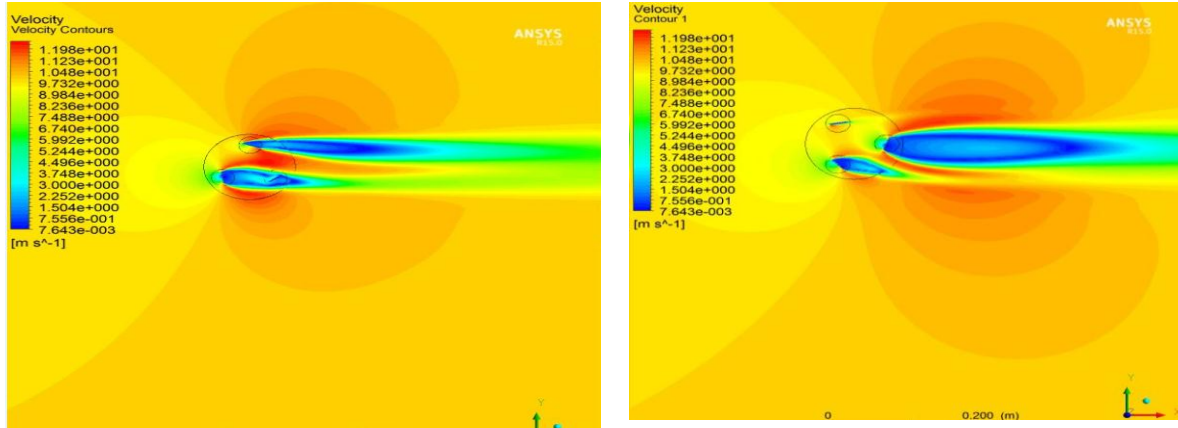
#### 4.2. Comparison of Velocity Contours

Using the numerical results obtained into the first stage of the study, [3] both numerical results obtained with the Sliding Mesh feature and Moving Frame of Reference (MFR) for VAWT can be compared.

Let's first have a look at Fig. 5 which represents the made comparison of the Velocity Contours obtained with both features available at ANSYS Fluent.

Observing Fig. 5 the velocity contours around VAWT obtained with both features, (see Fig 5 a) with MFR, see Fig. 5 b) with Sliding Mesh) look pretty similar but we can see from Fig. 5 b) with Sliding Mesh that the velocity contours are slightly curved to the side compared to the Fig 5 a) with MFR. Last one means that the made numerical simulation with Sliding Mesh into this stage of that study predicts a little bit better what happens on the way behind the blades. Using Sliding Mesh techniques is referred to be even more actually accurate for the obtained and analyzing of the VAWT's flow field. And the last statement is the reason of conducted this stage of the study of investigating VAWT's flow field using both techniques available in Fluent: MFR and Sliding Mesh feature.

So even though the numerical simulations realized with MFR features and the papers written on their basis are useful and qualitative education of the velocity field the transient analysis for the flow behavior around VAWT using Sliding Mesh is referred to be even more actually accurate for the obtained and analyzing of the VAWT's flow field.



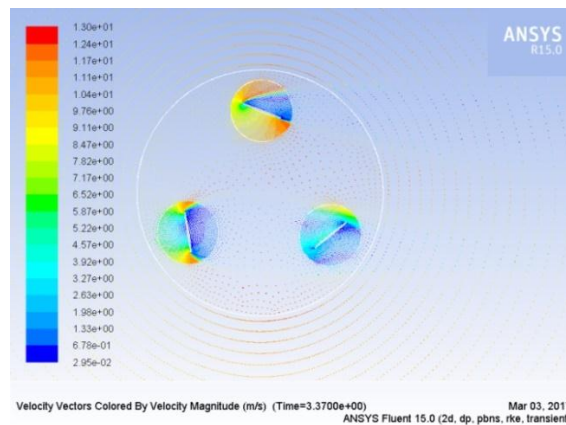
a) Velocity Contours, MFR

b) Velocity Contours, Sliding Mesh

**Fig. 5** Velocity Contours

### 4.3. Velocity Vectors

ANSYS Fluent gives an ability to observe velocity vectors around modeling object. Fig. 6 shows the obtained velocity vectors around VAWT with Sliding Mesh Features. It can be seen the velocity field distribution around whole VAWT.



**Fig. 6** Velocity Vectors obtained with Sliding Mesh Features

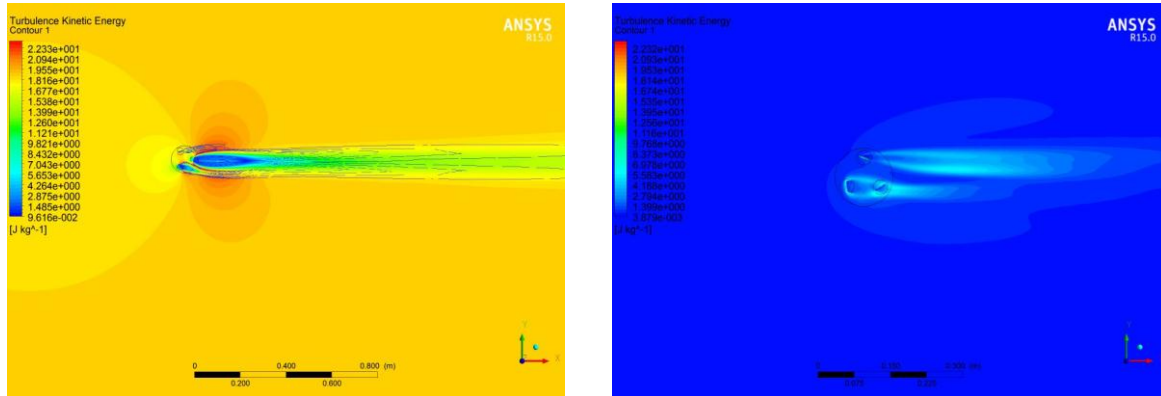
### 4.4. Turbulence Kinetic Energy (KE)

Fluent has an ability to show also the turbulence KE. It's important to analyze the turbulence KE distribution downstream of the VAWT.

Observing Fig. 7 it can be concluded that making the numerical simulations for the analyzing of the flow field around VAWT using MFR and Sliding Mesh features its gives the

same value for turbulent KE around the turbine. The difference between obtained Turbulent KE with both features is in the distributions of kinetic energy around VAWT.

Also it can be noticed looking at Fig. 7 that considering Turbulent KE the MFR is overestimating a little bit compared to the Sliding Mesh.



a) Turbulence KE, MFR

b) Turbulence KE, Sliding Mesh

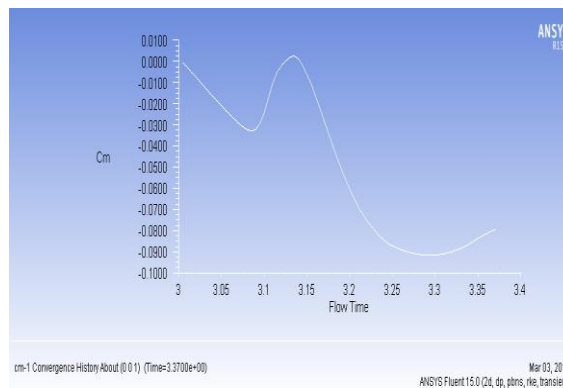
**Fig. 7** Vortices Contours

### 5. Verification and Validation of obtained Results.

Using source [2] the realized numerical experiment and the obtained and shown up numerical results can be verified starting the numerical simulations again for transient process by using the different values about some input parameters. Changing reference value,

- Area to 0.0012m<sup>2</sup>
- Length to 0.02 m
- Velocity to 10 m/s
- Run the calculation for 150 time steps

Citing [2] it is important to notice that we should not take the new moment monitor Cm (see Fig. 8) for granted because it's an account for the pressure and the viscous forces on the blades. Since we don't have a very fine match on the blade right above our results for drag shall be enough précised.



**Fig. 8** Moment monitor Cm, in verification process

Hence this last part is just to illustrate a little bit in order to get a better prediction of  $C_m$  one should inflate mesh around the blades' airfoil tip get a finer mesh around them. Before was around 0.05. Now looking at Fig. 8 it can be noticed the exact same shape as before, (See Fig. 4) except for just scaled up and also it has to be remembered that it's not precise. So in that case there is a need to replace the mesh around the blades just to make sure we got a more precise moment monitor  $C_m$ . This oscillation that can be observed for Fig. 8 is due to the relative position of our blade's airfoil related to the incoming wind.

The forces acting on the blade's airfoil, the drag will generate the moment that is indirect what is being measured here.

So depends on the position of rotor's blades there are no related incoming wind believed in the drag it is always generate a positive moment or a negative one.

## 6. Conclusion

This study is a continuation of already realized numerical experiment using Moving Frame of Reference exposed at [3]. Here the examination of the flow behavior around VAWT is realized using Sliding Mesh feature in ANSYS Fluent so that the transient problem is simplified to a steady state situation.

It's used CFD post comparison of the numerical results for velocity contours and turbulent kinetic energy obtained with Moving Frame of Reference (MFR) and Sliding Mesh features.

Also for the validation and the verification of the obtained numerical results with that numerical simulation of the flow around VAWT is repeated with different kind of input parameters' values. By checking the moment monitor  $C_m$  (See Fig. 8) it can be seen that the suggested numerical approach, according to [2] for the modeling and the investigation of the flow behavior around VAWT has been a sufficiently precise. The last statement has to be an indication that the model works properly.

As a recommendation for the next stage of that study it should be consider the possibility of modeling the flow in 3D, which will reflect in the complexity of the VAWT.

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# IMPROVING AIS DATA RELIABILITY

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**Abstract:** In 2000, IMO adopted a new requirement (as part of a revised Chapter V of SOLAS Convention) for all ships to carry Automatic Identification System Transponders (AIS Transponders) capable of automatically providing information about the vessel to other vessels and to coastal authorities (IMO 2017). AIS is a system of worldwide importance which strives to achieve the following goals:

- **vessel tracking** - automatically exchange information about the ship's identity, type, position, course, speed and navigational status with appropriately equipped shore stations and other ships;
- **maritime security** by means of identifying threats to a country's sovereign borders;
- **collision avoidance** by plotting the course and speed of vessels within range;
- **efficiency** – monitoring port traffic allows for efficient transfer of vessels between harbors;
- **improved communication** – direct ship to ship communication;
- **information gathering** – monitoring hydrological and metrological factors, etc. (All About AIS, 2012).

Accidents caused by the navigators' trust in the AIS are possible, however, if vessels are not equipped with known and trustworthy sensors. These "AIS assisted accidents" might take place as has previously been the case with RADAR, ARPA and GPS assisted accidents. The navigators' assessment of collision risk depends upon their knowledge about own ship's motion and other ships' motion (Ramsvik 2001).

Nowadays most navigators are not familiar with the AIS technology and may use the AIS information uncritically and trust the AIS information in disfavor of the RADAR / ARPA information.

In this paper a huge amount of AIS data has been analyzed and a serious number of errors have been detected. The conclusion is that a great number of vessels transmit incorrect AIS data. The reason for these incorrect data is to be found in the actions of both the technicians installing the device and the crew members responsible for entering the data in the system. Examples of wrongly entered data include: Call Sign, AIS Type, Antenna Position, Draught, Destination and ETA, Navigational Status, etc.

Solutions to this problem are the more elaborative training of the technicians and navigators operating with the system as well as the more rigorous control measures on the part of the responsible authorities.

**Keywords:** AIS, Safety of Navigation, Human Factors, Reliability, Errors

## 1. Introduction

A number of electronic systems have been developed for the purpose of navigation security and safety enhancement such as, for example, the RADAR and the Long-Range Identification and Tracking system. One of those systems is the Automatic Identification System (AIS) broadcasting messages from a vessel or a coastal base station to all surrounding vessels and coastal base stations within the radio horizon range.

In 2000, IMO adopted a new requirement (as part of a revised Chapter V of SOLAS Convention) for all ships to carry Automatic Identification System Transponders (AIS Transponders) capable of automatically providing information about the vessel to other vessels and to coastal authorities (IMO 2017). AIS is a system of worldwide importance which strives to achieve the following goals:

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Nowadays most navigators are not familiar with the AIS technology and may use the AIS information uncritically and trust the AIS information in disfavor of the RADAR / ARPA information.

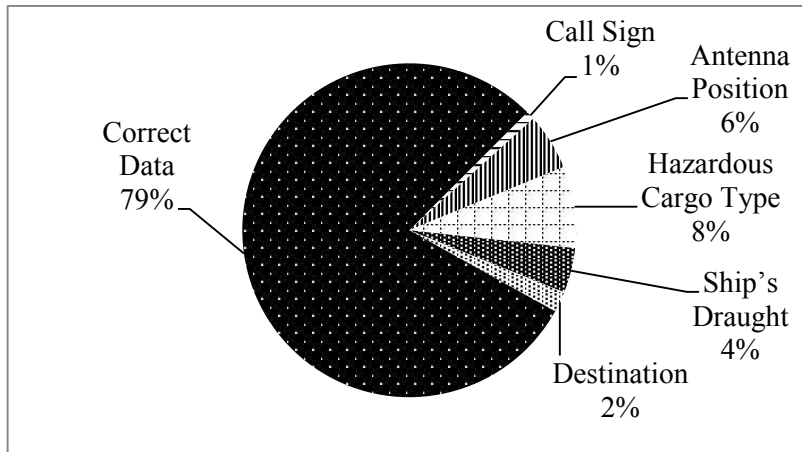
## **2. Source of Analyzed AIS Data**

As part of my Ph.D. research on the transportation and trade with petroleum products in the Mediterranean and Black Seas region I have worked with a huge amount of AIS data obtained from VT Explorer, a service provided by the Bulgarian software company Astra Paging Ltd. The analyzed data is related to the daily traffic of tanker vessels in the area of the Mediterranean and Black Seas for the period from 1<sup>st</sup> January 2013 till 31<sup>st</sup> December 2015. Throughout my work I have observed a serious number of errors in the AIS data and this has motivated me to research the issue more thoroughly.

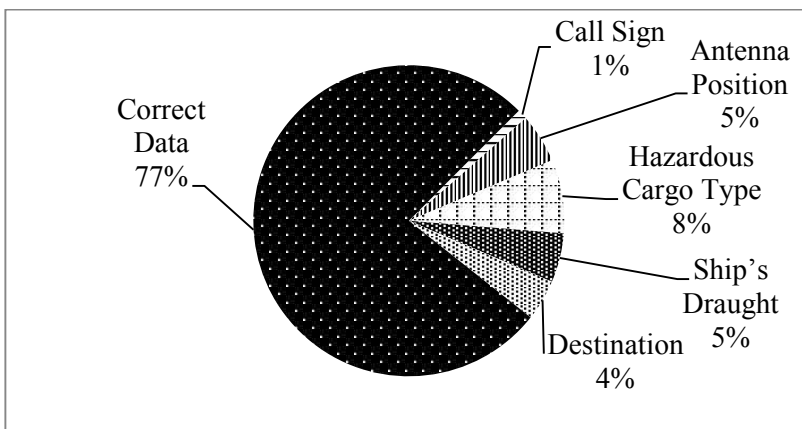
## **3. AIS Data Processing**

The data used for the current analysis have been segregated into three parts for each year. Each part consists of the following information: Date and Time, MMSI, Position, Speed Over Ground, Course Over Ground, IMO Number, Ship's Name, Call Sign, Hazardous Cargo Type, Antenna Position, Ship's Draught, Destination and ETA. Criteria for filtering have been applied for the categories Call Sign, Hazardous Cargo Type, Antenna Position, Ship's Draught and Destination. As incorrect data have been considered untypical signs used for the Call Sign, Hazardous Cargo Type provided for vessels other than tankers, untypical antenna positions, draught in discrepancy with the conventions and missing or unreliable description of the destination. The number of the vessels received after the filtration of each group has been presented as a part of all studied vessels.

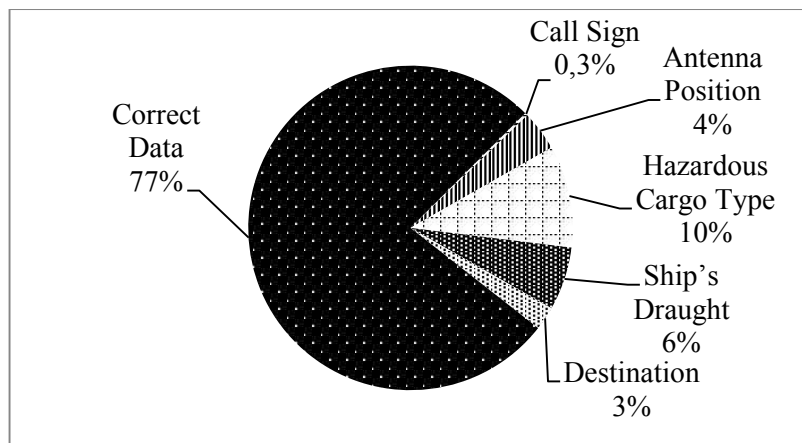




**Figure 1: Transmitted incorrect AIS Data from tanker vessels for 2013.**



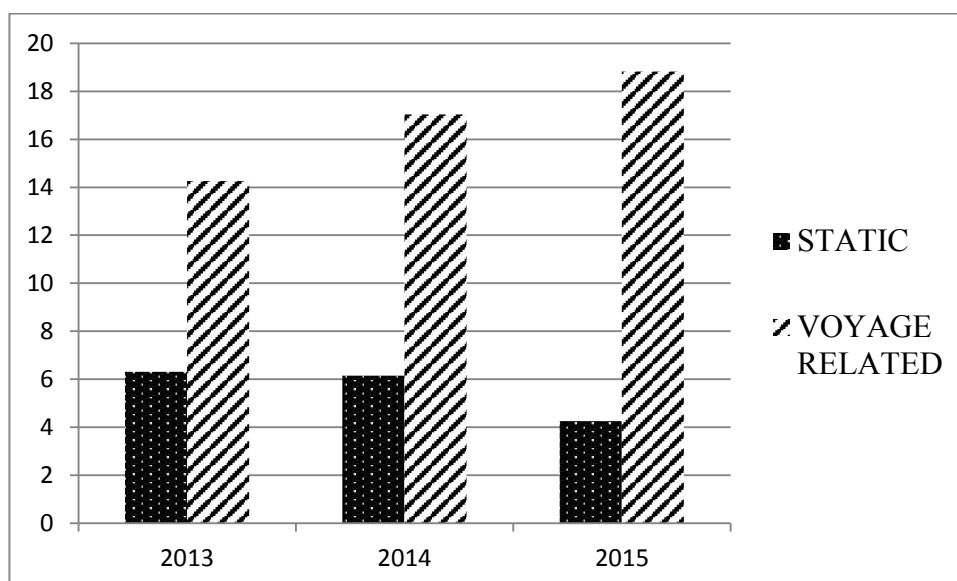
**Figure 2: Transmitted incorrect AIS Data from tanker vessels for 2014.**



**Figure 3: Transmitted incorrect AIS Data from tanker vessels for 2015.**

Comparison of the incorrect data based on the different type of the AIS data (i.e. static vs. voyage related data) has been made for the same period (Figure 4 below). Part of the static data

are the Call Sign and Antenna Position and these are the data entered by a certified technician during the AIS device installation whereas the voyage related data entailing Hazardous Cargo Type, Ship’s Draught and Destination are provided by the vessels’ navigational officers.



**Figure 4: Static vs. Voyage Related Data**

#### 4. Data Analysis

The analysis of the results depicted in figures 1, 2 and 3 shows that there is a steady percentage of the transmitted incorrect data from the tanker vessels and more precisely, 21% of incorrect data in year 2013, 23% in 2014 and 23% in 2015. The majority of the errors fall into the message of incorrectly provided Hazardous Cargo Type, followed by the messages Ship’s Draught, Antenna Position, Destination and the least number of errors is related to the Call Sign message.

Figure 4 above shows that the errors in voyage related data prevail significantly over the errors in static data which means that more incorrect data are provided by the navigational officers onboard the vessels rather than by the technical experts installing and supporting the system. Also for the reviewed three-year period (2013 – 2015) the following trend is observed: the percentage of errors in voyage related data (especially in the categories of Hazardous Cargo Type and Ship’s Draught) increases.

Considering the high percentage of incorrect AIS data (based on the analysis above around one-fifth of the transmitted AIS data include errors) the conclusion can be made that the AIS data is

not quite reliable. As these data are used worldwide for a number of reasons, it is of significant importance to improve their reliability.

## **5. Reliability of AIS Data**

Some recent studies distinguish among three major cases of bad AIS data quality, and more precisely: errors (when false data is non-deliberately broadcasted), falsifications (when false data is deliberately broadcasted) and spoofing (when data is created or modified and broadcasted by an outsider) (Ray, C., Iphar, C., Napoli, A., Gallen, R. & Bouju, A. 2015 pp. 2-6).

As the analysis above shows, as well as other studies worldwide have proven, the AIS Data is rather unreliable. But what might be the reasons for that significant percentage of errors in the AIS Data?

Data contained in AIS messages can be erroneous, falsified or spoofed for several reasons such as:

- lack of strong verification of the transmission,
- using a non-secured channel when doing the transmission,
- lack of knowledge on the part of the crew regarding some pieces of information or
- intentional hiding of information by the crew from other people's knowledge.

The factors above tend to modify and handicap the understanding of the maritime traffic (Iphar, C., Napoli, A., Ray, C., Alincourt, E. & Brosset, D., 2017. pp. 607).

## **6. Solutions to the Problem**

Since the development of AIS in the year 2000, a training on working with AIS has been introduced in the formal educational program of all navigation officers. Respectively, all maritime officers who had graduated before the year 2000 (i.e. the larger number of officers working with AIS) have not undergone such a training on working with the system (IMO Model Course 1.34). It is of utmost importance for such an additional training different maritime training organizations worldwide and for all navigational officers to attend that training and get certified on being able to work with AIS. Such a certificate should be required from all users of AIS as a prerequisite for their signing a work contract and boarding a vessel. Regular trainings for updating their knowledge and demonstration of competency in entering and checking ship's

AIS data should be organized as well for the technical experts installing and supporting the system as they are responsible for a certain amount of the errors in the transferred AIS data.

Apart from improvements to the AIS training programs, other solutions to the issue at hand and means for minimizing data errors that now pose challenges in the reliability and ease of use of AIS data can be:

- advancing the state of AIS technology,
- integration of AIS into ship and shore communication systems as well as
- feedback to mariners (Schwehr, K., McGillivray, P., 2007, pp.8).

## 7. Conclusion

In this paper a huge amount of AIS data have been analyzed and a serious number of errors have been detected. The conclusion is that a great number of vessels transmit incorrect AIS data. The reason for these incorrect data is to be found in the actions of both the technicians installing the device and the crew members responsible for entering the data in the system.

Solutions to this problem are the more elaborate training of the technicians and navigators operating with the system as well as the more rigorous control measures on the part of the responsible authorities.

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# UNMANNED SHIPS AND THE MARITIME EDUCATION AND TRAINING

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## **Abstract**

The unmanned ship has become a popular topic in the speculation of the future of sea transportation. Many experts foresee that unmanned and autonomous ships will gradually replace manned ships and become a key technology of safe, cost-effective and environmentally friendly marine transportation. The main benefits would be improved safety and reduction of operating costs. Also better energy efficiency and protection of environment support the idea of using unmanned ships for transportation of goods and raw materials over longer distances. Since the unmanned ship operates without an onboard crew, the development could have a strong impact to maritime education and training. What kind of new competences would be necessary for successful utilization of autonomous ships? How the unmanned ships should be taken into consideration in the education of seafarers? Are seafarers going to lose their jobs and will the profession of seafaring still attract young generations? How quickly and how widely unmanned ships would replace traditional manned ships? The conclusion is that some answers to these questions are more connected with the development of the international legislation than of the development of the technology. Seafaring has been a conservative branch of economy. It has been slow in accepting cultural changes. Therefore, the speed of the development might surprise some of the most eager supporters of the new technology. On the other hand, if the benefits of using unmanned ships are clear and undisputable, the development can be quick. In any case, seafaring as a profession will not disappear but develop and adapt to requirements of the new technical innovations. Opposing the inevitable development is not an option.

**Keywords:** Unmanned ship, Autonomous ship, Maritime Education and Training

## **Introduction**

Unmanned ships has been recently an up-to-date topic in the discussion of the future of sea transportation. However, different versions of automatic, though not unmanned, ships have existed already for some time (Manley, 2008). For instance, automatic dynamically positioned (DP) vessels have been utilized by the offshore industry for over 40 years. The concept of an unmanned cargo ship was tested and demonstrated in Japan already in the 1980's. Autonomous Unmanned Surface Vessels (USV's) are today fully operational in ocean research, coast guard and military applications.

The shipbuilding industry has started to consider unmanned and autonomous ships as vital components of sea transportation systems in the future. The key arguments are the improvement in safety and the reduction of investment and operational costs. Also better energy efficiency and protection of environment support the idea of utilizing unmanned ships for cargo over longer distances.

Recent European research and development projects are the international MUNIN-project (MUNIN PROJECT, 2016) and the ReVolt project (DNV GL, 2017). A major research and development effort on this subject is the ongoing AAWA project in Finland (Jokioinen, 2016). One of the key findings in the MUNIN-project was that the unmanned vessels can indeed contribute to a more sustainable marine transportation and that the use of autonomous ships might reduce operational costs and the environmental impact of shipping. The ReVolt project revealed that the fully autonomous, unmanned, battery powered concept ship could have a potential for cost savings over a million euros annually (Tveté, 2014).

## **The impact of the introduction of unmanned ships to maritime education and training**

An unmanned ship can be equipped with fully autonomous operation modes as well as with remote manual control modes. The unmanned ship can operate fully independently or it can sail remotely operated. The operating status of an unmanned ship can vary, based on the operational situation, between fully autonomous execution, partially remotely assisted operation and direct remote control (Rødseth et al., 2014).

Introduction of unmanned ships would undoubtedly have a strong impact to the maritime education and training. One might think that by removing the human operator from the ship the human element will also be removed and there is no more need for education of seafarers. This assumption is not correct (Ahvenjärvi, 2016). History has shown that automatization in

general has not reduced the need of skilled people, but underlined the importance of good education. When the degree of automation gets higher, the competence requirements also become higher on those who deal with design, operation and maintenance of the automated system.

The first question to be answered is: What kinds of new skills and competences are necessary for successful utilization of unmanned ships? This question can be approached from different angles. Members of different groups of people must have special skills and knowledge to cope with unmanned ships:

Operators of unmanned ships at the remote control center

- 1) Officers of manned ships and other sea-going vessels interacting with unmanned ships
- 2) People responsible for development and maintenance of unmanned ships
- 3) Port operators
- 4) VTS operators
- 5) Authorities, class inspectors, legislators, lawyers etc.

The first group, i.e. the operators of unmanned ships, must know how to control and monitor the vessel and its systems, when the unmanned ship is sailing in fully autonomous mode. The task seems easy, but it surely isn't. The work of the operator at the remote control center can be compared with the work of the operator of any automated safety-critical system, for example the user of the dynamic positioning (DP) system of a support vessel at an offshore oil field. Most of the time the DP operator doesn't have much to do. But when things start to go wrong, the operator must quickly understand what is happening, analyze the situation and available options, decide what to do and then act correctly. Such competence can not be achieved without extensive theoretical and practical studies and not be maintained without training of abnormal situations in a purpose-built simulator on a regular basis.

The second group, i.e. deck officers onboard manned ships and other sea-going vessels must also have knowledge about interacting with unmanned ships. There will be a long period – probably tens of years - when manned ships form the majority of vessels sailing on fairways and sea routes. It is a mistake to assume that the deck officers of manned ships would automatically know how to interact properly with unmanned ships sailing on the same traffic area. Today, if the captain has something to ask from or agree with the nearby ship, he can contact the colleague on the bridge of the other ship by phone, for example. What is the procedure when there is nobody on the bridge of the other ship? This might not a problem under normal conditions, but there can be surprises and difficult unexpected situations, for



example if several manned and unmanned ships are close to each other in bad weather. It has been learned from the past that automation has a tendency to provoke new working habits. People are innovative in taking advantage of new opportunities offered by automation, sometimes in ways that were not anticipated or meant by the designers. Undoubtedly this can happen with autonomous and unmanned ships as well. In order to prevent wrong habits and intentional misuse of automated functions of unmanned ships, seafarers must be trained to be aware of these risks and to interact correctly with these ships. Otherwise the expected increase of safety might turn into increased risks and too high dependence on automation.

The third group on the list are those responsible for development and maintenance of unmanned ships. This group consists of shipbuilding engineers, software engineers and maintenance engineers of shipping companies and service companies. First of all, unmanned ships must be very reliable, since there is a risk of collision, grounding, pollution, injury or even loss of lives if the ship does not operate correctly. Whenever there is a failure (and there will be one, sooner or later) in a critical system of an unmanned ship, there is no one onboard to fix the problem. The ship's systems shall be made fault-tolerant, which means that all critical components, systems and functions must be redundant. The design, construction and maintenance of the systems of an unmanned ship require different skills and knowledge than the design, operation and maintenance of the machinery of traditional manned cargo ships.

Port operations will also be affected by the introduction of unmanned ships. Apparently this means more automation. Thus the above mentioned remarks about new competence requirements are valid also for people responsible for port operations.

It will be a new situation for VTS operators to control traffic consisting of manned and unmanned ships and even manned and unmanned smaller crafts in the same traffic area. There is no doubt that certain kinds of unmanned boats will also be introduced together with unmanned commercial ships. Communication between the vessel and the VTS center will become quite different when the onboard crew is removed. This kind of setup will require new monitoring and communication procedures and they have to be trained in advance – using a VTS simulator, for instance.

The last group of people in the list above consists of authorities, class inspectors, legislators, lawyers and other persons involved with the legislation of ships and sea transportation. It will be a wide and interesting task to create all national and international laws, rules, regulations and standards that are needed for unmanned ships. Shipping industry is known for its conservatism and the process of updating the international legislation can take quite some

time. Anyway, all persons involved with unmanned ship operations must become aware of the new legislation.

How the introduction of unmanned ships should be taken into account in the development of maritime education and training? An answer can be drawn from the competence requirements above. The obvious conclusion is that there will be need for training on a large number of new subjects, when unmanned ships are taken into wider use in marine transportation. But on the other hand, the need for traditional maritime education and training will not disappear, because the great majority of ships sailing on the seven seas of the world will be manned for a long time from now.

The speed of this technical revolution on sea transportation is a very interesting question. How soon will we witness the breakthrough of unmanned shipping? There are different opinions about this matter. The first applications in Finland and Norway will be put into operation in a few years. The “*One Sea – Autonomous Maritime Ecosystem*” in Finland is aiming at establishment of an operating autonomous maritime ecosystem in the Baltic Sea by 2025 (TEKES, 2017). Introduction of unmanned cargo ships in the international sea transportation will not happen over one night, but gradually, step by step (Levander, 2016). It is difficult to estimate the speed of the development globally. It must be taken into account, that the life-time of a commercial ship is around 30 years (Equasis information system, 2016). For this reason most of the newbuildings ordered today will still be in traffic in 2040. So the growth of the popularity of unmanned ships will be limited by the simple fact that the global tonnage is renewed quite slowly. Another breaking factor will be the necessary renewal of international legislation. As stated above, seafaring is very traditional and conservative branch of business. A recent study at Satakunta University of Applied Sciences concludes that “To start operations with unmanned vessels on international traffic would require amendment of international conventions, possibly even compilation of a new convention for unmanned vessels and also its ratification process. Such process would take approximately ten years in minimum” (Roos, 2017).

Are seafarers going to lose their jobs and will the profession of seafaring still be a good choice? Are unmanned ships a threat for a seafarers’ career in the future? These questions are asked by young people who read news about unmanned and autonomous ships. As stated before, the profession of a seafarer will not disappear, but perhaps get even more interesting and challenging in the future. We must ensure that the message about the future of seafaring

as a profession is correct and realistic. Otherwise we will witness a decreasing trend in the number of youngsters willing to start studies in a Maritime University.

### **A model-scale platform for training and testing of the unmanned ship technology**

Satakunta University of Applied Sciences decided to establish together with a group of marine technology companies a model-scale platform for training and testing of the unmanned / autonomous ship technology. The platform called ELSA utilizes the 8,4 meter model ship *Kaisa*, which was built in 1994 for training of ship handling and harbor maneuvers by sea captain students at Rauma Maritime College (Markkanen, 1994). *Kaisa* was originally a 1:15 scale towing model of a passenger cruise ship “Society Adventurer”, built in Rauma in 1991.



**Figure 1.** The 1:15 model ship *Kaisa*

A block diagram of the general structure, the instrumentation and the signal transmission of the system is shown in Figure 2. The electric power for the equipment is provided by a battery pack, and the ship is equipped with solar panels for loading the batteries. Shore connection is available for quick load. The remote control centre is located in the simulator center of the Faculty of Logistics and Maritime Technology of SAMK. The wireless communication link between the ship and the remote control centre is accomplished using a commercial 4G network. The location of the control centre can be changed. The equipment can be installed on a van and moved to virtually any location with a decent 4G coverage.

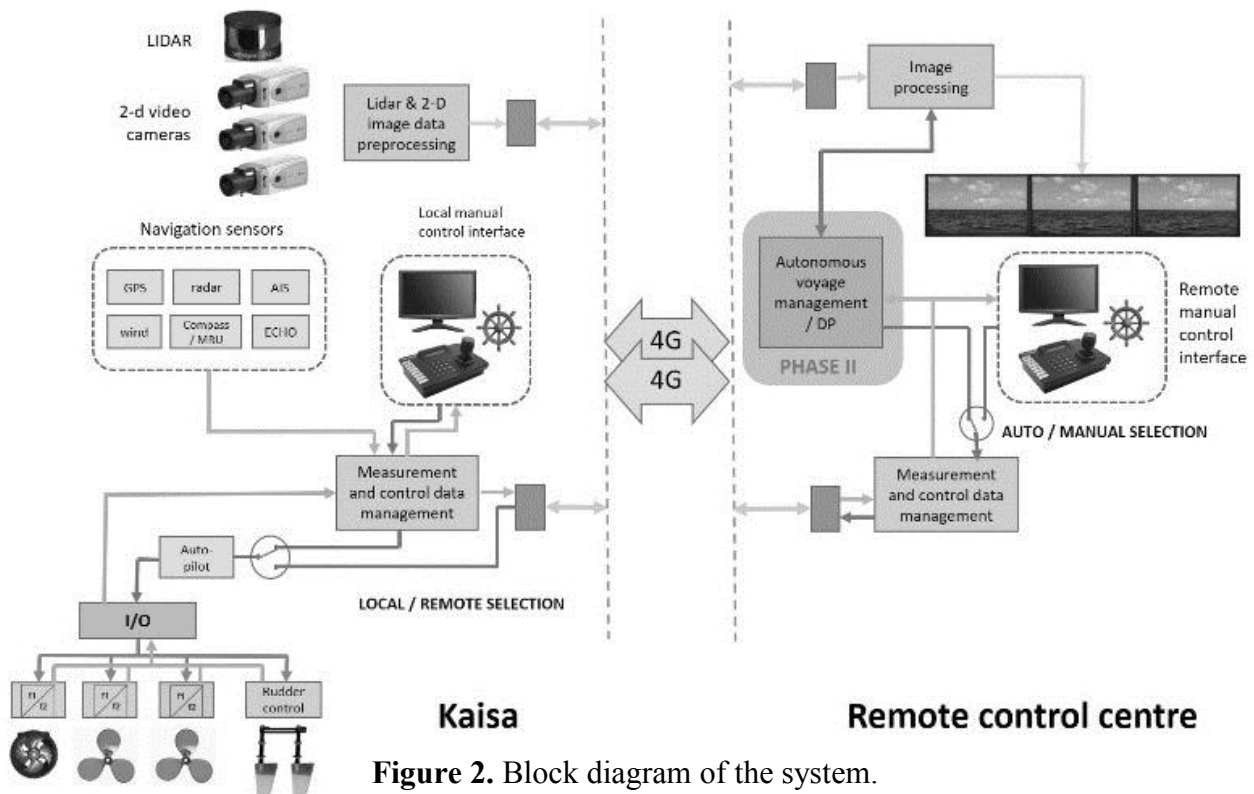


Figure 2. Block diagram of the system.

### The use of the “ELSA” platform

The goal of the ELSA project is to create a useful and a cost-effective environment for training purposes and for testing, demonstration and development of the autonomous ship technology. ELSA offers the possibility to run practical tests and demonstrations cost-effective in the real environment. The capital costs, the operation expenses and the safety risks are smaller, when the size, mass and the speed of the ship are scaled down. The platform can be used for research purposes in different ways. Interesting research areas would be, for instance

- the use of lidar and machine vision cameras for detection of objects
- algorithms for controlling the ship in abnormal traffic situations
- ergonomics and functions of the human-machine interface at the remote control centre
- training needs and good ways of building competence of the operators of the remote control centre

- necessary modifications in legislation and classification rules for autonomous ships
- autonomous operation in port, automatic berthing systems etc.
- interaction between an autonomous ship and an intelligent fairway

The ELSA project offers good opportunities for sea captain and marine engineering students of SAMK to increase their knowledge about the autonomous ship technology. Several Master's and Bachelor's degree theses will be published during the ELSA project on topics related to unmanned ship technology.

## **Conclusion**

Within the coming decades we will witness a break-through of unmanned ships in sea transportation. It has been predicted that unmanned cargo ships will gradually replace manned ships, beginning from short routes and special applications and expanding later to international traffic. Unmanned ship technology has the potential to bring many benefits to the ship owners and to the public. The following ones have been proposed (Haugland, 2016):

- a) Increased safety
- b) Reduced operational cost
- c) Reduced construction costs
- d) Increased environmental sustainability
- e) Increased social sustainability
- f) Increased competitiveness
- g) Reduced risk of piracy

The unmanned ship operates without an onboard crew. This will have also an impact to maritime education and training. The nature of this impact is discussed in this paper. What kind of new competences are needed for successful utilization of unmanned ships? How this will affect the education of seafarers? Are seafarers going to lose their jobs and how the profession of seafaring will maintain its attraction among youngsters? The conclusion is that maritime education and training must develop hand-in-hand with the technical development. New skills and competences are necessary for those who deal with design, operation and maintenance of unmanned ships. Also automated port operations, developing legislation, VTS operations and also interaction between manned and unmanned ships ask for good education and training of many new subjects. An interesting question is the speed of this development. Seafaring has been a conservative branch of economy and it is slow in accepting cultural changes. The time of first commercial unmanned ships in international traffic can be a

surprise. In any case, seafaring as a profession will not disappear but develop and adapt to requirements of the new technical innovations.

Satakunta University of Applied Science has decided to be involved in the development of training facilities for the future by planning a model-scale platform for training, demonstration and development of the unmanned ship. The ELSA platform is a cost-effective alternative for research, development and training purposes. ELSA will offer great opportunities for students of SAMK to get familiar with the technology and challenges of unmanned ships.

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# MARITIME ENERGY MANAGEMENT SYSTEM (MARIEMS) ONLINE DELIVERY PLATFORM

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**Abstract:** Maritime accounts for approximately 90% of trade in the world today. The maritime transport is responsible for polluting the atmosphere and the forecast of new scenarios about the shipping emissions predicts an increase between 50% and 250% by 2050, depending on future economic and energy development. The Industry has taken steps to reduce its Air Pollution and Carbon footprint. IMO introduced several new regulations such as the Ship Energy Efficiency Management Plan (SEEMP), Energy Efficiency Design Index (EEDI), & Energy Efficiency Operational Index (EEOI), while the MARPOL Convention new regulations have imposed strict emissions caps in emission control areas. Ship owners have reacted to fulfill these requirements meeting the future environmental requirements set for 2025.

Maritime Energy Management Specification (MariEMS) is an industry-academia collaboration project funded by the EU under the Erasmus+ programme. The project started in October 2015 and the duration is 30 months. The purpose of this Partnership is the development of an energy management training strategy and specification, and the development and implementation of an online learning and assessment system for the



proposed training programme so that current cadets, as well as existing seafarers, can up-skill themselves to the new regulatory requirements and good practice.

The paper presentation includes the handouts of the proposed methodology for developing specification and training content for the programme for the ship energy management as well as a demonstration of the MariEMS online e-learning platform.

**Keywords:** maritime energy management, energy efficiency, online, e-learning

## **Introduction**

It is generally accepted that around 90% of world trade happens by sea. The maritime transport emits around 1000 Mt of CO<sub>2</sub> per year about 2.5% of global GHG emissions (3<sup>rd</sup> IMO GHG study). Indeed the IMO's own International Shipping Facts and Figures report in 2012 stated that the number of propelled sea going vessels across the globe of at least 100 Gross Tonnage was 104,304 ships, with cargo carrying vessels being 55,138 ships (Ziarati, 2016).

With awareness and understanding increasing around the world about the effects of pollution on the Global Environment the International Maritime Organisation (IMO) has tried to tackle the level and type of emissions produced by the Maritime Industry through new regulations. The majority of the IMO requirements on ship emissions are contained within MARPOL, with Air Pollution being the focus of Annex VI. The MARPOL regulations impose strict emissions caps in two emissions control areas (ECA) which are (partly or completely) inside the EU - The North Sea and the Baltic Sea. These emissions caps are intended to control the main air pollutants contained in ships exhaust gas, including, CO<sub>2</sub>, sulphur oxides (SO<sub>x</sub>) and nitrous oxides (NO<sub>x</sub>), and prohibits deliberate emissions of ozone depleting substances (ODS).

As the regulations and technologies governing Energy Efficiency on board ships become ever more complex it has been recognised by the IMO and the shipping industry that seafarers themselves need to be trained to a much higher level in these fields. To this end the IMO (IMO Train The Trainer Course, 2016) has created in a sense a new position on board ship of viz., Energy Trainee/Officer/ Manager; a position that whether collective or given to an individual will play a crucial role in making ships and ports energy conscious and more efficient.

While the efforts by IMO and the many maritime communities particularly in Europe have been commendable the recent US reports to forego the outcomes of recent climate treaties is a

cause for concern particularly considering that US and China are the biggest maritime polluters in the world (Oceana report cited in Sahayam, 2014).

In a recent IMO WMU paper by the vice president of BIMCO (Kaptanoglu and Ziarati, 2015) it was stated that the key challenge facing the shipping industry is the competitiveness and environmental issues. It emphasizes that the IMO's own reports (Marine Environmental Protection Committee (MEPC), 64 session, Agenda item 4, 29th June 2012) and similar reports by learnt societies and classification societies give a clear view of the roadmap for reducing the energy consumption and marine engine emissions. MariEMS project is designed to support the training aspects of implementing this roadmap.

### **IMO Regulations**

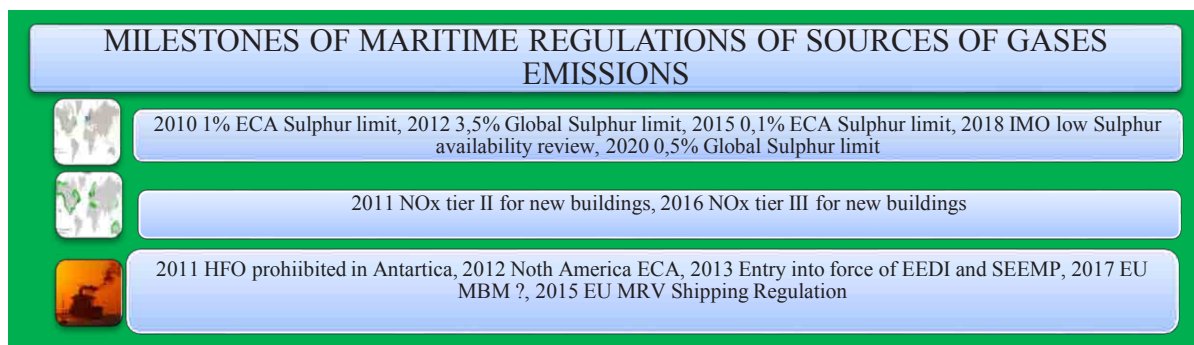
The IMO has also introduced regulations (DNV, 2014) such as the **Energy Efficiency Design Index (EEDI)**, **Ship Energy Efficiency Management Plan (SEEMP)** and **Energy Efficiency Operational Index (EEOI)** which all entered in force on January 1st 2013. SEEMP is an operational measure that establishes a cost-effective mechanism in improving the ship's energy efficiency. This measure also assists the shipping companies in providing an approach for managing ship and fleet efficiency performance over time with the help of the EEOI as a monitoring tool. The assistance on the development of the SEEMP operational measure for new and existing ships includes best practices for efficient ship's operation, as well as procedures for deliberate use of the EEOI in new and already existing ships ([MEPC.1/Circ.684](#)). SEEMP therefore is a plan to improve the energy efficiency implementation in a ship's operation, reported to provide cost savings of about 5 to 15% and help to bring down GHG emissions; A plan to reduce fuel cost (prediction of 35-65% reduction of operational costs have been reported (Ziarati and Akdemir, 2015; Sahayam, 2014)) with a range of environmental impact based port fees and so forth.

Kollamthodi et al (2008) claims from an interview with the Norwegian ship association that, the charterers (contractors) are ready to pay higher amounts for energy efficient ships when comparing with other normal vessels (Sustainable shipping, 2012). On the other hand, Faber et al. (2011) concludes that, the ship owners investing in ships that are fuel efficient will not be able to recoup their investments unless otherwise their own ships are being operated or by having a long term agreement with charterers. But an argument, on the other side is, investments in the energy efficiency vessels increase the rate of success for winning contracts and hence provides a better utilisation of ships.

## Energy Management

Energy management is a collective responsibility and requires team work. The role of the person designated for energy management should therefore involve all on board and incorporate the improvements in both transformation and use of energy with a view to also reduce harmful pollutants. There are a number of related areas, such as new regulation on sulphur content which in itself is a full-time job as described below, for the Energy Manager on board a vessel, when sailing through Emission Control Areas (ECA) designated waters.

Authorities given responsibility to oversee the implementation of ECA such as USCG and EMSA are issuing safety alert on fuel switching as of recently. Many losses of propulsion have occurred in different ports and have been associated with changeover processes and procedures. At a recent meeting at EMSA it was clear that polluter can be spotted and brought to justice based on evidence gathered by the agency. A review of recent legislations Sahayam, (2014) clearly shows that in terms of legislation there are in reality only two efforts regarding the 2010 ECA Sulphur limit and the 2011 NO<sub>x</sub> tier II so far of any significant value which is far short of what is required to make an effective inroad to reduce harmful pollutants as demonstrated in the following figure n° 1.



**Figure 1.** Milestones of Maritime Regulations of Sources of Gases Emissions

Ziarati and Akdemir (2015) have argued that to make a real impact on reducing engine emissions there needs to be a combined effort applying a range of options such i) Maximising thermal efficiency, ii) considering adaptation of hybrid propulsion, iii) using alternative fuels and or fuel cells/batteries, iv) integration of novel catalysts, exhaust recirculation systems and exhaust treatment, v) including multi-Stage inter-cooling, vi) using variable Geometry turbochargers, vii) considering use of lighter materials, viii) using more efficient bearings, ix) Injecting water after end of combustion to reduce NO<sub>x</sub> formation and for cooling the engine hence reducing heat losses through primarily conduction, x) using novel injectors with high injection pressures as part of the common rail systems.

### **Maritime Record Verification, MRV**

The management and oversight of any fuel oil mixing that may be part of a changeover process including, proper control and reduction of the operating temperature of fuel supplied, varying ratios of the mixed fuels and control of mixed fuel viscosity to the engines must take place before the vessel enters the ECAs or after the vessel leaves the ECAs.

The EU has the aim to reduce the emissions of CO<sub>2</sub> from shipping and has created a system called Monitoring Record Verification, MRV, to control the CO<sub>2</sub> emissions from vessels larger than 5000 GT and which call at any EU port. The shipping companies must prepare a monitoring plan for each of their vessels that has to comply with the MRV Regulation. The MRV Regulation was adopted in April 2015 and entered in force on July 2015; by August 2017 the shipping companies must have submitted the monitoring plans to the administration or accredited verifier. In January 2018 each vessel will start to voyage reporting till December of that year, that will be completed a period. In the next year the EC will publish the data of MRV. The parameters that must be monitored per voyage are: Port departure and arrival, including date and hour of departure and arrival, type of fuel consumed and the quantity and emission factors of each one, CO<sub>2</sub> emitted, distance travelled, transport carried and transport work.

### **Energy Efficient Ship Operation Training The Trainer course (EESO-TTT) and the MariEMS Project**

IMO in recent years has produced an Energy Efficient Ship Operation Training The Trainer course (EESO-TTT). The MariEMS Project was initiated for the intended trainees of this course and also for use by all ship crew particularly those with direct responsibility for energy management and efficient ship operation. MariEMS is primarily an online training programme composed of two courses, a short course of one week duration for more experienced seafarers and a 60 hrs nominal course for ship officer cadets; the project has several intellectual outputs. The first key output is the design of a specification for the role that the trainees of the IMO EESO-TTT course are anticipated to play and the second key output is the specification for the trainees training programme in a similar way that EESO-TTT was for the trainers. To this end, care has been exercised in ensuring the full use of the IMO EESO-TTT content so that the trainers and trainees would use a common teaching/learning material. Currently there are no training strategy and specification for ship energy management for seafarers or cadets and the role that all on board should be playing in reducing fuel consumption and the resulting pollutions. Furthermore, there are no training specifications for the intended trainees/energy efficiency team members and so existing crew members are

learning 'on the job' how to implement these new regulations as best they can, which is not an effective method of applying these regulations and will of course mean that the best results are not currently being achieved.

The purpose of this Strategic Partnership is the development of an energy management training strategy and specifications, and the development and implementation of an online learning and assessment system for the new training programme so that current Cadets, as well as existing seafarers, can up-skill themselves to the new IMO regulatory requirements. The needs that this proposal will fulfil are as follows:

1. The need for qualified personnel to be implementing the new regulations and technologies.
2. The need for Energy Efficiency to be embraced by Shipping Companies in order to achieve the best results through cost savings gained through more efficient use of fuels etc.
3. Enhanced employability and mobility in a global labour market for EU seafarers and cadets who take the qualification either as part of their initial studies or as part of a continuing VET; ensuring that these are also ECVET compliant.
4. METs continuing to offer courses that are relevant and comply with latest regulations and requirements of the industry.
5. Integrating and developing e-learning and digital skills into the EU MET's so that they can design and deliver e-learning materials and an online learning platform. In the 2010 STCW amendments the IMO officially recognised the validity of e-learning for the maritime sector.

The partners are anticipating to bring together a unique blend of industrial, academic and industrial partners who can bring to the table valuable and necessary experience in ship types, ship propulsion, ship navigation, energy transformation, electrical and mechanical parts and circuitry, safety issues, national certification, accreditation and validation of learning materials, pedagogical aspects of learning and last but by no means least online application. The partners have developed a sustainability plan and the activities contained in this plan are expected to invite as many ship companies, ports and other key stakeholders including maritime institutions into the project team. Within their sustainability plan several areas have been identified which could help to reduce ship fuel consumptions as well as reducing harmful emissions both due to reduction in fuel consumption and due to other measures being introduced to filter or re-circulate/burn some of the more vicious pollutants using now novel systems as are the following: slow steaming, weather routing, green energy wind and sun (Flettner rotor & sun panels), use of sea currents, e-navigation, ballast water management, hull and trim optimisation, ship-port and port-ship system integration, port-road-train-airport

system integration, on-board ship management and Artificial Intelligence and Virtual Reality applications such as virtual arrival and departure, advanced satellite and drone communications, Just-In-Time data using neural network predictive techniques.

### **Innovative aspects of the Project**

The innovative characteristic of the project is to develop the first European training strategy and specifications primarily for the Ship Trainee/Officer/Managers, as well as developing the standards and specifications for the intended training courses for the ship officers, and the specifications and first online delivery platform for these training courses and materials. The skills shortage that is currently emerging between traditional education and the latest technologies, requirements and practices for maritime energy efficiency needs to be addressed urgently in order for cadets and seafarers to have the skills necessary to implement the latest regulation and technologies to their best effect and thus secure the energy efficiency and pollutant reduction needed to help the EU meet its 20% reduction target by 2020.

Another innovative characteristic of this project is the involvement of the shipping industry in the formation of mentioned training courses right from the specification stage. It is expected that someone on board or within a company will take up the role of Maritime Energy Manager which entails involvement of all on board. The team of project partners has the opportunity to embed the industry's requirements into the training courses right from their development stage. Also with industry involvement in the design and development stage of the training courses comes the ability to accurately tailor the training programme to the current skill and knowledge level of seafarers working in the industry.

The ship energy management team is primarily responsible for managing all aspects of energy management and efficiency on board vessels. The manager/coordinator of the team should have knowledge, understanding and application of IMO Energy Requirements/Regulations and is expected that the manager should be familiar with application of EEOI and EEDI with a specific knowledge of energy transformation on board of vessels, with skills in energy saving practices including engine propulsion, heating cooling and so forth. The manager should be familiar with the ISM practices, and company specific measures including aspects relating to any quality standards which may relate to ISO 9000/EN 29000 or ship specific standards such as ISO 50001 and ISO 14000. The manager/coordinator must be aware of IMO's MARPOL, SOLAS, and other related standards including aspects concerning maritime environment protection. It is for this reason that within the project a job specification has

been drafted as a blue print to ensure all relevant attributes for the person designated to coordinate the ship energy management is taken into account.

Both training courses have four parts; the first part has seven sections: Knowledge, Understanding and Application of IMO Energy Management Requirements/Regulations, EEDI Reference lines – significance, Company Specific Measures, Energy Saving System – Internal and Existing Environmental Protection Requirements. The second part is about Skills, Experience and Qualifications. The third part is about Personal Characteristics and the fourth part is about the term of the contract along with the points discussed and agreed at the point of interview. At the end of course the learners are able to: identify, implement, assess, evaluate the energy efficiency measures of all kind of propulsion and systems on board, and provide guidance to the crew and compliance with the international legislations and requirements

### **Expected Impact**

At the national level the impact of the MariEMS project is to increase the capacity of the partner METs through developing the e-learning infrastructure and capabilities of these institutions and their staff to use and run the MariEMS e-learning platform and training courses to help METs deliver the brand new Energy Manager field of training, to both their cadets and to already qualified seafarers resulting is a more skilled, competent and mobile Maritime labour force educated to the latest regulatory requirements.

Another national impact is that cadets and seafarers who complete one of the MariEMS courses and become qualified Energy Managers/Coordinators will be heavily in demand by the industry as they seek to appoint and Energy Manager on each ship.

The exchange of good practices and knowledge between the partner METs, and also between the partnership and international shipping companies and ports, as well as with the IMO (170 member states and growing) and international awarding, accrediting and licensing bodies will be a truly international impact of the project as it will allow for industry, academia and policymakers to exchange knowledge and best practices right at the birth of a new educational field so that the MariEMS outputs developed as a result of the project will reflect all parties involved.

International impact is expected to be a decline in emissions from ships and countries that train and employ truly qualified and effective Energy Managers. It is believed that the Maritime Industry currently account for some 50% of CO<sub>2</sub>-emissions at ports with substantial level of other dangerous pollutant particularly outside the ECA zones, and so the energy saving measures that are intended by the IMO to be employed by the Energy Managers, such

as reductions in fuel consumption, will result in emissions drops of by at least 20 to 30% (Sahayam, 2013). The environment is a global issue and so such a reduction in emissions by the shipping Industry will also have a global impact.

Another international impact of the project will be the designing of the first full training specification, courses, e-learning delivery platform and sample training materials for the new Energy Management Team, and then submitting this to the IMO as a possible basis for a new model course. The impact of having a single standardised model course for the Energy Management would be tremendous because many METs in the IMOs 170 member states prefer to use IMO model courses rather than design their own courses from scratch. Currently almost all METs make use of IMO Model Courses and so the level of uptake and impact that the Energy Manger Model Course would have can be judged to be substantial. By providing a possibility of a Model Course being developed MariEMS would be speeding up the global timetable of the implementation of the Energy Management training courses complementing the IMO's EESO-TTT course. The user-friendly e-leaning and e-assessment courses will be available free of charge at any place and at any time provided there is access to-the-internet.

## **Conclusions**

The whole of Central and North America coastal areas are now almost an Emission Control Area (ECA) and it is expected that many other coasts will become ECAs, constituting some 90% of shipping routes so the implications are serious for the maritime community.

The most important impact of the project is expected to be the reduction of energy used on board vessels and as the MariEMS course also incorporates ISO 50001 will ensure saving are made. ISO processes will enable a continuous system of development to be in place which is expected to help ship operators and owners, to be more respectful of environment issues.

The training strategy and specification and learning material so far developed as part of the MariEMS project are in hand and have been validated by two multiplier events in Finland and in the UK. The feedbacks from these events have been very helpful. A meeting was also organised at EMSA to seek comments on the project from the Agency. There are several other opportunities to present the project at national and international professional networks and seek further feedback. A real debate is as to whether MariEMs should focus on preparing the cadets and in parallel up-dating the competence of the existing seafarers in ship energy management aspects and/or focus on creating a new job and/or training specification for the role/position of energy manager/coordinator.



The roadmap for the future work is the development of a competence-based set of assessment criteria for both intended courses, and to seek accreditation for the courses from a major professional body.

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# ANALYTICAL COMPARISON OF DIFFERENT MOORING SYSTEMS

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**Abstract text.** The number of ships and ports are increasing in connection with growing transportation demand in the world each passing day. And thus the numbers of mooring operations are increasing. Mooring operations are one of the most dangerous operations for ships and ports. Lots of accidents that result in deaths, injuries and financial loss have been lived during mooring operations. Lack of mooring equipment maintenance, untrained and inexperienced personnel, equipment failures, available weather conditions, poor communication, safety procedure errors, risk assessment failure are main factors that triggering mooring accidents that occurred while using conventional mooring system involving ropes and windlass. There have been various innovations in the maritime industry in terms of mooring systems, like the automated vacuum mooring systems, magnetic mooring systems, berthing aid systems, to reduce the hazards associated with mooring operations. Still most of vessels use mooring arrangements involving ropes and windlass. These systems have benefits, as they are flexible and enable berthing at most ports. However, the risks associated with operating conventional mooring system involving ropes and windlass continue to increase as vessels become larger and number of mooring operations increase. In this study, working principles of vacuum based automated mooring system, magnetic mooring system and conventional mooring system involving ropes and windlass will be expressed briefly. Three different mooring systems compared with each other in terms of defined criteria as operation safety, operating cost, maintenance cost, environmental effect, ease of handling, limitations of systems etc. With this study, advantages and disadvantages of vacuum based automated mooring system, magnetic mooring system and conventional mooring system involving ropes and windlass revealed. Analytic Hierarchy Process (AHP) which is a multi-criteria decision making method used for comparison of different mooring systems. The analyses using the AHP method performed by Super Decisions which is a software tool.

**Keywords:** mooring operation, safety, mooring systems, AHP

## 1. Introduction

Maritime transport which has lots of high risk, labor intensive and time consuming operations is the most common type of transportation and the backbone of international trade. Technological developments have enabled safer and faster opportunities for various maritime operations. Although mooring and unmooring operations are dangerous, time consuming and labor intensive for ships and ports, conventional mooring systems involving ropes and windlass are still mostly common systems used for mooring and unmooring operations. For a long period conventional mooring system involving ropes and windlass has been used by the maritime industry to secure vessels. It has been a reliable system that has worked well but is now somehow out of synch with the maritime industry's focus on continuous improvements in productivity and efficiency. Failures of conventional mooring systems have been attracted attention nowadays. Especially safety defects of conventional mooring systems have been discussed. Lack of mooring equipment maintenance, untrained and inexperienced personnel, equipment failures, available weather conditions, poor communication, safety procedure errors, risk assessment failure, fatigue are main factors that cause serious injuries and losses. In a report of UK P&I Club Loss Prevention Department, it is stated that major accidents involving mooring equipment in the last 20 years had injured many seafarers and had cost the UK P&I Club over US\$34 million. (UK P&I Club, 2009) Alternative mooring systems such as magnetic mooring system and vacuum mooring system are innovative systems and enable safer and faster opportunities, but these systems are not commonly used. Different mooring systems have advantages and disadvantages. Various options instead of conventional mooring systems are available now. These are vacuum mooring system, shore-tension hydraulic mooring system, dock lock magnetic mooring system and other innovative subsystems. In a study, different mooring systems, shore-based mooring lines, softer fenders, a combination of softer fenders and shore-based mooring lines, vacuum mooring system, shore-tension hydraulic mooring system, dock lock magnetic mooring system were analyzed by means of dynamic mooring simulation. The ship motions for the dynamic mooring analysis were determined with the Baird in-house model Quaysim. This program comprises a time domain simulation to analyze the dynamic behavior of a moored ship subject to combined swell and long waves. The mooring line and fender loads follow from the computed ship motions and the characteristics of the mooring lines and fenders. According to the results, the best reduction of vessel motions and mooring line forces was achieved by installing a combination of pneumatic fenders and constant tension winches set to 30 ton, or nylon breast lines with a

pretension of 25 ton for the study. (Molen, 2015) In a research project, named Alternative Berthing, conventional mooring system, vacuum mooring system and vacuum mooring system were researched and their working principles, advantages and disadvantages were stated in the study. Interviews, desk research and qualitative research methods were tried to collect information. (Bodegom, 2014) In a bachelor's thesis, alternative mooring systems were researched and two alternative mooring systems, vacuum and magnetic, were defined without ropes or lines. Mooring systems were evaluated mostly on the basis of interviews that were carried out by producers of mooring systems. (Himanen, 2016) Different studies about new mooring systems and comparisons by using different methods are available, but analytic hierarchy process method has not been used to compare mooring systems. In this study, conventional mooring system, magnetic mooring system and vacuum mooring system are compared by using analytic hierarchy process method. The aim of this study is to compare different mooring systems in terms of safety, operating cost, flexibility to ship movements and environmental conditions, operating limitations and environmental effect and to decide optimum mooring system.

## **2. Mooring Systems**

### **2.1 Conventional mooring system**

Conventional mooring system involves mooring ropes and windlass. Tension to mooring lines to keep them tight is necessary to hold vessel. Tension is enabled by windlass that may have hydraulic or electric driving motors. Mooring ropes hold the vessel when alongside. Loading and discharging operations, ship movements and environmental conditions such as wind, tide and current changes tension of ropes. Ropes should be at its optimum tension to hold vessel appropriately. More tension may cause breaking of ropes that cause serious injuries or losses. Less tension may cause giving away of vessel from quay. That's why, continuous watch keeping and arranging the tension of ropes according to changing conditions are necessary when alongside. In a conventional mooring system operation approximately six crew necessary onboard and four linemen on shore for handling ropes. Crew number for mooring operation may change according to vessel size. Fore and aft mooring crew get ready before mooring operation. They arrange and plan their ropes and positions for mooring operation. When the vessel approaches to the quay planned ropes are send out to the linemen to be made fast by using bollards on shore. When the vessel is in necessary position at quay all ropes are send out and mooring operation completed.

## **2.2 Vacuum mooring system**

Vacuum mooring system is more complicated and innovative system that has vacuum pads which are used instead of ropes. Vacuum pads have measurable working load, providing safe connections between ship and shore. (Popesco, 2009) When combined with the innovative, three dimensional supporting apparatus, the mooring units emulate the range of movement, resilience and elasticity of a line mooring. When the vessel is a few meters away from the quay the vacuum pump is started up and the vacuum pads suck the ship to the quay. In case of system failure, the system does not lose its vacuum for two hours so there is enough time to work on a leak in the system or to get the power back on. If leakage of vacuum pads is 60% system will give a signal to the crew so they can immediately with the repair so the vessel does not lose its vacuum. A power generator is also a possible solution to prevent a black out of electricity. The vacuum system makes use of a vacuum pump, hydraulic system, steel, monitors and power supply to control the whole system. The system has sensors and monitors that indicate vacuum force, ship movements and alarms. (Bodegom, 2014) This automated ship to shore interface system has been used for mooring at some ports.

## **Magnetic mooring system**

Principle of electromagnetism is used for magnetic mooring system. An electromagnet is a type of magnet in which the magnetic field is produced by an electric current. Electric current is used for making temporary magnets known as electromagnets that work on the magnetic effect of electric current. Combination of a solenoid and a soft iron core constitute an electromagnet. Soft iron should be used to remove magnetism of electromagnet when the electric current is cut off. Electromagnets can be made of different shapes and sizes depending on the purpose for which they are to be used. Laura Himanen explains structure and working principle of the magnetic mooring system that the system has the electrical cables, fenders to protect the quay and vessel, the magnetic pads connected to the hydraulic arms and the power supply that provides the magnetism. Electrical power produces electromagnetic fields turns on the magnets and electromagnetic fields are used for mooring the ship. (Himanen, 2016) Zhang Qiang, Zhou Zhao-xin and Ma Jian state that the magnetic ship automatic lockage device is designed, to improve the existing problem of conventional mooring systems and they calculated the power required for different types of vessels to pass the lock is analyzed, and the relationship between different breadth and power is also listed in their study. (Qiang, 2015)

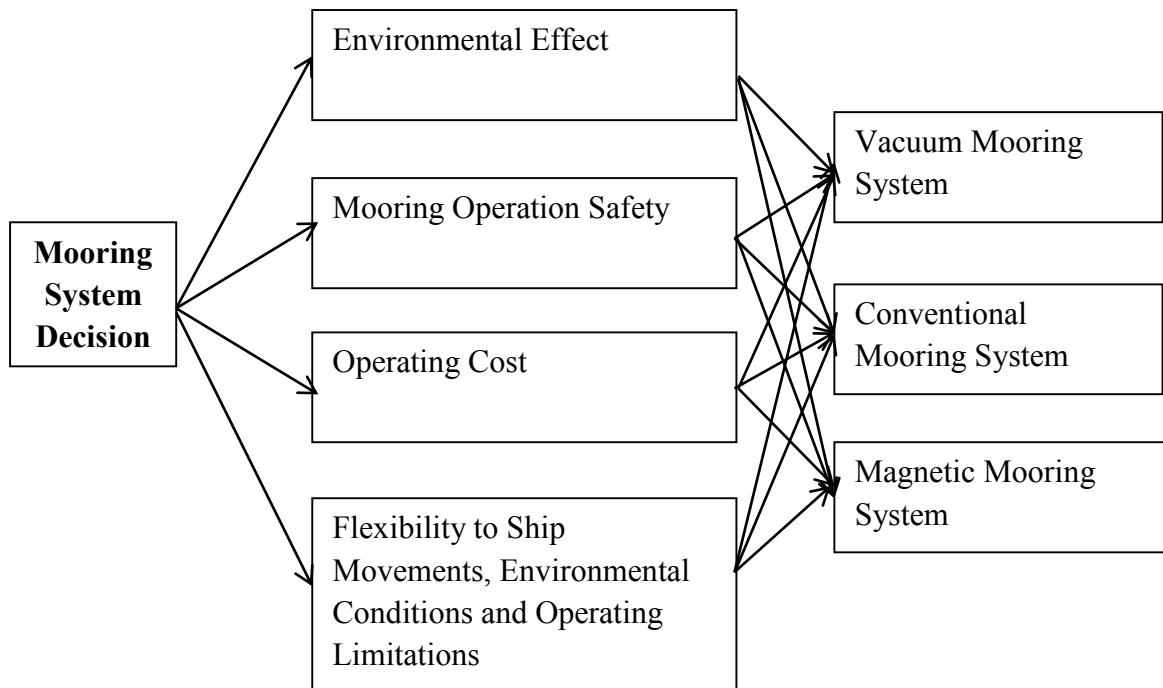
### **3. Method**

#### **3.1 Analytic Hierarchy Process**

Analytic Hierarchy Process (AHP) is a multi-criteria decision making method that was developed by Thomas L. Saaty who states that the factors that are important for that decision are arranged in a hierarchic structure descending from an overall goal to criteria and alternatives in successive levels. He developed this method for measuring tangible or intangible factors through paired comparisons using judgments from a 1 to 9 fundamental scale and resulting in priorities for the factors. (Saaty, 1990) This is structured technique for organizing and analyzing complex decisions, based on mathematics and psychology. This method has different areas of application and used for decision making, in fields such as government, business, industry, healthcare, manufacturing and education. (Saaty, 1987)

AHP method has been used for selection, evaluation, cost and benefit analysis, planning and development, priority and forecasting. If decision making related literature review is made it is possible to find numerous studies in which AHP method has been used. Vaidya and Kumar made a literature review of the applications of AHP that had been used in almost all the applications related with decision-making. More than one hundred application papers reviewed and analyzed in this study. (Vaidya, 2004)

Because of the fact that, the aim of this study is to determine the most suitable mooring system in terms of defined criteria, studies about selection among alternatives were elaborated on. Byun used AHP for deciding on car purchase. Exterior, convenience, performance, safety, economic aspect, dealer and warranty was defined as main criteria for selection and three automobiles were defined as alternatives and the most suitable car was determined in this study. (Byun, 2001). Podgorski used AHP method for prioritization and selection of key performance indicators measuring occupational safety and health management system in his study. (Podgorski, 2014) There are lots of software tools that perform AHP method. One of them is Super Decisions that is user friendly software and it can be accessed easily. This software which was used for implementation of AHP, provides tools to create and manage the method. Super Decisions software also gets results and perform sensitivity analysis on the results. (<https://www.superdecisions.com/tutorials>)



**Figure 1:** Hierarchical Structure for Mooring System Decision

### 3.2 Implementation of Analytic Hierarchy Process and Results

For decision making of the most suitable mooring system, three different mooring systems were defined as alternatives. Criteria were defined for comparison of vacuum mooring system, magnetic mooring system and conventional mooring system in terms of safety, cost and environment. Environmental effect, mooring operation safety, operating cost, flexibility to ship movements, environmental conditions and operating limitations were defined as main criteria for analytic comparison. Criterion of flexibility to ship movements, environmental conditions and operating limitations was used for defining which mooring system was more flexible in different environmental conditions such as in big tidal differences, in strong winds and for ship movements due to loading, discharging operation and shifting. Criterion of operating cost was used for defining which mooring system needed less crew for mooring operation, which mooring system needed less cost for maintenance and repair, which mooring system takes less time for completion of mooring operation. Criterion of environmental effect was used for defining which mooring system was less harmful for environment. Criterion of mooring operation safety was used for defining which mooring system is safer and which mooring system was faster and easier to leave from the quay in an emergency situation at port such as fire. For implementation of AHP, pairwise comparisons for the criteria with respect to the goal were prepared and a questionnaire comparison table created by using Super Decision

software. Pairwise comparison is a process that people are able to express their sense of preference or importance with respect to determined criteria. (Saaty, 1987) The Saaty rating scale was used for pairwise comparison.

1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance
2,4,6,8	Intermediate values

**Table 1:** The Saaty Rating Scale

The Saaty rating scale describes pairwise comparison with the 1-9 ratio scale. Criterion of mooring operation safety should be rated at 5 if a criterion such as mooring operation safety is strongly more important than another criterion such as operating cost and this means that operating cost is more important than mooring operation safety and is valued at 1/5. These pairwise comparisons are carried out for all determined criteria. The results of these comparisons were entered into the comparison table of Super Decision software.

Environmental Effect	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Flexibility and Limitations
Environmental Effect	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Mooring Operation Safety
Environmental Effect	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Operating Cost
Flexibility and Limitations	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Mooring Operation Safety
Flexibility and Limitations	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Operating Cost
Mooring Operation Safety	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Operating Cost

**Table 2.** The Questionnaire Comparison Table

The questionnaire was applied to 8 participants who are experts in mooring operations and mooring systems. The questionnaire comparison table was created by means of average values that were calculated by using participants' answers.

Inconsistency: 0.07418	
Environmental Effect	0.15118
Flexibility and Limitations	0.26534
Mooring Operation Safety	0.50829
Operating Cost	0.07520

**Table 3.** The Results of the Pairwise Comparisons



The software calculates inconsistency index for checking the consistency of the evaluations. Small values of inconsistency may be tolerated. If inconsistency index is less than 0,1this is tolerable, and a reliable result can be expected. The inconsistency index that calculated by the software is 0.07418, so correction of judgments is unnecessary.

<b>Name</b>	<b>Ideals</b>	<b>Normals</b>
Conventional Mooring System	0.506956	0.253015
Magnetic Mooring System	0.496700	0.247897
Vacuum Mooring System	1.000000	0.499088

**Table 4.** The Results for Alternatives

The Normals column presents the results in the form of priorities. The Ideals column is obtained from the Normals column by dividing each of its entries by the largest value in the column. These results show that Vacuum mooring would be the best choice. The “Ideal” column shows the results divided by the largest value so that the best choice has a priority of 1.0. The others are in the same proportion as in “Normals” and are interpreted this way: Magnetic mooring system is 49.7 % as good as vacuum mooring system and conventional mooring system is 50.7% as good as vacuum mooring system.

**4. Conclusion**

When conventional, magnetic and vacuum mooring systems are compared each of them has different advantages and disadvantages. However, vacuum mooring system has more preferable than the other mooring system according to results of analytic comparison. Conventional mooring system which has been used for years is usual for marine industry, so it has extensive market, suppliers and technical support departments all around the world. It is easy to find technical support or equipment when necessary for the system. Initial investment cost for vacuum mooring system is much more than conventional mooring system. However, operating cost and maintenance cost is less for vacuum mooring system. In terms of safety, danger of injury to linesmen and ship crew due to mooring ropes can be eliminated by vacuum mooring system which can be operated and monitored by one personnel. On the other hand, more personnel are necessary for mooring operation in conventional mooring system, so much more personnel expose to danger throughout mooring operation and also for longer period in contrast with vacuum mooring system that enable fast attachment and instant release. Especially for tanker terminal, vessels may have to leave from quay immediately because of an emergency such as fire or explosion in tanker terminal. Emergency shore leave

for vacuum mooring system is easier and faster than conventional mooring system. Fast mooring also enables less operation of the ship's propulsion, of tugs and lines' boats and consequently diminishes emissions into the port when it is thought from the stand point of environment. As a result, vacuum mooring system has much more advantages. It is understood from this study vacuum mooring system is safer, faster, and more environment-friendly than conventional and magnetic mooring system. For this reason, use of vacuum mooring system should be extended and the system should be developed.

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# **OIL RESPONSE IN ARCTIC WATER – DIFFERENT POSSIBILITIES FOR RECOVERING OIL IN ICY CONDITIONS**

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**Abstract** The aim of this article is to introduce methods for protecting environment in ice-covered waters in possible oil spill situation. The future trends predict increasing marine business activities in the environmental sensitive Arctic Sea areas, which establish demands for development of vessel's operational safety procedures and creates new challenges for protecting these untouched waters. Many means of mechanical oil recovery solutions have been developed and research have been active during decade's but still a lot of improvement and considerations need to be done.

Vessels operating in the Arctic Sea areas meet many risky situations, which are related for instance to rough weather conditions, limitations of nautical charts and publications or activities in isolated territory where vessels have to manage on their own without any outside help. In addition, organizing rescue and environmental cleaning operations are demanding in these areas.

Oil spill finding, observing and planning of cleaning operations in iced areas differs from open water cleaning operations due to properties of oil. Because of mentioned reason, techniques of preventing of oil spill, which are used in normal open water condition or in the warmer sea areas, may be ineffective or useless under cold and icy circumstances.

The main purpose of effective oil recovery is to choose and implement combination of different techniques, which are preventing short- and long-term effects to the sea environment. Generally known strategies are mechanical, combination of in situ burning and dispersion and normal natural extinction. Finnish are a pioneer in the matter also in regard to the development of collecting techniques and that is a part of our export industry, of research and innovations. This article covers the mechanical methods and use of vessels in arctic oil recovery.

**Keywords:** Arctic region, marine environment, oil recovery, oil-cleaning methods

## **Introduction**

The shipping and marine business activities in polar areas will increase in volume in the long term due to decreasing of ice fields and exploitation of natural resources in the area. (Haaslahti, 2015) In addition, trends of growing arctic tourism and passenger vessel cruises are starting to show in these remote icy areas.

There is a number of unique risks ships are exposed to like for example harsh weather conditions, limited communication systems, lack of good nautical charts and publications as well as the remoteness of rescue and environmental clean-up operations. When ships are operating in cold air temperatures the functionality of equipment such as deck machinery and life saving appliances can be reduced. The cold and icy conditions increase extra loads on the ship hull, propulsion and have effects on vessel's stability. (IMO, 2017)

The growing activity in arctic areas creates remarkable risk for the sensitive sea and coastal environment in the arctic areas. At this moment there is lack of adequate infrastructure, search and rescue as well as oil spill preparedness in these regions. (Husebekk, et al., 2015)

## **Oil response in icy conditions**

The primary goal of the efficient oil destruction is to choose and implement a combination of response techniques, which would be as effective as possible to prevent or minimizing short and long term influences of the oil spillage for the sensitive sea and the coastal areas.

The usual strategies for responding oil spills in icy waters are the same general suite of counteractions seen elsewhere in the world. The methods are:

- mechanical containment
- a combination of strategies to concentrate the oil and burn it *in-situ*
- dispersants
- detection and monitoring while conceivable planning a subsequent response
- natural attenuation through evaporation and dispersion (Council, Arctic, 2015)

Oil spill finding, observing and planning of cleaning operations in iced areas differs from open water cleaning operations due to properties of oil. Because of mentioned reason, techniques of preventing of oil spill, which are used in normal open water condition or in the warmer sea areas, may be ineffective or useless under cold and icy circumstances. (Tammiala, 2017)

A collectively known term “weathering” means the physical and chemical changes that spilled oil undergoes. When determining the accessible windows of opportunity for various response strategies, weathering rates play a major role in that respect. One example for this is

usage of dispersant, which will become much less efficient as the oil spreads and as oil viscosity increases. The time available for applying dispersant can be limited - hours to days because of increased oil viscosity. Similarly, if mechanical collection methods are used, there might be need for changing the type of pumps or skimmers as the oil weathers and viscosity grows. There can be difficulties with in situ burning and has need of a greater starting oil thickness as the oil emulsifies and weathers. Weathering starts instantly when the oil is released from its container such as a tank, pipeline or vessel through multiple processes of:

- Biodegradation
- Dissolution
- Dispersion
- Evaporation
- Emulsification
- Oxidation
- Sedimentation (Council, Arctic, 2015)

In the arctic, ice covered areas emergency response is especially demanding due to many reasons. Among other things coping with the dynamic nature and unforeseeability of the ice; the remoteness and long distances that adds challenges in responding to accidental spills; effect of cold temperatures, icy and inhospitable working environment on response personnel and equipment; and the lack of shore-side infrastructure and communications to support and maintain a major response effort. (Council, Arctic, 2015)

### **Mechanical means of recovering oil from ice**

Along with use of dispersants and in-situ burning, mechanical recovery is a method for responding to on oil spill on water. When collecting oil from icy sea, the basic principle is in mechanical oil recovery to get the spilled oil in reach of recovery equipment. The skimmers of the big capacity has also been developed to operate in oil spill response in icy conditions. (Arctic Response Technology JIP, 2015) For example, Finnish company Lamor has developed solutions such as skimmers (Figure 1.) for oil clean-up operations and oil spill equipment have been delivered for all over the world. (Lamor Oy, 2017)

In the mechanical process, oil is removed from the surface of the water with skimmer or with the help of the direct suction and the collected fluid will be stored. Usually skimmer supports the operation with containment booms, which directs oil towards the skimming system. The

comprehensive mechanical collecting operation contains the extermination or recycling of collected material. (Arctic Response Technology JIP, 2015)

When oil is trapped under drifting ice floes, mechanical recovery is a significantly demanding case. At the moment, there are no proven technologies or techniques for managing with scenario where there would be medium or large spill involved. In addition, there is still lack of technological inventions to position and track the oil from icy waters (new sensors are under development but not yet functional). (Council, Arctic, 2015) The developed arctic skimmers (Figure 2) are able to process larger numbers of a cold oil and ice mixture. The heating of critical systems is important to prevent freezing. In addition, oil pumping equipment and techniques have been developed to be suitable for cold conditions. (Tammiala, 2017)



**Figure 1** Brush bucket skimmer (Lamor)



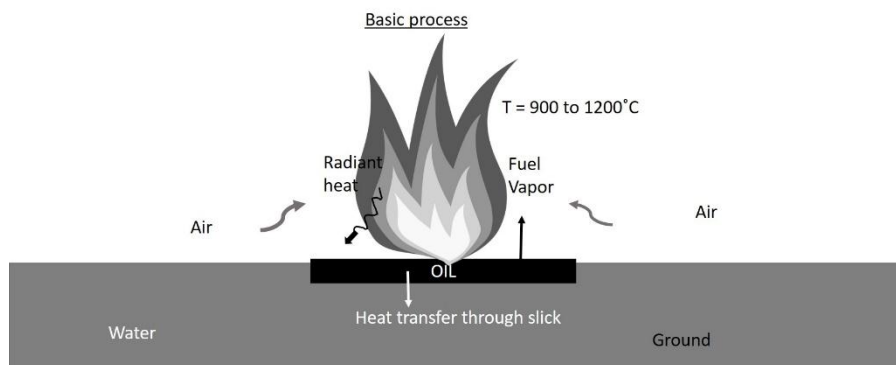
**Figure 2** An oil skimmer

There is some additional challenges in mechanical recovery in ice-covered waters versus to open waters. When the ice coverage go beyond 10 -20%, it is difficult to operate with booms while the ice itself can act as a boom to border the oil. In icy waters, skimmer needs to be capable of deflecting the ice to reach the approach to the oil. (Sørstrøm, et al., 2010)

The experience of the decades of the mechanical oil destruction in the cold circumstances has developed the understanding of the collecting process and has led to the developing of special equipment and tactics. Ice-strengthened vessels are used in the arctic areas where there can be ice. (Tammiala, 2017) The vessels that have been equipped with the Azimuth (ASD) propeller equipment are especially valuable due to their maneuverability, the ability to support of the collecting and the ability to dispersant spreading. (Sørstrøm, et al., 2010)

### **In situ burning**

Controlled in situ burning (ISB) (Figure 3) is a safe, environmentally acceptable and proven technique in open water, snow and ice-covered conditions already used since 1958. (Arctic reponse technology JIP, 2015) There is many applications in extensive-range field research and experience from accidental spills from several decades. (Arctic Response Technology JIP, 2015)



**Figure 3** In-situ burning of oil process

There must be three components existing in order to ISB to be effective: fuel, oxygen and a source of ignition. (Arctic reponse technology JIP, 2015) Furthermore, subsequent circumstances should be observed: slick thickness, wind speed, wave height, emulsions, igniters and fire-resistant containment booms. (Tammiala, 2017) The ISB method is suitable especially in the Arctic areas because ice forms the block for oil to sustain the required oil thicknesses for firing, without the necessity for restrict the spill with booms. The primary restriction governing the success of ignition and burning is appearance of a minimum oil foil thickness for the certain kind of oil. In addition, there can be other influences that affect the total efficiency, like the grade of emulsification, swell, forceful winds and slush or crushed ice blended with the oil. The use of the aerial adoption of verified herding agents and igniters is a new swift response measure for spills in open drift ice where the ice concentrations are not enough to sustain a burnable foil thickness. (Council, Arctic, 2015)

A wide range of research indicate burning to be environmentally safe as regards to smoke particulates and fumes, carcinogens (PAHs) and remainder harmful substances in the water. However, in situ burning is not approved as allowed or anticipated response tool by every Arctic countries. (Council, Arctic, 2015) Burning of crude oil is valued to generate 12% water and 75% carbon dioxide. The leftover fume substances are from oil, which is passed to black carbon and carbon monoxide. From imperfect combustion, there will remain residue, which can be collected on land. (Arctic reponse technology JIP, 2015)



ISB method needs less human resources and equipment than other recovery techniques. The benefits are that method is more diversify in its application and it can be applied in the district where infrastructure is undeveloped. When using ISB method, oil is taken out from environment, the need for gathering of oil, storing and delivering of recovered oil is significantly diminished. (Arctic reponse technology JIP, 2015)

Effectiveness of ISB method varies based on ice situation. Fire resistant booms can in open sea conditions be tugged by vessels to thicken slicks for combusting. An area where there is 40-60% ice cover, ice in the sea will lessen slick diffusion, but cannot fully constrain it. Using booms and towing vessels can be risky and probability of boom failure is increased because of interference by ice. Thicker ice concentrations can work as a boom to efficiently control a slick. The concern in this kind of situations is still how to reach the slick to fire it. (Arctic reponse technology JIP, 2015)

### **Dispersion of oil**

Dispersants are generated to boost normal dispersion by lessen the tension of the surface at the oil/water confluence so that it's easier for waves to form little oil droplets that are fast thinned in the water column such that usual levels of nutrients are able to maintain microbial degradation. Dispersants work as an efficient spill response tool when used correctly. With this method, oil can be fast removed significant amounts from the sea surface by transferring it into water column where natural processes will broke it down. (Council, Arctic, 2015)

Environmental and economic advantages can be achieved with dispersants when other spill response techniques are less usable options due to weather conditions or the accessible of resources. (Council, Arctic, 2015) The advantage is that dispersants can remotely applied from aircraft and there is no need for personnel on the water surface. The response time will be the shorter. (Arctic reponse technology JIP, 2015)

Nevertheless, like with other response methods, dispersants have also their weaknesses there have to take consideration the chemical properties of the oil dealt with, state of sea and weather conditions and environmental issues. In every situation, each response method should be considered taking into account factors such as salinity, currents, water depth, and profiles of temperature and species in danger. (Council, Arctic, 2015)

Dispersion of oil is widely applied as the most prioritize means of combatting open water spills but in an Arctic environment, the usage of dispersants is still strongly controversial. The potential to unfavorable effect to fisheries in these sensitive sea areas such as Greenland,

Barents Sea and the Bering Sea need careful consideration when deciding to use dispersants. (Council, Arctic, 2015)

## **Conclusions**

When activity in the Arctic regions increases, there is need for development of an infrastructure to improve the safe operation. The changing activity in the Arctic areas require also simultaneous efficient development of measures of support. For example, oil drilling, oil transports and increasing vessel traffic need effective and improved means for oil spill response. The arctic environment is vulnerable and increasing activity in the areas have to meet the requirements for responsible and sustainable development. The primary concern at moment is that there is a lack for the readiness for environmental protection in the sea and at the coasts.

There are many methods and innovations developed for responding oil spill such as using dispersants, in situ burning technique or various ways of collecting and storing the oil. The numerous research and development projects about the topic have been done during decades and means of responding oil spills have been generated. Researchers have found many promising practical solutions for cleaning the oil from sea even in icy conditions. It is in vital to consider the most efficient method in every incident.

The ice-strengthened vessels or icebreakers are needed for mechanical oil response in icy areas and there is a requirement for ship crew have acknowledgement of ice management, operations in cold conditions and how to protect sensitive sea areas.

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# RESEARCH AND BUILD A MULTI-CHANNEL VIBRATION MEASUREMENT SYSTEM FOR DYNAMIC STUDYING OF THE MARINE PROPULSION PLANTS

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**Abstract** The article presents the results of the researching and building a modern multi-channel vibration measurement system (MVMS), based on the standard industry hardware (sensors and computer), with the Data Acquisition (DAQ) and the software LabView of National Instruments (USA). The MVMS consists of two measurement sub-systems. The first sub-system includes a set of sensors, DAQ NI-9234 and chassis cDAQ 9184 (Ethernet), used to form a system which has total 16 measurement channels. In this sub-system, the sensors are mounted on the non-rotate parts of the measurement machine. The second sub-system consists of the strain gauges to measure the shearing and axial stresses of the loaded rotate shaft, DAQ NI-9237 (DSUB, 4 channels) and the chassis cDAQ 9191. This sub-system rotates together with the shaft. The NI-9237 has 04 channels with the Wheatstone bridge (full, half or quarter modes) of the strain gauges. The highest sample rate of the DAQ 9237 is  $F_s = 50$  kilo-samples/s/channel, but for the DAQ 9234 this  $F_s = 51.2$  kilo-samples/s/channel. The outputs from the two DAQs are transferred to Wi-Fi Router and from this Router to computer through an Ethernet link. We use the MVMS to carry out some experiment researches of the different vibrations types on the diesel –generator set and on the main diesel propulsion plant of the training ship “SEA STAR” which belongs to Vietnam Maritime University (VMU). The MVMS software has many useful features, such as: automatic setting devices; processing of the measured signals in the real time domain, FFT, Cepstrum, 1/3 Octave, Order analysis; save data to files; read data from files and report the research results. The obtained results will be used to design the vibro-monitoring and diagnostic equipment. It also can be used to estimate the machine power with the training and education purposes of the high quality human resources (the post-graduated and PhD students, etc.) at the VMU, and other industry purposes.

**Keywords:** Vibration Measurement System, Accelerations, Torsional and Axial Vibrations.

## **1. Introduction**

In the dynamic and vibration investigation on the marine diesel engines and plants there is a need to use a modern multi-channel vibration measurement systems (MVMS). The MVMS must be able to measure the different types of the linear and angle vibrations, such as linear vibrations (accelerations / velocity rate / deviations on the fundamentals, cylinder head, and turbocharger cover), the torsional and axial vibrations on the shaft –line of the diesel propulsion plants [3]. In the theoretical research works, Prof. DrSc. Minchev N.D has already proposed some dynamic –mathematical models for related torsional–whirling vibrations, torsional –axial, torsional – whirling –axial vibrations [2]. Today, marine diesel makers (for example, MAN B-W) introduce the axial vibrations of the two cycle engines for new building seagoing ship. In the technical exploitation of the diesel power plants we have strategies to manage technical conditions of the diesel engines (main and auxiliary), propeller and the hull for increasing economy efficiency and decreasing the environment pollutions. The condition management of the main diesel engine and the propeller is related directly with the power monitoring of the main diesel engine and propeller and un-directly related with the torsional moment on the shaft-line and rotation revolution. The second condition management of the propeller with a role such as power source and the hull - power consumption is related to the thrust force of the propeller and ship velocity. Therefore, building an equipment to measure torques and thrust forces has a mean for optimum exploitation of the marine diesel propulsion plants.

In the researching process, related with the education and training high quality human resources (PhD or master courses) we propose to build in Vietnam Maritime University a modern multi-channel vibration measurement system. The MVMS must have 10 - 20 channels for measuring vibration signals on the marine diesel engine and the marine propulsion plants. Today, using technology products of National Instruments (NI, USA), such as the compact and modern Data Acquisition (DAQ) and software LabView with other useful toolkits of NI –company, we've successfully built a new modern MVMS with following ability:(a) 8 channels for accelerations; (b) two channel –torsional vibrations according to electro-magnetic method; (c) 1 channel –torsional vibrations on the shaft-line; (d) 1 channel –axial vibrations on the shaft-line; (e) 1 channel –revolution of the shaft-line, and for remarking the phase and working cycle of the diesel engine. The software for MVMS has many useful features to analyze vibrations according to different desired tasks, such as characteristics in time and frequency domains

(RMS, peak –peak, FFT, 1/3 –octave, Order analysis). In this paper we will discuss about the MVMS and results of experimental vibration study on different marine diesel power plants with the MVMS.

## **2. Building MVMS.**

**2.1. Hardware configuration.** We group the sensors into two sets: the first one consists of the different analog sensors, which are mounted on the non-rotation parts of the object and the second set – two vibrations types of the rotation shaft-line (torsional and axial vibrations, measured by strain gauges with the Wi-Fi transferred method for measured signals on the shaft). The first group sensors: 1 phase sensor (optical); 02 electro –magnetic sensors with the operation principle of induction impedance change and 08 vibration accelerators are connected with the DAQ NI -9234 (03 slots, each slot has 4 channels). These 3 slots are placed into the DAQ –chassis, cDAQ NI -9184 (has 4 slots with the 16 channels for analog signals). The output signals from cDAQ NI -9184 are transferred to computer by Ethernet cable. The maximum sample rate in the first sub-system is 51.2 kHz/ channel (51200 sample/ second/ channel).

The second measurement sub-system consists of two strain gauges, placed on the shaft and the cDAQ NI -9191 chassis with DAQ NI-9237 (DSUB) (4 channels, we only use 2 channels in this study). The output from cDAQ NI -9191 transferred to PC (Laptop) through Wi-Fi media. The maximum sample rate in the first sub-system is 50.0 kHz/ channel.

We modify the signal transmission with the new way. The output data from DAQs of the two sub-systems are transferred into Wi-Fi Router, after that the measured signals of the two sub-systems are transferred to PC by Ethernet cable [1]. By this way, the data transmission from measured sensors to PC is better and we don't have any problem in the carried out different experimental studies about the vibrations on the marine diesel plants. In the fig. 1 we show a modified principle scheme of the MVMS, using the Wi-Fi Router.

**2.2. Software.** Using the NI products (licensed): LabView version 15; Sound and Vibration Toolkits (SVT) and Report Generation, we create the software for the MVMS with the following abilities: Configuration the devices (sensors, DAQ with DAQ –chassis) –Setting up; Module for measurement and monitoring signals; Save measured vibration signals to files; Load (read) the measured signals from files; Process measured data to get final results; Save and Report results.

The software codes are written in the Block Diagrams (BD) and the Front Panel (FP) is created in LabView. Controls and Indicators are placed in the FP, and in the BD we write the algorithms for every task mentioned before.

### 2.2.1. Setting up interface devices and DAQ – assist.

Firstly, we need to connect correctly physical devices to MVMS. In the first step, MAX (Measurement and Automation Explorer of LabView) can be used for configuration. The devices are automatically identified by the MAX. Then, we create new tasks for channels. In the MAX configuration \Create New task, choose: Acquire Signals\ Analog Input\”Voltage” or “Accelerations” or “Strain” (according to types of the used sensors) and press the “finish” button. After that, we configure for every channel in “Device” - Fig.2 (for example the voltage signals), select the input signal types (DC for channel\_1 and AC for channel-2 and 3), sample settings (sample rate, samples to read, Acquisition mode).

In the second step, after identifying devices, we set up DAQ using DAQ assist (in the “Express” or in “Measurement I/O”) in the written code on DB. In the “Create New...” function, we set up for every channels of the two chasses (cDAQ9184 (NI9234) and cDAQ9192 (NI9237)). For channel setting, we select signal type “Analog” –input signal \ Signal Input Range (for example [0, 5] V or [-5, +5] V (fig.3).

### 2.2.2. Build VI for measurement, data processing and monitoring

We have to control measurement process by monitoring necessary number of measured signal graphs. In addition, we calculate the rotation revolution of the shaft by using the phase sensor and remark the beginning point to save the sample period (length). In the FP, there are 6 graphs of the following signals (from left to right and top to bottom). In the first graph, we place the phase signal (after its filtering) to define shaft rotation revolution, the marked number of the pulses via number sample order, corresponding to the measured phase signal in the cDAQ NI-9184. In the top of the fig.4, we show the position vector (calculated vector  $P_1 = [553, 1580]$ ) of the increase –left edges of the I<sup>rst</sup>, II<sup>nd</sup> pulses, and other vector - the position vector ( $P_2 = [573, 1603]$ ) of the decrease –right edges of the impulses, relatively. The average calculated revolutions of the shaft-line in the ½ work cycle of the 4-stroke diesel engine are estimated by following equations:  $N_1 = f_1(\Delta P_1, F_s)$  or  $N_2 = f_1(\Delta P_2, F_s)$ , where:  $\Delta P_1 = P_1(2) - P_1(1)$ ;  $\Delta P_2 = P_2(2) - P_2(1)$ ;  $F_s$  –sample rate. For example in measurement  $F_s = 25600$  sample/s/channel = 25600 Hz/channel. In these cases, there are calculated revolutions (rpm):  $N_1 = 1494.63$ ;  $N_2 = 1491.26$  and  $N_{mean} = (N_1 + N_2) / 2 = 1493.4$  With the calculated revolution, we can decide the number of samples to save in the file for processing later. In the example, we select  $N = 1500$  rpm and the end, the 4096 sample will be saved to files for further study experiment.

On the second graph (in the fig.4), the data received from Electro-Magnetic Sensors (EMS) are shown. The operation principle of EMS is drawn in the fig.5. On the third graphs, we group the 4 waveforms of the 4 acceleration signals, measured on the 4 cylinder heads. And the next graph

(under the third), we present the 4 waveforms of the 4 acceleration signals, measured on the 4 frame positions of the diesel –generator set (support of the generator, shaft for measurement – addition making, diesel position under flywheel and the 1<sup>st</sup> cylinder). On the last graph (on the right side) we show the two waveforms of the torsional vibrations (in the fourth graph) and the axial vibrations (in the sixth graph), measured by the strain gauges. The values on the y-axis are in strain unit ( $\epsilon$  strain –relative, without dimension).

### *2.2.3. Build VI for saving measured data to file*

Saving is one of the important tasks in any software building for measurement and data processing. The saving data need to have the same length of the sample arrays, corresponding to the work cycle of the cylinder (for the 4 stroke diesel we have to organize the data via 2 revolutions). To increase the accuracy while reading the cycle revolution, due to the un-stability diesel working condition and the expensive experiments, we save the measured data for 2 cycles, which means 4 working cycles of 4-stroke diesel.

For organizing repeatable measurements in the same regime, we program the SAVE.VI with the ability to auto-write the file name, such as Hour –Minute –Second –Moon –Date –Year \_00x. Therefore, only one press (quickly) on the SAVE button (in the fig.4), the measurement software save data files with the same time period of the diesel working. We save the measured data of the two different sub-systems into two separate files with different length of the data arrays, corresponding to the sample rates of the DAQs features (for example, for the channels with the DAQ NI9234,  $F_{s,max} = 51.2$  kHz/channel, we set  $F_s = 25.6$  kHz; but with the DAQ NI9327 for strain measurement,  $F_{s,max} = 50.0$  kHz/channel, we have  $F_s = 50$  kHz). When we release the SAVE button, on the caption of this button is changed to “NO-SAVE”, click on this button again, "SAVE" is displayed.

### *2.2.4. Build VIs for reading data from data files and data processing*

We build module in the BD to read the measured data from files, using the “Read Measurement File” from Express panel. There are two files need to be read for data processing of the torsional or axial experiments, because we have to use information of the phase signal, which is written in different file with the strain data for these vibrations, but for analyzing the accelerations or EMS signals we need to read only one file. This file is contained the combination of the different channel signals (with the same sample rate), which are able to measure by the cDAQ NI-9234. Firstly, we analyze the phase signal to track only one working cycle of the measures data by the technique mentioned above. The output of this process shows us the exact positions of the samples, corresponding to the exact one working cycle of the 4-stroke diesel engine. Using these results we can track the other measured signals, which we want to process in future.



For analyzing every type vibrations we need to use relatively algorithms, for example, for the EMS, the accelerations and the strain signals to receive torsional or axial vibrations. For building code in the BD, we re-use already made existing VIs of the Sound and Vibration Toolkits (SVT, licensed), it meets us convenience (fast and exact) for building the MVMS software.

-The accelerations signal are analyzed in the real time and frequency domain to receive the following parameters: RMS (root mean square), peak –peak, mean; FFT (amplitude, phase via frequency); 1/3 –Octave.

-The torsional and axial vibrations are processed to output the following parameters in the time and frequency domain: RMS, peak –peak, mean; FFT (amplitude, phase via frequency); Orders.

-The electro –magnetic signals (EMS) are used to investigate torsional behaviors (angle deformation and angle velocity differences between the two gears, see fig.5, placed on the measurement shaft between diesel and generator). The algorithms for torsional vibrations detection work in the two ways:

+ The immediate revolutions  $n_1(t)$  and  $n_2(t)$  of the two gears are calculated by two EMS, using the procedure mentioned above to calculate the average revolution per  $\frac{1}{2}$  working cycle of the 4-stroke engine (one pulse, relatively one tooth). We receive:  $n_{12}(t) = n_1(t) - n_2(t)$ , and the next step we calculate angle deformation:  $\varphi_{12}(t) = \varphi_1(t) - \varphi_2(t) = \int n_{12}(t)dt$ , then by using the approximation formulas, the trapezoid area is calculated.

+ The immediate angle deformation (vibrations) is calculated directly by using phase difference of the two EMS. In this case, we transform the EMS to square signals and use the logical procedure to detect these phase differences. The XOR logical command has a characteristic, that is:  $XOR(x_1, x_2) = XOR(x_2, x_1)$ . Therefore using the XOR command, we cannot identify the sign of the phase difference. For overcoming difficulties to calculate the angle deformations between two gears (relatively the EMS<sub>1</sub> and EMS<sub>2</sub>) we make a modified logical algorithm, which is written in the following code m.file (in MatLab):

```

counter =0;
for k=1:N
    if and(x1(k) >0,x2(k)<0)
        counter =counter +1;
    elseif (and(x1(k) <0,x2(k)>0)
        counter =counter -1;
    else
        counter =0;
    end
end
end

```

In the next step, we use the m.file and Mathscript node of LabView to build the virtual instrument to calculate the angle vibrations. In the fig.6 are shown the results of the EMS processing. In this case, the angle deformations are calculated by using the XOR logical command and modified procedure mentioned above.

### **3. Vibration experiment study on the diesel propulsion plants**

Using the MVMS we carry out the vibration experiment research on the D –G set 110 kW in the lab of the Institute of Research Development (VMU) and on the main diesel propulsion plant of the training M/V ‘Sao Bien’ (Sea-Start, VMU). In the experiments we measure 11 signals using the cDAQ NI 9184 with 3 slots DAQ NI-9234 such as mentioned before. For measuring the torsional and axial vibrations on the immediate shaft, we use two strain gauges and the cDAQ NI-9191 with DAQ NI -9237 (DSUB). In the section, we will show some received results of the experiment study and data processing, using the MVMS.

Experiments are carried out in the diesel revolutions: 1000, 1200, 1350 and 1500 rpm. In every speed regime, we carry out the measurement process when all of cylinders are work normally and others experiments, when the sixth cylinder is misfired. The measured data is written in files when carrying out the measurements. After that, we read the measured data and place this data in proper form. In the fig.7, fig 8 and fig 9 we show some results of the experiment studies.

### **4. Results and discussion**

On the front panels of the data processing module, the received results are shown in fig.(7, 8, 9) and indicate that these output satisfy the requirements states in torsional vibrations standards documents (calculated in the FFT, 25 Orders for 4-stroke diesel and in time domain with the RMS, peak -peak). This data also present the linear vibrations on the D-G set (in the 1/3 – Octave, unit mm/s and dB) [3]. The results are shown in the table forms, which makes convenience for more easily signals processing.

The results of the vibration data processing in the FFT are calculated with high accuracy label by resampling according to exactly defined diesel revolution in experiment moments and filtering the received measured vibration signals. The results of the torsional signal analysis show that the main harmonics (orders 3, 6, 9) of the 4-stroke diesel are considerable, but other second ones are very small. The results of the axial vibration signal processing show that the second harmonic is bigger than others. The behavior needs to be studied more in the future.

## 5. Conclusion

The MVMS is satisfied for dynamic researching of the different types vibrations on the diesel propulsion plant and could be developed to apply for vibro-diagnosing and vibro-diagnostics purposes.

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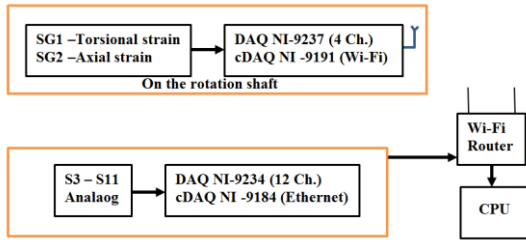


Fig.1 Principle scheme of the MVMS, using the Wi-Fi Router

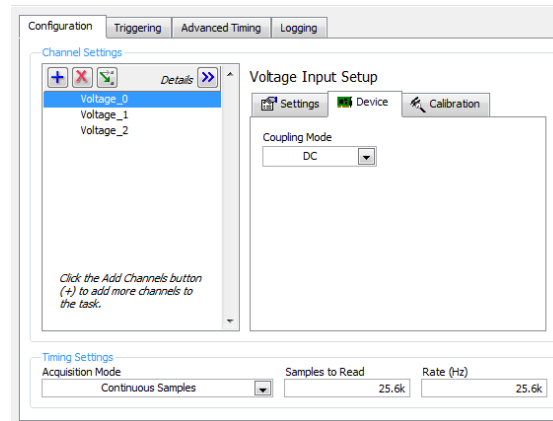


Fig.2 Channel setting in MAX for MVMS

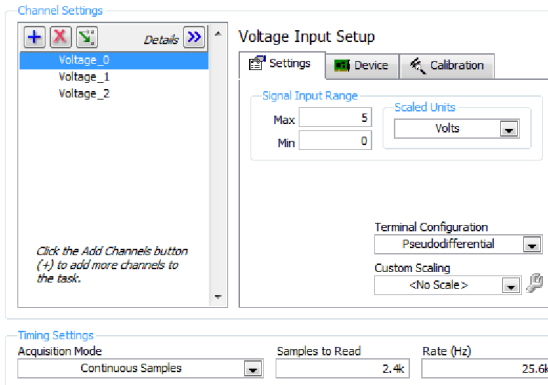


Fig.3 Channel setting in the DAQ assistant

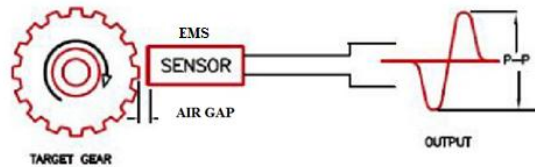


Fig.5 Operation principle of the Electro-Magnetic Sensors, using in the MVMS



Fig.4 Express data processing and monitoring measurement vibrations on D-G set 110 kW using MVMS, experiment regime N=1500 rpm, I=100A (Load)

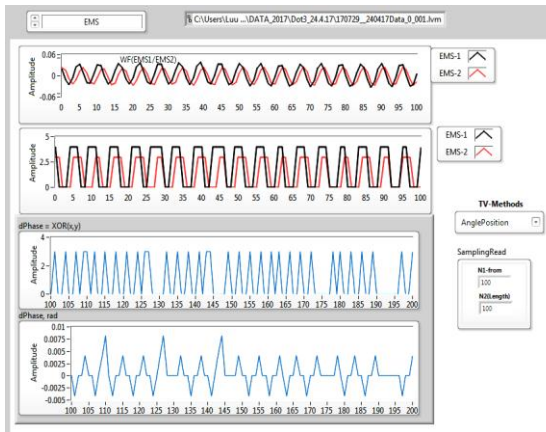


Fig.6 Data processing of the EMS<sub>1</sub> and EMS<sub>2</sub> for torsional deformation of the immediate shaft of the D-G set 110 kW using MVMS

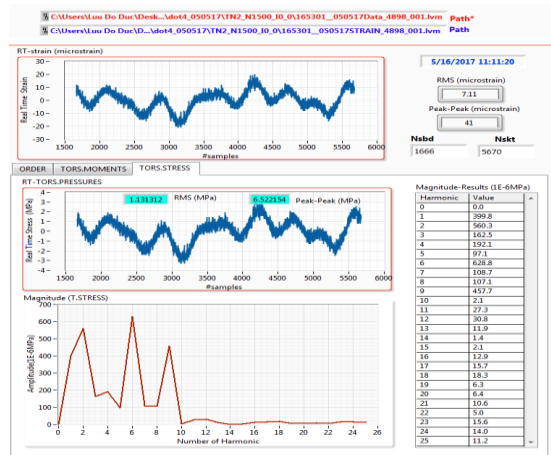


Fig.7 Results of data processing of the torsional stress on the immediate shaft of the D-G set 110 kW using MVMS

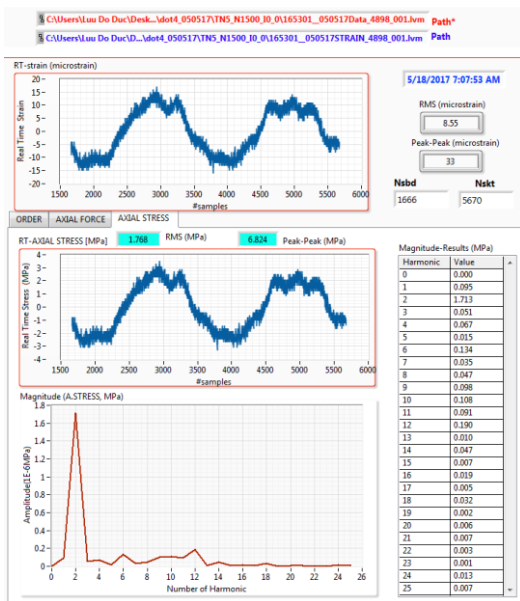


Fig.8 Results of data processing of the axial stress on the immediate shaft of the D-G set 110 kW using MVMS

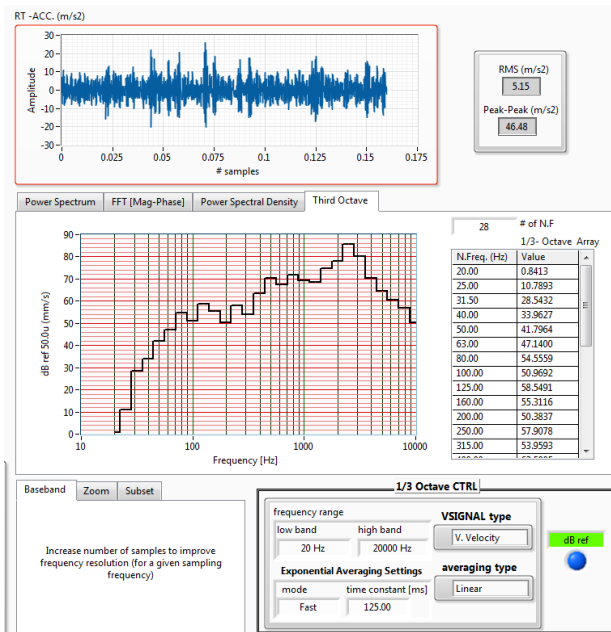


Fig.9 Results of data processing of accelerations on the D-G set 110 kW using MVMS

# INVESTIGATION OF ELECTRIC AND MAGNETIC FIELDS GENERATED BY A SYSTEM FOR FORMATION OF HIGH VOLTAGE DISCHARGE PROCESS IN LIQUID BASED ON CAPACITIVE ENERGY STORAGE

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**Abstract:** Various technological applications require formation of a high voltage discharge pulse in liquid medium. The process is accompanied with generation of UV radiation, production of chemically active species in the medium, intensive increase of the temperature of the discharge channel, generation of shock waves, etc. The last are caused by the release of large amount of energy especially at the beginning of the discharge process.

The experimental system used for generation of a high voltage pulse discharge is based on capacitive energy accumulation. The formation of the pulse in the liquid considering the specifics of the process in such medium also affects on the processes in the electrical circuits in the device – loading of the elements, creating electromagnetic disturbances in the power supply system, generation of electromagnetic field around the device.

The paper is dedicated to investigation of a system with capacitive energy storage for generation of a high voltage periodically attenuating pulse discharge. The purpose is to be measured the electric and magnetic fields generated during the charging and discharging processes near the system for assessment of the device electrical safety for the personnel.

**Keywords:** High voltage discharge, Pulse discharge in liquid, Electromagnetic field, Safety requirements

## 1. Introduction

Pulse high voltage discharges in water are object of study of many scientific researches. They give the possibility for appearance of highly ionized plasma in a limited volume (the plasma channel), assume secondary effects such as arising of a hydraulic wave, UV radiation,

generation of chemically active components, which spread in large volumes of the water medium, etc. (Anpilov, 2001, Kang, 2003).

For generation of such discharges in liquids systems based on capacitive energy accumulation are mainly used. The structure of these devices includes charging and discharging circuits. The processes in them are mutually connected and influence each other as they have a common element from the electrical scheme – the work capacitor battery. It is usually charged to units or tens of kV, which provides high energy for the discharge pulses in the liquid. The charging and discharging process create electromagnetic fields (EMF) around the devices and more specifically near the commutation and switching elements. They can be harmful for the working staff if they exceed certain norm values.

The evaluation of the generated EMF is performed by comparison of the measured values of the electric field strength  $E$  [V/m] and magnetic flux density  $B$  [ $\mu$ T] with the action levels (ALs) for the respective frequency range, which are set in terms of external field quantities, defined in the (Directive 2013/35/EU, 2013).

The EMF Directive defines two ALs for low frequency electric fields - low and high. Compliance with the low AL will ensure that neither of the applicable exposure limit values (ELV) will be exceeded and will also prevent spark discharges in the work environment. If the electric field strengths exceed the low AL, it is necessary to implement additional technical, organisational and, if appropriate, personal protective measures to limit spark discharges (Non-binding guide to good practice for implementing Directive 2013/35/EU, 2013).

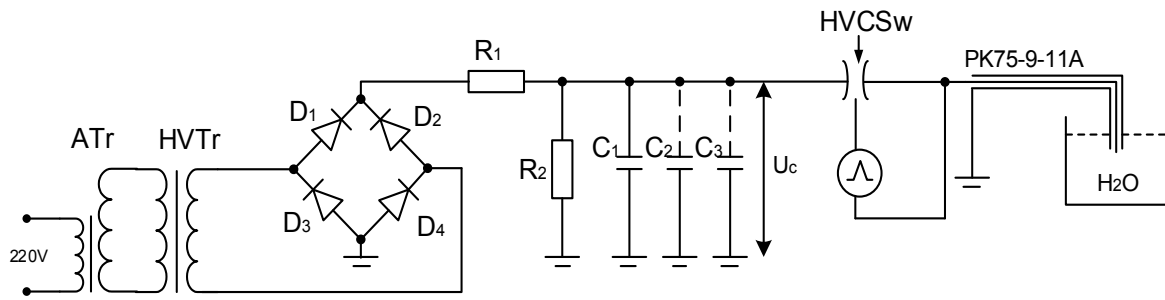
The paper is dedicated to investigation of a prototype system with capacitive energy storage for generation of a high voltage periodically attenuating pulse discharge with respect to the generated electromagnetic fields during the charging and discharging processes in them.

## **2. Experimental setup**

The experimental system used for generation of a high voltage pulse discharge based on capacitive energy accumulation is shown in Fig.1 (Ivanova, 2013).

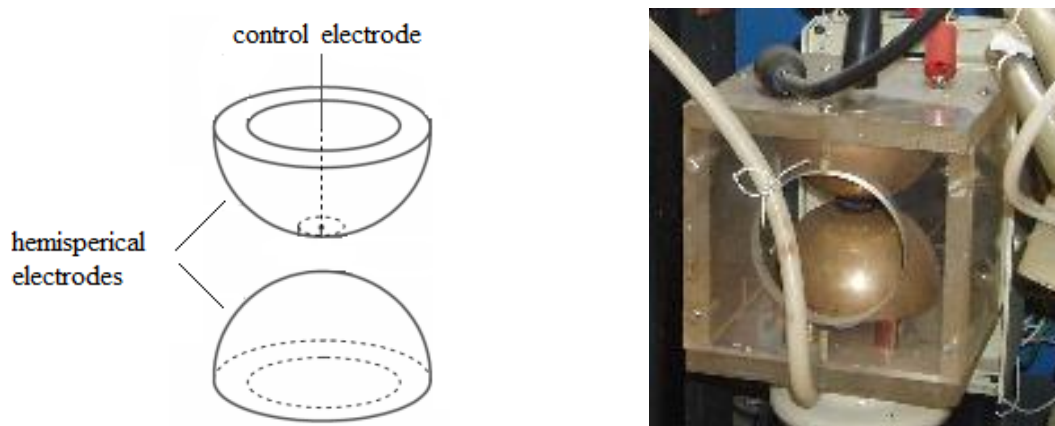
The system is supplied by AC voltage with  $U=220\text{V}/50\text{Hz}$ .

The charging circuit consists of an autotransformer  $A_{Tr}$ , a high voltage transformer  $HV_{Tr}$ , rectifier ( $D_1 \div D_4$ ), through which is charged the work capacitor battery with capacitance  $C$  ( $C_1, C_2, C_3=1\mu\text{F}$ ) to voltage  $U_c$ . The discharge circuit comprises a high voltage controllable switch ( $HVCSw$ ), a coaxial cable and the discharge gap in the water.



**Fig. 1.** Experimental prototype

For the case, as a HVCSw is used a controllable air discharge – trigatron (Fig.2) with two separated discharge circuits and two spatially divided gas-discharge channels, evolving consistently in time (Ivanova, 2012). The first channel ensures the appearance of a discharge between the control electrode and the electrode adjacent to it on the base of a single packet of high voltage high-frequency pulses. The other channel forms a high voltage pulse discharge on the base of the energy accumulated in the capacitor battery between the two main electrodes.



**Fig. 2.** Trigatron

The electromagnetic fields near the commutation and switching elements (autotransformer, high voltage transformer and trigatron) are measured at the following system parameters:

- Capacitance of the work capacitor battery  $C=2;3\mu\text{F}$ ;
- Voltage, to which the work capacitor battery is charged –  $U_c=1\div 6\text{kV}$  (charging process) and  $U_c=7\div 11\text{kV}$  (discharge process).

Experimental data by using a Multi Field EMF Meter EMF 450 (Fig.3) is recorded.

In the operating frequency range of the system  $f=1\text{Hz}\div 100\text{kHz}$  (including both the processes in the charging and discharging circuits) the effects over the human body are non-thermal, expressed in sensory, nerve and muscle stimulations (Non-binding guide to good practice for implementing Directive 2013/35/EU, 2013).



Assessment of the compliance with the limits, presented within the Directive 2013/35/EU is done by the maximum field value, measured near the system elements, where the field is at its maximum. The device is tested in a laboratory so there could be open live parts during the measurements. The personnel can be standing very close to the device elements and could be exposed to the maximum field values. If the measured parameters of the electric (E) and magnetic fields (B) comply with the specified norms (Tables 1 and 2) it won't be necessary to perform spatial averaging of the generated fields.

**Table 1.** ALs for exposure to electric fields from 1Hz to 10MHz.

Frequency range	Electric field strength Low ALs (E, Vm <sup>-1</sup> ) (RMS)	Electric field strength High ALs (E, Vm <sup>-1</sup> ) (RMS)
$1 \leq f < 25$ Hz	$2 \times 10^4$	$2 \times 10^4$
$25 \leq f < 50$ Hz	$5 \times 10^5/f$	$2 \times 10^4$
$50 \leq f < 1,64$ kHz	$5 \times 10^5/f$	$1 \times 10^6/f$
$1,64 \text{ kHz} \leq f < 3$ kHz	$5 \times 10^5/f$	$6,1 \times 10^2$
$3 \text{ kHz} \leq f < 10$ MHz	$1,7 \times 10^2$	$6,1 \times 10^2$

**Table 2.** ALs for exposure to magnetic fields from 1Hz to 10MHz.

Frequency range	Magnetic flux density Low ALs (B, $\mu$ T) (RMS)	Magnetic flux density High ALs (B, $\mu$ T) (RMS)	Magnetic flux density ALs for exposure to limbs to a localized magnetic field [ $\mu$ T] (RMS)
$1 \leq f < 8$ Hz	$2 \times 10^5/f^2$	$3 \times 10^5/f$	$9 \times 10^5/f$
$8 \leq f < 25$ Hz	$2,5 \times 10^4/f$	$3 \times 10^5/f$	$9 \times 10^5/f$
$25 \leq f < 300$ Hz	$1 \times 10^3$	$3 \times 10^5/f$	$9 \times 10^5/f$
$300 \text{ Hz} \leq f < 3$ kHz	$3 \times 10^5/f$	$3 \times 10^5/f$	$9 \times 10^5/f$
$3 \text{ kHz} \leq f < 10$ MHz	$1 \times 10^2$	$1 \times 10^2$	$3 \times 10^2$

The low ALs and the high ALs are the root-mean-square (RMS) values which are equal to the peak values divided by  $\sqrt{2}$  for sinusoidal fields.

### 3. Experimental results

The voltage of the two transformers from Fig.1 – ATr and HVTr is with frequency  $f=50$ Hz.

The low and high ALs of the electric field strength for  $f=50$ Hz are respectively  $1,41 \cdot 10^4$ V/m and  $2,82 \cdot 10^4$ V/m (peak values), according to Table 1.

The low and high ALs of the magnetic flux density for  $f=50\text{Hz}$  are respectively  $1,41 \cdot 10^3 \mu\text{T}$  and  $8,46 \cdot 10^4 \mu\text{T}$  (peak values), according to Table 2.

The results from the measurements of the electric and magnetic fields near the two transformers in the system during the charging process of the capacitor battery at different  $C$  and  $U_c$  are presented in Tables 3 and 4.



**Fig. 3.** Multi Field EMF Meter 450

**Table 3.** Electric and Magnetic field values near the transformers in the charging process for  $C=3\mu\text{F}$ .

$C=3\mu\text{F}$ $U_c$ , kV	Autotransformer		High voltage transformer	
	Magnetic field B, $\mu\text{T}$	Electrical field E, V/m	Magnetic field B, $\mu\text{T}$	Electrical field E, V/m
1	22,9	856	0,36	13
2	25,6	891	0,53	56
3	26	983	1,6	132
4	28,1	1040	10,1	163
5	31,1	1060	13,6	182
6	34,8	1120	18,7	202

**Table 4.** Electric and Magnetic fields values near the transformers in the charging process for  $C=2\mu\text{F}$ .

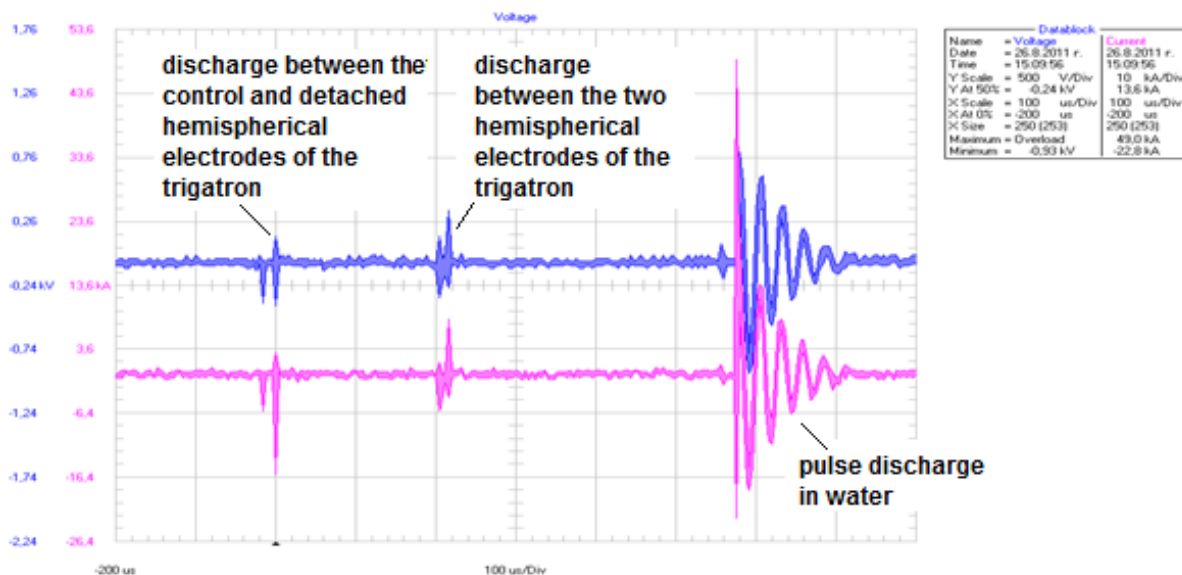
$C=2\mu\text{F}$ $U_c$ , kV	Autotransformer		High voltage transformer	
	Magnetic field B, $\mu\text{T}$	Electrical field E, V/m	Magnetic field B, $\mu\text{T}$	Electrical field E, V/m
1	30,2	985	4,47	49
2	32,6	992	6,47	80
3	35,2	1000	8,57	125
4	37,8	1012	10,26	163
5	39,4	1050	11,8	202
6	41,3	1160	12,8	240

All the measured values are lower than the low ALs for the electric and magnetic fields. The results show that a stronger field is generated by the autotransformer ATr.

Hence, the generated electromagnetic fields are not considered as harmful to the human health.

The discharging process at which a high voltage discharge pulse arises in the liquid medium, has some specifics:

- The accumulated energy in the capacitor battery is transferred in the water as high voltage periodically attenuating discharge pulses (Fig.4) arise in the discharge gaps of the trigatron and in the liquid.
- The discharge processes in the HVSw and in the water have different time duration.
- The maximum amplitude of the discharge current in the water is several kAmp, which leads to generation of a magnetic pulse.
- The generated discharge pulses in the water are with frequency  $f=50\div 70\text{kHz}$  and the pulses repetition rate is  $5\div 10\text{Hz}$ .



**Fig. 4.** Discharge process at  $C=2\ \mu\text{F}$  and  $U_c=11\text{kV}$  (upper curve – discharge voltage, lower curve – discharge current).

The results for the generated electric and magnetic fields by ATr and HVTr for  $C=3\ \mu\text{F}$  during the discharge process are presented in Table 5.

The received values for the magnetic flux density  $B$  for both of the transformers are much higher (approximately by 70% for the highest values of the voltage  $U_c$ ) than the values measured in the charging process. The generated electric field ( $E$ ) is  $3\div 5$  times weaker than the generated one in the charging process of the capacitor battery.

**Table 5.** Electric and Magnetic fields values near the transformers during the discharging process for  $C=3\mu\text{F}$ .

$C=3\mu\text{F}$	Autotransformer		High voltage transformer	
	Magnetic field B, $\mu\text{T}$	Electrical field E, V/m	Magnetic field B, $\mu\text{T}$	Electrical field E, V/m
7	27,5	169	20,1	14,7
8	34,6	189	23,6	15
9	45,2	236	27,5	19,2
10	56,8	287	30,7	25,6
11	64,9	321	32,1	34,8

The increase of the magnetic field can be explained by the generation of a magnetic pulse in the discharge process due to the high amplitude of the discharge current. The measured values are again under the low ALs for the electric and magnetic fields.

Measurement near the metal water container when a discharge pulse occurs are performed. Despite the high frequency of the discharge pulse, no significant data for the generated electric or magnetic field is recorded due to field shielding by the container.

For safety precautions, the measurements of the fields generated near the trigaron are done at a distance of 1m so that the measurement equipment and the person working with it could not be subjected to an electric shock by a spark discharge. The results are  $E = 230 \text{ V/m}$  and  $B = 10 \mu\text{T}$  for  $C=3\mu\text{F}$  and  $U_c=11\text{kV}$  which are again safe values.

#### 4. Conclusion

Investigation of the generated external electric and magnetic fields in the work of a prototype system based on capacitive energy accumulation for generation of high voltage periodically attenuating discharge pulses in water is performed as:

- The values of the electric field strength E and magnetic flux density B are measured during the charging and discharging processes near the device elements (transformers and discharge gaps);
- Evaluation of the compliance of the measured values with respect to the norm values defined by (Directive 2013/35/EU, 2013) is done;
- Safe work conditions are set at the device operation.

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# METAL FATIGUE IN VESSEL STRUCTURES DUE TO DYNAMIC MOVEMENT

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**Abstract:** Metal fatigue that occurs due to dynamic movement in a vessel. Two case studies using reliability engineering are diagnosed with modern technology, using vibration analysis and laser alignment on their propulsion systems. These types of ships have characteristics where both have different hull structure and material type; dynamic movement will occur no matter the features of the vessel. In both studies, it was found that the propulsion systems were not installed correctly and dynamic movement was detected which results in the re-occurring faults that the vessels were experiencing. The understanding of reliability engineering needs to be used when diagnosing metal fatigue.

**Keywords:** Reliability engineering, metal fatigue, Modern Technology, Dynamic Movement, Laser Alignment.

## 1. Introduction

The fatigue of metal occurs when a structure starts to fail from considerably low stress levels, or the metal is subjected to cyclic fluctuating stresses. Normally it occurs over long periods. Approximately 90% of all field failures of metal is due to fatigue [1]. One common source of metal fatigue is due to repeated variations of stress and excessive vibration. This is a significant re-occurrence in all types of drive train structures throughout the marine industry.

The major fault of any rotating machinery in the industrial world is the incorrect installation of the rotating equipment. An error can be captured using Vibration Analysis (VA) also known as condition monitoring. Using a transducer to obtain the complex frequency that a piece of machinery produces, then using the Fast Fourier Transfer(FFT) the faults can be read from a spectrum; these can be executed when following an ISO standard for example, ISO 10816. VA is used to detect many errors, a well-known error that occurs in a spectrum is misalignment from incorrect installation [2]. The basic understanding of alignment is needed, this is described when two or more shafts centre lines must be within a tolerance of each other in both offset and angular parameters at the coupling. These tolerances are checked in both the horizontal and vertical position when taking measurements [3]. Aligning of two shafts could be done by eye or a straight edge, if you want the life span of any machinery to last longer more precise tooling should be used. To gain these tolerances a dial indicator or laser is needed to achieve the tolerance within an acceptable range. Conducting an alignment on a vessels propulsion system can be carried out with a well-known, yet older technology such as one or two dial indicators which would carry out the alignment between couplings to ensure these types of machinery are positioned correctly. Examples of such machinery are; steady bearings, gearboxes and motor/engines.

Traditionally a piano wire is used to locate the centre line of the machinery and the final coupling of the drive train; for example, a stern tube or Z-drive thruster. Piano wire and dial indicators have been out of date since the introduction of laser technology which is today's modern technology. The laser has many other features that help perfect any alignment, such as: Drive train, Straightness, Offset, Off Line 2 Run (OL2R) and Geometric alignments. Another laser that is hardly used in the marine industry in Australia is a 3D laser tracker. The tracker involves a laser mounted on a tripod and a prism. The laser tracks, the reflected lens when placed or dragged over a machined surface. Two case studies are examined in this paper, one being a ductile vessel (Vessel x) and the other being a brittle vessel (Vessel y). Shaft alignment of both vessels has been undertaken using a combination of the above methods. These measurements are taken to determine whether dynamic movement is a primary cause of metal fatigue in ship structures.

## **2. Case Studies**

### *2.1. Case Study 1 (Vessel x)*

Vessel x is a 55m planning monohull, that has two high revving 3500hp diesel engines with a down angle propeller shaft (see Figure 1). Vessel x had three major faults that were occurring, identified by the vessels operator:

- Bearings in the stern tube were failing which would in turn cause the shaft to bind up.
- The vessel experiences excessive vibration over 1450rpm.
- Cracking was observed occurring between the engine beds, frame 33 and at the king post.

2.1.1 First Test

Vibration analysis was executed at three different rpm ranges on the drive train at the following locations.

- Horizontal Drive End = HDE
- Horizontal None Drive End = HNDE
- Axial = A.

The test points were attained at the following positions:

- Engine: HDE and A
- Gearbox Input Shaft: HDE, A and HNDE
- Gearbox Output shaft: HDE, HNDE and A
- Stern Tube HDE and A

The three different rpm ranges tested were at idle at 1000rpm, 1450rpm and full speed at 1900rpm. The readings showed that there was an increase in misalignment, this was a good indication of dynamic movement occurring, as shown in figure 2.

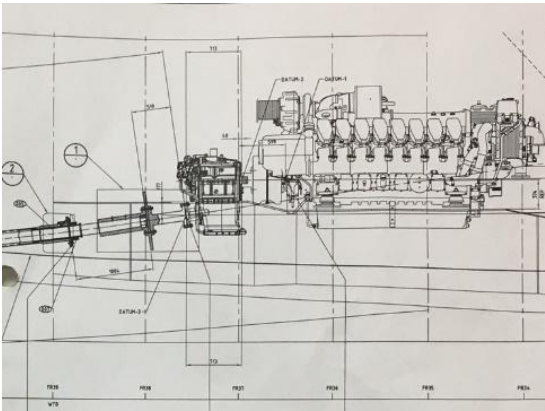


Figure 1 - Drive train configuration

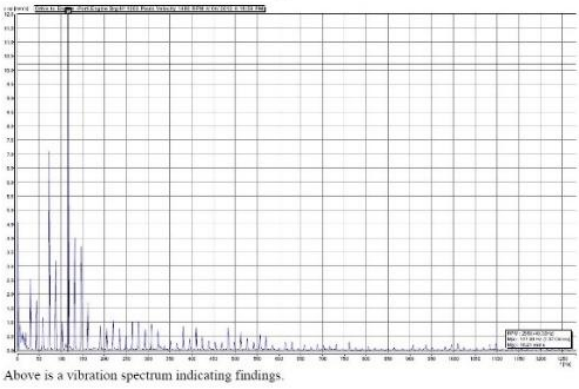


Figure 2 – VA misalignment spectrum



### 2.1.2 Second Test

Following the first test there was recorded data of progressive movement present, therefore the next step was to capture the dynamic movement. The lasers were set up between the engine and gearbox (see figure 3). A misalignment of greater than 20mm, which can be recorded by the detectors was present. Due to the excessive movement, a third test was required. The lasers were set up from the engine bell housing of the engine to the stern tube bulkhead in the engine room. At the highest rpm of the engines (1900RPM), a movement of roughly 35mm was measured as it was outside the detectors, a rule was used.

### 2.1.3 Third Test

Due to time restraints, only the starboard drive train could be tested. Adjustable rollers had to be constructed so that the centre of the stern tube bearing could be found. When the centreline of the bearing was found, the rollers were then locked off to simulate a steady bearing for the propeller shaft (Both the propeller shaft and the gearbox output shaft should rotate together for precision alignment when lasers are being used). The alignment between the shaft and gearbox were greater than the allowable tolerances. The engine to gearbox check was just within tolerance. On the inspection of the soft footings on the engine, the front left mount was loosened, a 14mm gap was present. Due to the high ductility of the vessels hull, a soft footing of this magnitude would put high stress on both the engine bed and hull of the vessel (see figure 4).



Figure 3 – Dynamic movement set up on Vessel x



Figure 4 – Shaft alignment on Vessel x

#### 2.1.4. Discussion

The vibration readings that were recorded were over 12mm/s rms when the vessel exceeded 1450rpm. At the full speed of the vessel (1900RPM), the vibration readings were much higher, as the dynamic movement readings attempted were not achievable a shaft alignment was carried out to reduce the misalignment around 1450rpm +/- 5%. When undertaking the alignment, it must be ensured that the couplings are in tolerance and that all soft footings are removed. As the results of the sea trial following the realignment, the outcome was more than satisfied as the vessel could now achieve higher rpm range without vibrations throughout the vessel. The vessel is now achieving 1600rpm cruise speed this an acceptable change from 1300rpm. The vibration was still present from 1600-1900rpm due to the dynamic movement on the engines.

Recommendations for Vessel *x*:

- Put in place a 3-monthly VA routine to monitor the misalignment that is occurring.
- Rewrite the alignment procedure.
- Implement dynamic movement alignment procedures.

Continuous work has been done on this vessel since this job; Vessel *x* went through a remediation process. The ship was then strengthened by inserting four longitudinal beams through the engine room. Due to these four beams in place the cracks at frame 33 and the king posts have shown no signs of growing. Although forward of the vessel at frame 25 cracking has commenced. This will only keep occurring as the major fault of this ship is due to the incorrect installation and dynamic movement that is taking place in the drive train of the vessel.

#### 2.2. Case Study 2 (Vessel *y*)

Vessel *y* is a 58m displacement hull that has two medium revving diesel engines at 3500hp with a Z-drive thruster (see figure 5).

Vessel *y* had four major faults that were occurring identified by the vessels operator:

- High vibration that was felt throughout the ship at most rpm ranges.
- Bolts were loosening on bearing 1 on both Starboard and Port first intermediate shaft.
- Welds were cracking on the base plates of bearing housing 1 on both Starboard and Port intermediate shaft 1.
- Overheating on bearing 6 both Port and STBD intermediate shafts.

### 2.2.1 First test

Vibration Analysis was taken at three different rpm ranges. The same keys from 2.1.1 apply below. The test points were taken at the following positions:

- Engine: HDE and A
- Clutch box input shaft: A, HDE and HNDE
- Clutch box output shaft: A, HDE and HNDE
- Intermediate shaft 1: HDE, A, HNDE and A
- Intermediate shaft 2: HDE, A, HNDE and A
- Z-drive thruster: A, NDE and HNDE.

The three different readings were at idle 450rpm, 600rpm and full speed of 750rpm. Readings showed that there was an increase in misalignment, this was a good indication of dynamic movement occurring. Offset and angular misalignment was observed at each coupling and Cardan shafts (see figure 6, highlighted in red).

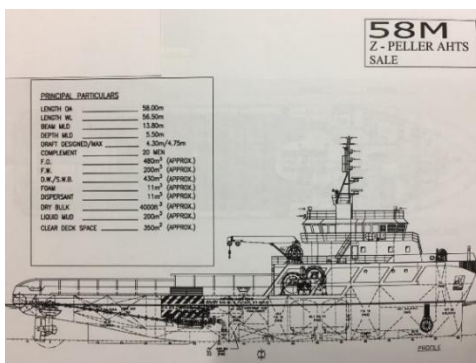


Figure 5 - Vessel y

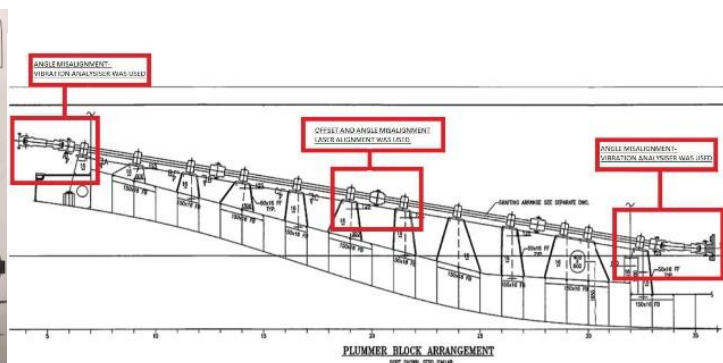


Figure 6 – VA misalignment position

### 2.2.2. Second test

Executed alignment measurements throughout the drive train both Port and Starboard. Figure 7 is the reading from the coupling between the two intermediate shafts. This was the indication that bearing six would be over heating due to the misalignment. It was revealed that bearing 6 was a thrust bearing which was not designed to hold an 8m shaft on a 7 degree down angle. Offset brackets are used for aligning Cardan shafts, although this couldn't be done due to the intermediate shafts being at an angle of 7 degrees, therefore a third test was required.

### 2.2.3 Third test

A 3D laser Tracker was used to undertake this test due to complexities of the drive train system. To begin the alignment the engine block was used as the reference, then the tracker zeroed in the coupling on the clutch box, both intermediate shafts and Z-drive thruster. The distance between the clutch box and Z-drive thruster was 16m apart. The offset misalignment was 13.7mm and the angle angular misalignment was 6.5mm. The two intermediate shafts had high stress applying to the bearing housing as these shafts carried the misalignment (see figure 8 and 9).

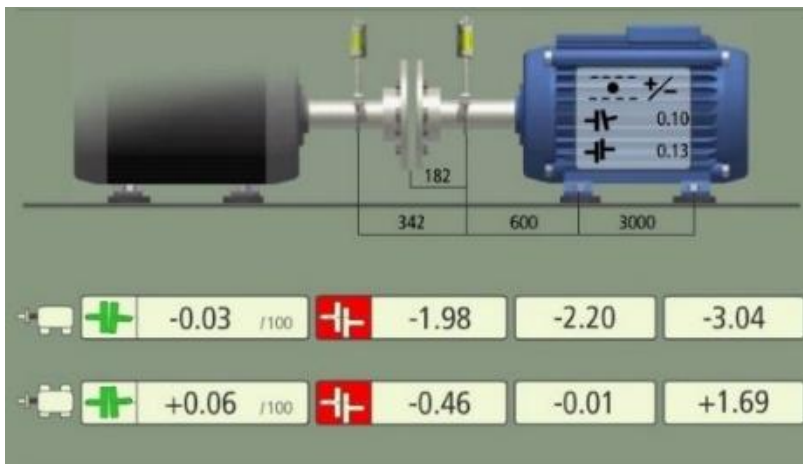


Figure 7 – Shaft alignment result

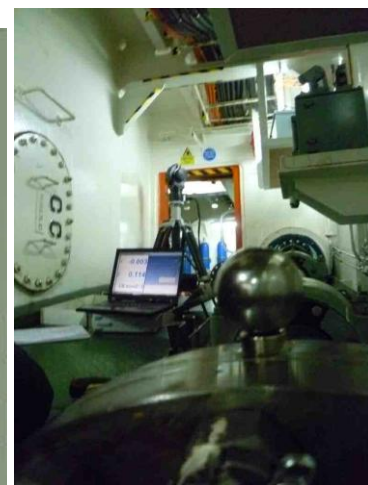


Figure 8 – 3D laser

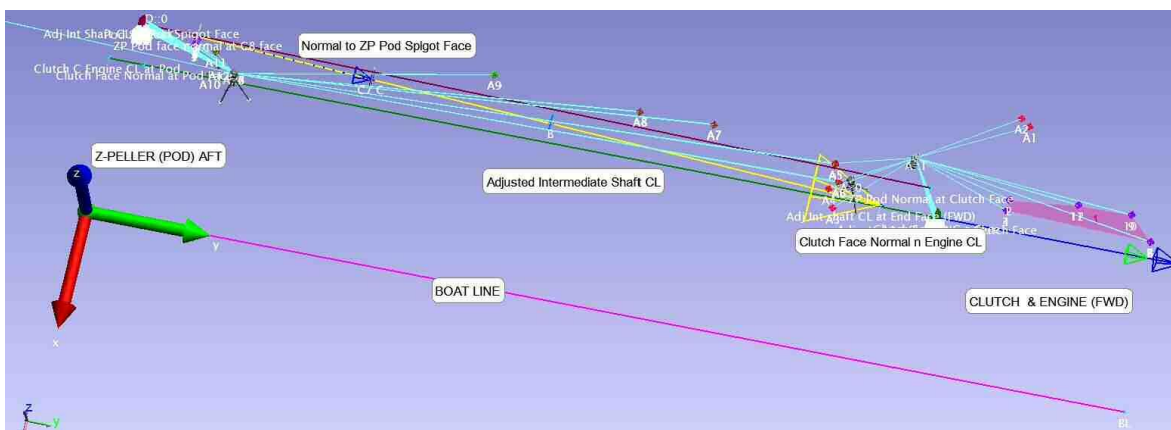


Figure 9 – 3D laser measurement results

### 2.2.4 Discussion

The vibration readings were over 12mm/s rms through the drive shaft. The starboard bearing 1 on the intermediate shaft was 23mm/s rms due to one loose bolt and cracked welds in the base plate. The intermediate shafts needed to be redesigned between the clutch box and the Z-

drive thruster. The Z-drive also required repositioning to be parallel to the clutch box. Neither of these modifications were an option at the time. With the 3D tracker, an accurate calculation could be made on the Cardan shafts. After looking at the specification of the Cardan shaft, the shaft works highly within the spline tolerance between the two universal joints. This spline allows for the absorption of axial loads when the couplings are not parallel with each other. The Cardan shaft was on the limit of its design for axial movement. Due to the maximum limit on the Cardan shafts when the dynamic movement occurs, the Cardan shaft then became overloaded. Causing the faults in bearing 1 such as the bolts coming loose and cracking welds in the base plate. This explains the high vibration throughout the whole vessel.

Recommendations on Vessel y:

- Redesign the drive train between the clutch box and z-drive thruster as this will fix bearing faults, specially bearing 1 and 6.
- Introduce new alignment procedure with new drive train to allow for dynamic movement. The failure of the high vibration throughout the vessel will be minimised

### **3. Conclusion**

Dynamic movement caused the same faults that occurred in both cases due to incorrect installation of drive train. The studies show that these faults are independent of the ductility of the hull. Further studies will have to be done to compare the present procedures of fault finding metal fatigue to the procedures of introducing reliability engineering tooling, for example the use of vibration analysis and dynamic movement into detecting the cause of metal fatigue.

### **Acknowledgments**

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# ORGANIZATION AND INTEGRATION OF BULGARIAN MARITIME NATIONAL OBSERVATION AND SURVEILLANCE SYSTEMS

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**Abstract:** This paper presents briefly the idea of integrated platform to be used for unified information exchange in the maritime domain between interested correspondents in the European Union (EU). The project is known as Common Information Sharing Environment, (CISE). The principles listed consider requirements and how-to-build the platform developed by the CISE work groups. A brief overview of the implemented systems in EU, as well as national ones is presented. Referring to the architectural vision of CISE, the authors propose a three-layer model of organization of different User Communities attended to the CISE National Node. The model is oriented towards functional use of the integrated system. Goals and objectives resolved in the various layers of the organizational model are defined.

**Keywords:** Surveillance systems, Integrating information, Platform, Organization, EU

## 1. Introduction

Increasing awareness, better maritime picture compilation, timely response to different situations as they occur are the key components of the goals of the Member States authorities and European Commission Directorate-General for Maritime Affairs and Fisheries (DG MARE). The process of integration of already implemented systems results in Common Information Sharing Environment (CISE) project (<http://www.eucise2020.eu/home>).

The European Union (EU) maritime domain could be described as the waters under the sovereignty and jurisdiction of EU Member States. The maritime domain also consists of activities

carried out in other international areas where the EU has a maritime interest (Fig.1) (<http://www.eucise2020.eu/home>).

**2. CISE-what is it and why? Basic Principles** (DIGIT/DG MARE/JRC, “CISE Architecture Visions Document”, *Study supporting the Impact Assessment*, ver. 3, 06.11.2013 – pp. 18-20)

Maritime CISE is a process of collaboration to enhance relevant information sharing between maritime surveillance authorities and their information systems in the EU. This process includes development of common hardware and software implementations in order to connect previously installed and operating surveillance and communication systems.



*Figure 1 European Maritime Domain and Areas of Interests.*

Increasing efficiency, quality, responsiveness, and coordination of surveillance operations in the EU maritime domain using CISE will benefit prosperity and security of the EU and its citizens.

Maritime CISE will reduce collecting the same information concerning maritime picture or detail in it by one maritime authority from a given country instead of sharing it with already collected information by other authorities in other countries, thus freeing up services and resources for more detailed and deep maritime picture compilation.

Seven functions presented also as User Communities are covered : Defence; Customs; Border Control; Fisheries Control; Safety, security and pollution preventing from shipping; Environmental protection; General law enforcement.

Each member state in the EU has a different approach, organisation and execution of these functions by the relevant national authorities.

The nine basic principles implemented by CISE are listed bellow :

- 1) Any public authority in the EU and in the European Environment Agency (EEA) involved in maritime surveillance must be allowed to interlink in CISE;
- 2) Based on need-to-know and responsibility-to-share rules, CISE must increase maritime awareness;
- 3) Decentralised approach at EU-level must be preferred in CISE;
- 4) Interoperability among civilian and military information systems must be enabled in CISE;
- 5) Interoperability among information systems at the European, national, sectorial and regional level must be enabled in CISE;
- 6) Reuse of existing tools, technologies and operating systems must be preferred in CISE;
- 7) Seamless and secure exchange of any type of information, relevant to maritime surveillance must be enabled in CISE;
- 8) CISE must be system neutral;
- 9) Information providers must have the possibility to change their service offering.

**3. Summary of EU-level initiatives** (DIGIT/DG MARE/JRC, “CISE Architecture Visions Document”, *Study supporting the Impact Assessment*, ver. 3, 06.11.2013– pp. 101-106)

### **3.1 Border Control**

**EUROSUR – European Border Surveillance System** – this is a decentralized network of national nodes, referred as National Coordination Centers (NCC). Each NCC collects information from different national law enforcement bodies and border control sites in order to create coherent maritime picture. The operational information of interest is shared in the form of EUROSUR platform structured messages between connected NCCs and FRONTEX via secured internet connection (VPN). There is no raw data information processed via EUROSUR.

**VIS** – The Visa Information System consists of central system (CS-VIS), and the national interfaces (NS-VIS) of Schengen Member States. CS-VIS provides central capabilities and data storage room, NS-VIS provides access of Member State Authorities to CS-VIS via secure network sTESTA.

### **3.2 Customs**

**CCN/CSI (e-Customs)** – this is an EU-prescribed private communications network between Member States and European Commission. It consists of a physical gateway and a set of protocols and APIs.

### **3.3 Fisheries Control**



**IFDM – DG MARE’s Integrated Fisheries Data Management** program, which is part of 2020 EU vision for establishment of integrated European information system for management of Member States fishery fleet activities. The main projects are Data Exchange Highway (DEH), Electronic Reporting System (ERS) and Data Warehouse (DWH). This projects form the basis for data exchange and reporting.

**VMS and ERS - The Vessel Monitoring System and the Electronic Reporting System** – these are separate systems for data exchange between fishing vessels and national Fishing Monitoring Centers (FMCs) over mobile satellite communications.

### **3.4 Defense**

**MARSUR** – this is a decentralized network between voluntary agreed Member States, connected via national nodes (MEXS) through an API interface over a secured internet (VPN).

### **3.5 Law enforcement**

**EUROPOL SIENA** – Secure Information Exchange Network Application – this is the platform for exchange the operational information concerning international crime between EUROPOL and its associates.

**SISII and SIRENE – Schengen Information System II** consists of Central Schengen Information System (C-SIS), located in Strasbourg (France) and National Schengen Information System (N-SIS) nodes for some Member States, or using available APIs for other Member States.

### **3.6 Marine environment**

**INSPIRE – The Directive on Infrastructure for Spatial Information in the European Community** – it was created to support policies and activities connected with the environment issues. There are 34 spatial data themes under common Implementing Rules (IRs).

**EMODNet** – The European Marine Observation and Data Network (EMODNet) is created for open maritime observation data exchange. EMODNet data is split into 6 datasets, each of which having own web portal.

**SEIS – Shared Environmental Information System.** This system is built to improve exchange, collection and use of environmental data in EU. It consists of several interconnected systems and initiatives, supported and managed by the DG Environment, EEA, JRC, Eurostat and Member States. **ReportNet** is one of the main systems in SEIS; this is an electronic reporting system with central storage in EU. Two other important projects are **Wise Marine** (a set of agreements

between EU Commission and Member States of exchanging of marine environmental data) and **Eye on Earth** (public website to access environmental information services).

**CleanSeaNet** – satellite-based surveillance system used to observe about oil spills and vessel detection. Technology implemented use SAR (Synthetic Aperture Radars).

**Copernicus (previously called GMES)** is complicated Earth monitoring European system with satellite and ground based components. It collects environmental and security data from multiple space, air, ground and maritime sources.

### **3.7 Maritime Safety and Security**

**SafeSeaNet** – this is the Internet-based system with distributed databases, aiming to prevent marine pollution and accidents at sea. AIS (Automatic Identification System) data is the main one exchanged over the SafeSeaNet. In addition four types of information services are performed: ship notifications, incident reports, port notifications and hazmat notifications.

**LRIT** – Long Range Identification and Tracking of all EU flag vessels is executed in the EU ELRIT Cooperative Data Center (EU ELRIT CDC) worldwide.

**Thetis** – this system supports the new Port State Control inspection regime by easing the planning, logging and publishing the vessel inspections. It is centralized web-based system, accessed via the LifeRay web portal.

**IMDateE Integrated Maritime Data Environment project** – is run by European Maritime Safety Agency (EMSA) under supervision of Directorate-General for Mobility and Transport (DG MOVE). The project aim is to integrate different EMSA managed systems (SafeSeaNet, Thetis, LRIT, CleanSeaNet) information to provide more complete services.

**CECIS** – web-based centralized system with centralized data which supports EU Monitoring and Information Center (MIC). Data collected concerns civil protection and marine pollution resources from participating States in case of an emergency.

### **3.8 Other Community Initiatives**

**Blue Hub** – initiative, led by JRC to develop data prototype platform for systems integration, gathering, analysis and prediction of local, regional and global data in maritime domain from various sources (AIS, LRIT, VMSs, etc.).

**Single Window in EU Member States** – electronic format reporting system for ships arriving in/departing from EU Member States ports approved under EU Parliament Directive 2010/65/EU and entered into force since 01 JUN 2015.

## **4. Summary of Bulgarian National Maritime Surveillance Systems**

### **4.1 Border Control**

**BLUE BORDER Project** – since 2011, Ministry of (Inner Affairs) Interiors implemented system for sea coast and borders monitoring. It is run by the Border Police and gives operational information in favor of National Law Enforcement Authorities. It consists of Radar, CCTV, AIS and VHF Radio subsystems for monitoring of sea area of interests. There are 18 sites, 2 Local Coordination Centers, 1 Regional Coordination Center, a number of sea vessels and cars, equipped to communicate and share information (MINISTRY OF INTERIOR, DIRECTORATE “BORDER POLICE”, Technical specification pdf format published 11 April 2017 [online] 2017 pp1-2).

### **4.2 Defense**

**EKRAN Project** – since 2011, Ministry of Defense implemented this system for maritime picture observation and surveillance. EKRAN system consists of Radar, CCTV, AIS, and V/UHF, HF Radio subsystems. It includes 8 sites, one National Center in Varna, two Regional Centers in Galata and Bourgas (FSI: “*Ekran MSS architecture*”, 2011).

### **4.3 Fisheries control**

**Fishery Vessel Monitoring System** -since 2006, all fishery vessels over 15 meters long and since 2014 all fishery vessels over 12 meters long are supervised via FVMS. This system has a satellite based component and GPRS tracking component. FVMS uses a web based software. It consists of National Fishery Vessels Monitoring Centre, situated in Varna and mobile complexes, mounted onboard fishery vessels (SCORTEL LTD., *Fishery Vessels Monitoring System*, 2017). FVMS is under the jurisdiction of the Bulgarian Ministry of Agriculture and Foods (ИАРА, *Екранни снимки от ЦНПК – ИАРА Варна* [IARA Monitor shortcuts from the FVMS Center of Varna], 2017).

### **4.4 Vessel Traffic Information and Management system**

**VTMIS** – Third generation system of Bulgarian VTMIS project run after 2015. The system consists of 22 sites, including two main centers – the port of Varna Control Center and the port of Bourgas Control Center. AIS, Radar, Relay, Meteo and VHF/ HF GMDSS subsystems, including MF NAVTEX component, built VTMIS-3 (TRANSAS LTD., VTMIS Technical Description, 2002).

## **5. Bulgarian National Maritime Node (BgNM Node)**

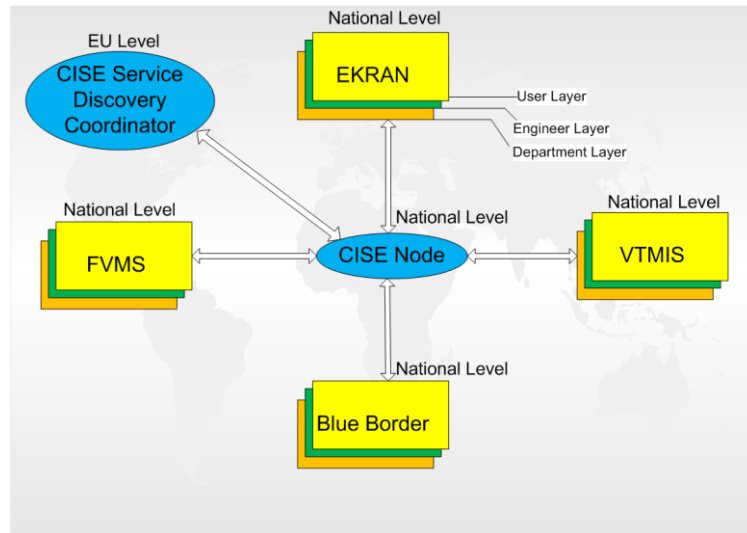
Due to the EU membership and future integration processes of the Bulgarian maritime national observation and surveillance systems, choosing optimal architecture of integration is a key element of integration system development.

According to publication of DG MARE (“CISE Architecture Visions Document”, *Study supporting the Impact Assessment*, 06.11.2013, pp 34-83) there are several architecture visions concerning the development of CISE – vision Core, A, B, C, vision C variant and Hybrid vision. Briefly, vision A means to have integration first at User Community Level, each Users Communities of Member States to be connected with each other (Defense of Member State A to Defense of Member State B, Border Authorities of Member State A to relevant Authorities of Member state B).

In vision B there is one National Authority which will act as “National CISE Node” and “Cervices Discovery Center” contemporary. The software referred to as “CISE service discovery coordinator” must be set, not only at the State, but also at the EU level. In addition, the software “CISE Node” is set to enable communication between different CISE participants. This vision is suitable for a Member State, but complicated due to additional software load per Member State. Also there are many technical details to be cleared about “CISE service discovery coordinator” software when implementation starts.

In vision C there is again a common “CISE Node” at Member State Level, but the “Service Discovery Coordinator” is EU level positioned and the “CISE Node” is only one for the Member State. This is the most appropriate variant for integrating of the implemented Bulgarian National Maritime observation and surveillance systems (Fig.2).

In accordance with the study and calculations between the three architecture visions mentioned above (DIGIT/DG MARE/JRC, “CISE Architecture Visions Document”, *Study supporting the Impact Assessment*, 06.11.2013 pp.71-75), vision C achieves the highest scores according to the applied criteria. In addition, integration means creating a unified platform, the accomplishment of which is much more difficult when “Service Discovery Coordinator” is based locally.



*Figure 2 Architecture vision of Bulgarian National Node*

Appropriate place to host the National Node is the Naval Academy; due to the present place of the Academy as a structure under the jurisdiction of the Ministry of Defense (MoD), Ministry of Transport (MTTITS) and Ministry of Education and Science (MON) simultaneously. Thus positioned, the Naval Academy staff has the rare possibility to experience and implement a proper management system, equipment and place in order to achieve interoperability among all the User Communities faster than any other organizational body.

## **6. Development of the Integration Organization Structure.**

All the process of planning, organization and implementation of such integration is better to be layered in three main layers (Three-Layer-Model):

1. Department Layer at Administrative Level.
2. Engineer (Support) Layer at Operational Level.
3. User Layer at Operational Level.

Figure 3 gives the idea of organization and interactions between the layers in governmental bodies aimed to integrate their systems in CISE National Node. There are two User Communities, relevant to two National Authorities (MoD and MTITS) for instance.

Primary users of the maritime observation systems for 24/7 in their service are in the pyramids' bases. The next layer - Operational Support Levels, includes Technical Support Section in MTITS and Logistic and Technical Support Sections in MoD Naval Headquarters. On the top of the pyramids are the department levels, leading to the relevant heads – Ministers in this example.

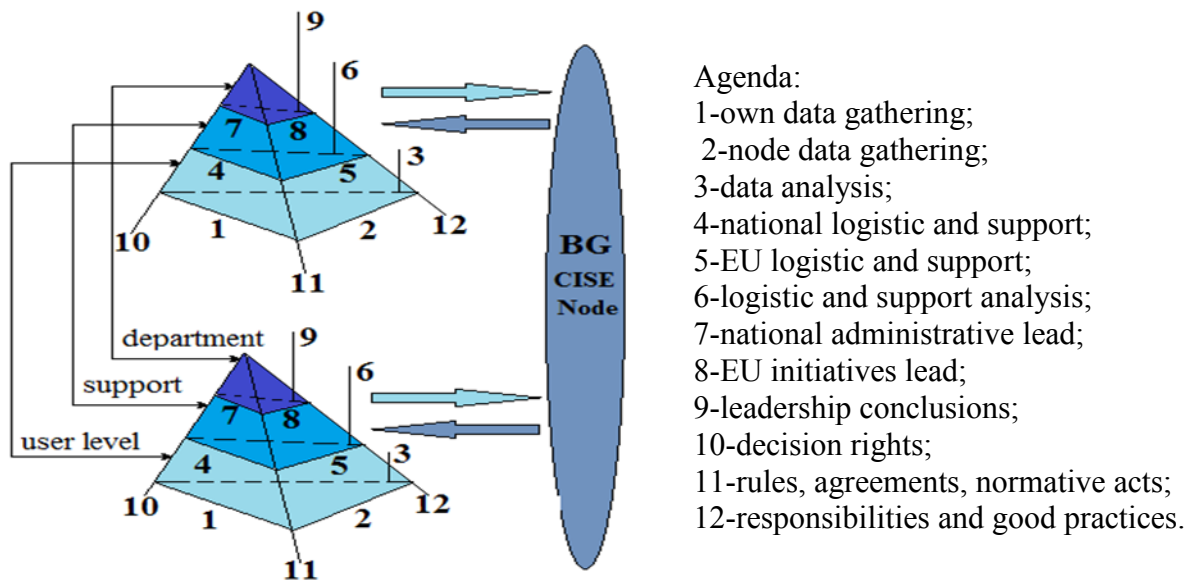


Figure 3 Organization Structure Example Scheme.

### Conclusion.

Integrating the already implemented Maritime Surveillance and Observing systems in EU will enhance the maritime recognized picture and increase awareness and responsiveness of Member States and EU bodies. The three-Layer-Model on National level contributes to overcoming the internal organizational differences among the different User Communities in order to achieve better integration coherence. Timely response to different situations as they occur, better resource use without doubling and tripling of the same information gathering is part of the positives of CISE – a common Member States and EU Commission project. This EU initiative will benefit all EU citizens and will improve the quality of services delivered to business, science and other activities across the Union and Union collaborators.

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# INCREASING OPERATIONAL EFFICIENCY OF HIGH SPEED RO-RO VESSELS VIA NEW HULL COATING TECHNOLOGIES

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## Abstract

The purpose of this study is to review results of new hull coating technologies for high speed RO-RO vessels and analyze the potentials to decrease fuel consumption as well as speed loss. In maritime economics, the fuel consumption of ships accounts for the important part of operational expenses and it is straight forward that every ship owner would aim to run their fleet as optimum as possible in terms of fuel efficiency. IMO has developed the Energy Efficiency Operational Indicator (EEOI) that provides information concerning the efficiency of the ships in operation where fuel consumption is the main criteria for the calculation. The reduction of fuel consumption through decreased frictional resistance of hull is one of the most well-known method in maritime industry to increase operational efficiency of ships. Ship operators are generally making their decisions according to real-life experiences. It is clear that literature needs further studies regarding hull performances with the real-life data even if there will be higher uncertainties compared to laboratory test results. In this study, actual field data of 8 high speed RO-RO vessels has been studied according to the new standard ISO 19030 - Ships and marine technology, Measurement of the changes in hull and propeller performance. Results indicate the importance of full blasting for hull performance and a significant fuel savings through decreased speed loss via new technology foul release silicone coatings.

**Keywords** – Fuel consumption, Antifouling coating technologies, speed loss, high speed Ro-Ro vessels

## 1. Introduction

The reduction of fuel consumption and fuel costs through keeping ship's hull as smooth as possible is one of the most known method in maritime industry to increase operational



efficiency of ships. Increased hull roughness leads to increased frictional resistance, causing higher fuel consumption and GHG emissions. The best method to reduce frictional resistance is to apply a treatment to a ship's hull, to minimize its physical and biological roughness.

Antifouling coatings are the most effective solutions to avoid fouling and help to keep hull performance as better as possible. Demirel et al. (2013) state that antifouling coatings are the primary protective measure to mitigate marine bio fouling and surface roughness on ship's hulls. \$60 billion of fuel saving, 384 million tones reduction in carbon dioxide and 3,6 million tones reduction in Sulphur dioxide emissions are estimated to be provided by the use of antifouling coatings.

There are technologies and solutions on the market undertaking to protect the hull and maintain good performance over the full duration of the docking interval. So, even there are available products and plenty of methods in the market, why is then hull and propeller performance still so poor? Which coating is best for which ship types or under which working conditions? Or is there any coating performs well under all conditions? These questions are still valid and still there isn't any clear reply even plenty of research carried out by producers and academicians.

On the other side, what is the problem and approach for the final user, i.e. ship operator? Also, problem for them to make decision to select correct antifouling technology for their fleet is going on and repeats again on every dry-docking cycle when new application will be applied.

According to Soyland and Oftedahl (2016) the problem has been a lack of measurability. You can't manage what you can't measure is an old management adage that is still accurate today. Now a multitude of measurement methods is being introduced in the market; but there has not been a specific standard of hull and propeller performance measurement method until ISO 19030 released. Previous studies have been carried out to determine the impact of antifouling coatings by laboratory tests of coated cylindrical or flat panels, CFD computer modelling tests, coated rotor tests, chemical comparisons or adhesions tests.

It was not easy for analyzers to reach real life data from ships due to most of the ships did

not have required measurement tools like torque meters and sensors, any data logging system to keep records, any useful and systematic recorded data to analyze in respect of hull and propeller performance. Also, uncertainty was well high for the data received from ships in respect to human error or equipment errors. To the best of our knowledge, only Corbett (2010) and his friends worked on real data from ships with a subject of “Energy and GHG Emissions Savings Analysis of Fluoropolymer Foul Release Hull Coating”. They compared results of Self Polishing Copolymer coating and Fluoropolymer Foul Release coating which were applied to 7 new built vessels, one tanker, one bulker and 5 sister container vessels.

It is clear that the related literature needs more studies regarding antifouling coating performances or hull and propeller performances with the real field data even there will be higher uncertainties when compared with laboratory test results. In order to fill the gap here, we studied a high-speed Ro-Ro fleet which has 11 sister vessels all built in the same shipyard in Germany with the same technical properties, working under the same operational conditions between the same ports in Mediterranean Sea since 2000.

In respect to the importance of hull performance on fuel costs, the Ro-Ro Company wanted to create efficiency via using new hull coating technologies and to define the best antifouling coating technology for high speed Ro-Ro vessels. Thus, the company decided to apply different type of new hull coating technologies to each sister vessel and measure the results of reference and evaluation periods of different applications.

All vessels have been coated with 1<sup>st</sup> type of self-polishing coatings at the beginning then tested with different type of new technology antifouling (self-polishing or foul release) coatings. Then results of reference and evaluation periods are compared in respect to speed loss and fuel efficiency according to the methodology described in ISO 19030 part 3. It is not possible fully comply with the ISO 19030 due collected data and collection period is different, but is tried to carry out analysis according ISO 19030 as practicable as possible.

## **2. ISO 19030 Ships and Maritime Technology, Measurement of Changes in Hull and Propeller Performance**

The aim of this International Standard is to prescribe practical methods for measuring changes in ship specific hull and propeller performance and to define a set of relevant performance indicators for hull and propeller maintenance, repair, retrofit activities.

Measurements of ship specific changes in hull and propeller performance can be used in a number of relevant performance indicators to determine the effectiveness of hull and propeller maintenance, repair and retrofit activities. There are 4 performance indicators defined in ISO 19030. These are Dry-docking Performance, In-service Performance, Maintenance trigger and Maintenance effect. The performance value, PV, is defined as the percentage speed loss compared to a reference speed-power relation.

## **3. Data and Methodology**

Application and test of new technology hull coatings to specified Ro-Ro Fleet started in 2013, 10 vessels docked until July 2014, 8 of them completed their first docking cycle with test application and docked again in 2015 and 2016, which we achieved performance of complete docking cycle on these vessel's results.

Reason of selecting these 8 high-speed sister Ro-Ro vessels listed below:

- All vessels built in the same shipyard with same technical properties, only there were some changes with the generations regarding the built date
- All vessels had the same technology SPC antifouling coating at the beginning
- All vessels have used the same fuel oil from same supplier during test period
- All vessels have been loaded with the same type of cargo (trucks and trailers)
- All vessels have been operated by the same technical management with same planned maintenance system
- All vessels have been maintained with only genuine spare parts during their engine overhauls and routine maintenance activities.
- All test vessels traded between the same ports in Mediterranean Sea.

**Table 1. Dry-docking History of Test vessels**

		DDn-1	DDn	DDn+1
VESSEL 1	Date of Drydock	4.05.2011	11.11.2013	13.08.2016
	Shipyard	BESIKTAS	BESIKTAS	SEFINE
	Blasting	SPOT	FULL	%10 sweep blasting
	Hull Coating	Self Polishing Coating 1	Foul Release Coating 1	Foul Release Coating 1
	Engine Overhaul	NO	NO	Both Engine 90.000 Hours overhaul Completed
VESSEL 2	Date of Drydock	17.08.2011	10.06.2014	17.01.2017
	Shipyard	BESIKTAS	BESIKTAS	SEFINE
	Blasting	SPOT	FULL	%10 sweep blasting
	Hull Coating	Self Polishing Coating 1	Foul Release Coating 1	Foul Release Coating 1
	Engine Overhaul	NO	NO	Both Engine 90.000 Hours overhaul Completed
VESSEL 3	Date of Drydock	8.04.2010	22.01.2013	29.03.2015
	Shipyard	BESIKTAS	GEMAK	GEMAK
	Blasting	SPOT	SPOT	FULL
	Hull Coating	Self Polishing Coating 1	Self Polishing Coating 1	Foul Release Coating 2
	Engine Overhaul	NO	NO	NO
VESSEL 4	Date of Drydock	29.06.2010	5.05.2013	16.05.2015
	Shipyard	BESIKTAS	GEMAK	BESIKTAS
	Blasting	SPOT	FULL	FULL
	Hull Coating	Self Polishing Coating 1	Self Polishing Coating 2	Foul Release Coating 1
	Engine Overhaul	NO	NO	NO
VESSEL 5	Date of Drydock	30.08.2010	27.07.2013	2.06.2015
	Shipyard	BESIKTAS	BESIKTAS	BESIKTAS
	Blasting	SPOT	FLAT BOTTOM FULL, VERTICAL SIDES SPOT	FULL
	Hull Coating	Self Polishing Coating 1	Self Polishing Coating 3	Foul Release Coating 2
	Engine Overhaul	NO	NO	NO
VESSEL 6	Date of Drydock	22.04.2010	8.03.2013	9.10.2015
	Shipyard	BESIKTAS	GEMAK	BESIKTAS
	Blasting	SPOT	SPOT	FULL
	Hull Coating	Self Polishing Coating 1	Self Polishing Coating 1	Foul Release Coating 1
	Engine Overhaul	NO	NO	NO
	Other			KAPPEL PROPELLER MODIFICATION
VESSEL 7	Date of Drydock	4.02.2012	31.05.2013	28.04.2016
	Shipyard	BESIKTAS	BESIKTAS	SEFINE
	Blasting	SPOT	SPOT	SPOT
	Hull Coating	Self Polishing Coating 1	Self Polishing Coating 1	Self Polishing Coating 4
	Engine Overhaul	NO	NO	NO
VESSEL 8	Date of Drydock	17.08.2011	28.08.2013	31.03.2016
	Shipyard	GEMAK	BESIKTAS	BESIKTAS
	Blasting	SPOT	SPOT	FULL
	Hull Coating	Self Polishing Coating 1	Self Polishing Coating 5	Foul Release Coating 1
	Engine Overhaul	NO	NO	Both Engine 45.000 hours overhaul completed.
	Other			CLT PROPELLER MODIFICATION

The following procedure is applied to understand if there is any significant improvement of speed loss and fuel consumption reduction by using new technology hull coatings:

**1-** Detailed tables are created as raw data for all test vessels from the company's official arrival, departure, and noon and Energy Efficiency Operational Index reports. Only data of the voyages completed in normal conditions included in the analysis. Any voyage which had any engine failure or any unexpected delay on schedule, were not included.

**2-** Raw data is filtered with  $\pm 5\%$  for displacement of model test or working displacement according actual data of test vessel, if the model test displacement does not fit with it. Any data for any voyage which is in not limit, not included.

**3-** The SFOC reference curve based on actual shop tests of the specific engine in question, was already corrected in shop test report for environmental factors as per ISO 3046-1:2002. Then it is also corrected for normal fuel of 42700 kJ/kg and the new SFOC curve is issued.

**4-** Delivered power of one engine is approximated for each data point based on calculations of brake power,  $P_B$  from an engine specific SFOC reference curve defined in Annex D of Part 2 of the standard.

**5-** Delivered power is multiplied by 2 to find total power of both engines

**6-** Model test predictions are available for 18557.6 tons Displacement. For all vessels, a correction factor is applied to Speed-Power curve according to ITTC displacement correction methodology.

**7-** Expected speed is calculated for each data point from a speed-power reference curve at the corrected delivered power of both engines.

**8-** Percentage speed loss which is defined as Performance Value in the ISO19030 is calculated for every data point in the corrected data set.

**9-** The average percentage speed loss over the Reference period(s) is calculated.

**10-** The average percentage speed loss over the Evaluation period is calculated.

**11-** Differences between the average percentage speed loss of the Reference period and the Evaluation period are calculated. The change in the average speed loss in the Reference period(s) and the average speed loss in the evaluation period is defined as performance indicator.

**12-** In order to evaluate changes on fuel consumption, average fuel consumption per hour value of Reference and Evaluation periods is calculated from the data set.

**13-** Due to Fuel consumption being effected by speed, fuel consumption of evaluation period is normalized based on average speed of reference period.

14 – Student t-test is used to check if the calculated differences were significant.

The limitations and assumptions related with the research are as follows:

- Methodology explained in the International Standard ISO 19030-Measurements of changes in hull and propeller performance, Part 3 is taken as a reference and tried to be used in this study as practicable as possible.
- Sample fleet is not fitted with Torque meter, therefore delivered power is calculated from fuel consumption. The model test result of the ship and engine acceptance test result are explained as in Part 3 of the International Standard.
- As all vessels are sisters with the same technical properties and working under the same operational conditions and due to data of high number of voyages has been observed which is covering nearly all seasons of the year, it is assumed that, all vessels have the same weather conditions as wind and sea states.

#### 4. Findings

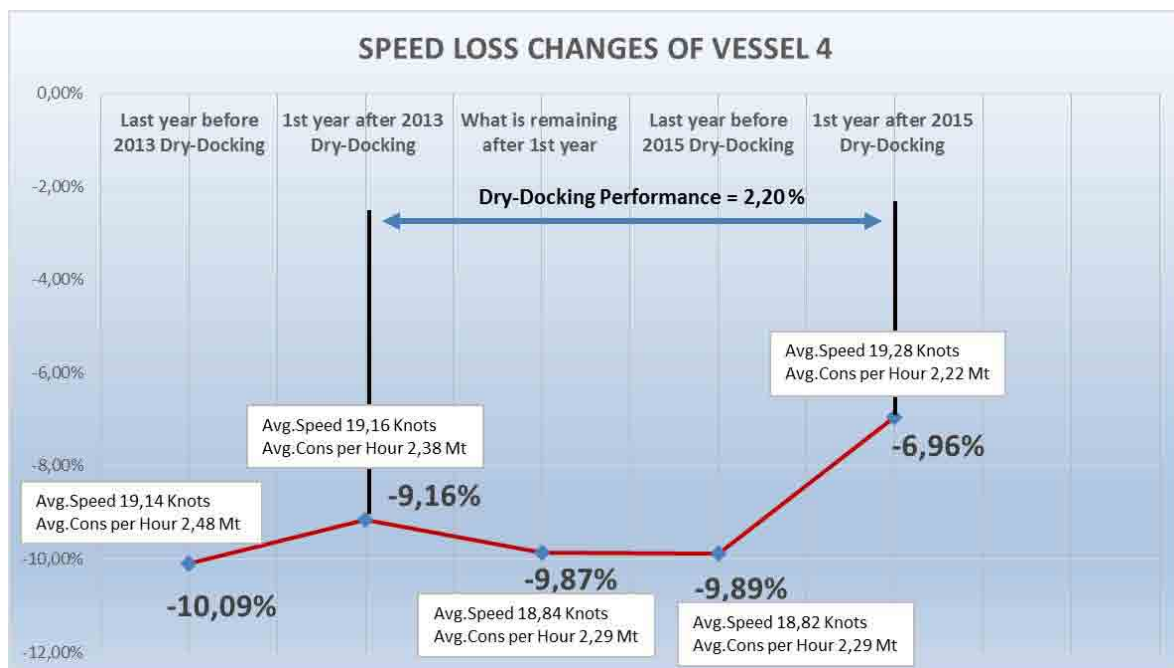
Actual field data of Ro-Ro fleet used in this study. Data of reference periods and evaluation periods described in ISO 19030 compared to measure and evaluate hull performance. 2 different technology of foul release coatings and 5 different technology of self-polishing coatings tested.

4 vessels used as a control sample to evaluate what would be result if self-polishing coatings applied to spot blasted hull. Table 2 presents results of these vessels together. Results indicated that, if hull spot blasted and self-polishing coating applied, hull performance goes worst after first year to next drydock. Fuel consumption increases dramatically and speed of vessel decreases. Therefore, full blasting is very critical for maintaining hull performance and avoiding increase of fuel consumption.

**Table 2.** Performance of self-polishing coated and spot blasted vessels

SELF POLISHING COATING + SPOT BLASTING APPLIED VESSELS' PERFORMANCE				
	Comparison of last year before and first year after dry-dock		In-service Performance	
	Speed Loss %	Fuel Consumption mt/hr	Speed Loss %	Fuel Consumption mt/hr
<b>VESSEL 3</b>	-0,84%	3,57%	-2,87%	13,80%
<b>VESSEL 6</b>	1,33%	-5,82%	-3,70%	17,88%
<b>VESSEL 7</b>	0,12%	-0,54%	-3,10%	15,13%
<b>VESSEL 8</b>	-1,43%	6,38%	-2,65%	13,13%
<b>Average</b>	-0,20%	0,90%	-3,08%	14,99%

Vessel 4 was the best test vessel where self-polishing coating and foul release coating applied with full blasting at consecutive dry-dockings in 2013 and 2015. It was possible to separate additional effect of foul release coating on individual ship. She sailed 2 years with fully blasted and self-polishing coating applied hull, then sailed again with fully blasted and 1<sup>st</sup> type of foul release coating applied hull for 1,5 years. When we focus on dry-docking performance of this vessel, foul release coating provided extra 9,42 % fuel consumption reduction and 2,21 % speed increase in respect to self-polishing coating. Below Figure 1 represent speed loss changes of vessel 4.



**Figure 1.** Speed loss changes of Vessel 4

Vessel 7 was only the sample where we could have chance to evaluate dry-docking performance of self-polishing coatings. We compared results of first year after 2013 dry-docking and first year after 2016 dry-docking where hull was completely coated with new coating. Results indicates that hull performance is reducing on every docking cycle and approximately 12 % fuel consumption increase proofs how hull condition is deteriorated dramatically without full blasting.

**Table 3.** Performance of Self polishing coated and full blasted vessel

DRY-DOCKING PERFORMANCE OF VESSEL 7		
	Dry-docking Performance	
	Speed Loss %	Fuel Consumption mt/hr
<b>VESSEL 7</b>	-2,52%	11,90%

2 different technology of foul release coatings tested on 7 vessels. Results indicated that, foul release coatings performed well. Fuel consumption of all vessels reduced 7,5 % in average regarding dry-docking performance results. Also, ships' speeds increased up to 2 %. Vessel 6 and Vessel 8 which also propellers modified and results were not satisfactory, effected average of foul release coating performances negatively. We suppose new propellers had negative effect on ship performance due to we couldn't observe expected efficiency of foul release coatings on these vessels.

**Table 4.** Dry-docking performance of Foul Release Coated vessels

DRY-DOCKING PERFORMANCE OF FOUL RELEASE COATINGS		
	<i>Speed Loss %</i>	<i>Fuel Consumption mt/hr</i>
<b>VESSEL 1</b>		
<b>VESSEL 2</b>		
<b>VESSEL 3</b>	3,00%	-12,40%
<b>VESSEL 4</b>	2,21%	-9,42%
<b>VESSEL 5</b>	1,94%	-7,93%
<b>VESSEL 6</b>	0,49%	-2,01%
<b>VESSEL 8</b>	1,42%	-5,97%
<b>Average</b>	1,81%	-7,55%

Regarding In-service performance comparison of self-polishing and foul release coated vessels, foul release coated vessels performed better than self-polishing coated vessels in respect to speed loss and fuel consumption. Table 5 presents compared data of both coatings.

**Table 5.** In-service performance comparison of self-polishing and foul release coatings

IN-SERVICE PERFORMANCE COMPARISONS				
	<i>Speed Loss %</i>		<i>Fuel Consumption mt/hr</i>	
	<i>SELF POLISHING</i>	<i>FOUL RELEASE</i>	<i>SELF POLISHING</i>	<i>FOUL RELEASE</i>
<b>VESSEL 1</b>		-1,77%		8,06%
<b>VESSEL 2</b>		-0,82%		3,60%
<b>VESSEL 3</b>	-2,87%	0,28%	13,80%	-1,26%
<b>VESSEL 4</b>	-0,71%		2,98%	
<b>VESSEL 5</b>	-2,25%	-2,55%	10,70%	11,73%
<b>VESSEL 6</b>	-3,70%		17,88%	
<b>VESSEL 7</b>	-3,10%		15,13%	
<b>VESSEL 8</b>	-2,65%		13,13%	
<b>Average</b>	-2,55%	-1,22%	12,27%	5,53%

Application of foul release coatings reduced fuel consumptions of test vessels, increased speed and improved operational efficiency.

## 5. Conclusion

This study reviewed the results of new hull coating technologies for high speed RO-RO vessels and analyze the potentials to decrease fuel consumption as well as speed loss. The



actual field data of 8 high speed RO-RO vessels has been studied according to *the* new standard ISO 19030 - Ships and marine technology, Measurement of changes in hull and propeller performance.

This study confirmed below results:

- Foul release silicone technologies seems performing well for 2-3 years of period for high speed Ro-Ro vessels. We don't have available data to say something for longer periods.
- Only 1 vessel was full blasted and tested with Self-Polishing coating. It is required to evaluate results of more samples which are full blasted and self-polishing coated in order to separate effect of full blasting and coating, also for better comparison of self-polishing and foul release coatings.
- 1<sup>st</sup> type of foul release coating technology performed well on all tested vessels.
- 2<sup>nd</sup> type of foul release coating technology performed well for both test vessels during first year after dry-dock. But regarding in-service performance results, it performed well only on 1 vessel and did not on another.
- Full blasting is very critical and important for hull performance. If ship's hull only spot blasted, even if it's completely coated with any self-polishing coating, ship's hull performance reduces dramatically. Most of the ship operators do not want to carry out full blasting for economic reasons and they do only spot blasting to reduce dry-docking cost. However, this approach causes more fuel cost and reduced operational efficiency of ships.
- It is observed that self-polishing coatings perform well max 1 year for high speed Ro-Ro vessels unless it is applied together with full blasting which increases this beneficial period. And it is observed that all self-polishing coated vessels arrived to next dry-dock with a fouled hull.
- It is observed that; hull fouling also occurs for the foul release coated vessels which causes reduce of hull performance but reduction was not worst as self-polishing coated vessels. Photos taken just after entering the dry-docks confirms foul release coated vessels' hull were in good condition.

As this study is about results of different hull coating technologies applied to high-speed Ro-Ro vessels under different conditions, the results of the same coating technologies may differ on different ship types and under different operational conditions. With the implementation of ISO 19030, we expect that more studies will be carried out for evaluating hull performance

changes with real field data which literature needs more studies in this area. It is clear that uncertainty of real field data will be always high unless they have carried out according to ISO 19030 Part 2 requirements which requires various sensors and data logging system. It is the fact that most of vessels don't have these sensors and data logging system. Therefore, this kind of studies will be helpful for ship owners, paint producers, academicians and all related parties.

It would be very useful if the ISO to strengthen the standard with new methods to cover voyage base methodology for liner vessels. Part 3 requires daily collected data to analyze. However, it would be more beneficial for liner vessels to compare results of each voyage or each leg if the vessel is trading on the same line for a period which covers required analysis duration.

ISO 19030 have been recently published on the 15<sup>th</sup> of November, 2016 and all parties offering performance monitoring systems have been started to implement their systems according to requirements of the standard.

We believe the results of this study will highlight performance of today's antifouling technologies even there will be some uncertainty due to analyzed data collected from arrival, departure and noon reports of test vessels instead of collecting them directly from required sensors and a data logger. For the future studies, it would be more beneficial to carry out analysis of sister vessels which have sensors and logging systems required as ISO 19030. Uncertainty will be very low and results would be more useful for all parties cares with hull performance solutions.

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# SHIP-WEATHER ROUTING APPLIED TO SHORT SEA DISTANCES: STUDY OF THE FEASIBILITY OF SIMROUTEV2 ALGORITHM

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## Abstract

Pathfinding algorithms to determine optimal ship routing for transoceanic distances have been widely used. However, the economic and marine environmental benefits of using ship routing for short distances have been little studied.

The main objective of this contribution was to evaluate the feasibility of the SIMROUTEv2 ship-weather routing algorithm in Short Sea Shipping routes, considering ship speed and weather conditions. A ship routing system was developed to obtain the optimal route and the minimum distance route from the A\* pathfinding algorithm. The methodology considers the impact of added resistance of ships in waves in terms of time. Moreover, the basis for further development of an optimal route applied to relatively short distances and its systematic use in the Short Sea Shipping (SSS) maritime industry were established. Ship routing for four routes related to five ports in the Western Mediterranean Sea was analysed, with special emphasis on Short Sea Shipping activities and Ro-Pax and Ro-Ro services. The results highlight the benefits of using ship routing systems in short distances.

**Keywords.** Ship routing, pathfinding algorithms, Short Sea Shipping, wave models, safety navigation, feasibility analysis

## **Introduction**

The European Community transport system has been overused because of the increase in intra communitarian commercial exchanges. Inland modes of transport have always predominated over maritime transport. The main problem regarding road transport is the massive number of trucks needed to transport a specific volume of goods. Fewer trucks on the roads would result in fewer pollutants in the atmosphere, lower traffic volume and fewer traffic accidents. This number would be reduced by using maritime transport, which would result in a significant reduction of emissions. From an environmental perspective, the actions of previous years have led to high emissions of polluting gases, resulting in an imbalance of gases in our atmosphere. This problem must be addressed since the vast majority of European Union countries are facing this issue. The solution hinges on an intermodal system, which emphasises maritime routes in general and Short Sea Shipping (SSS) in particular. Integration of SSS into an effective transport chain is a potential choice to avoid road congestion, enhance accessibility and provide ideal maritime routes.

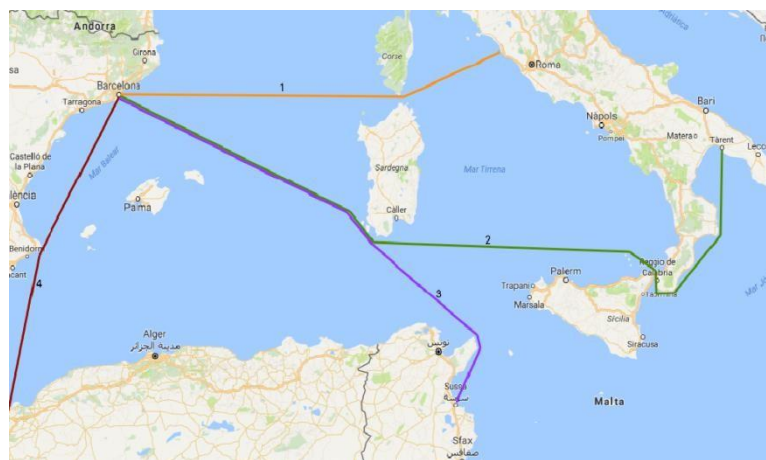
Academic research has focused on ship routing optimisation through pathfinding algorithms (Takashima et al. 2009, Mannarini et al. 2013, Szłapczyńska and Śmierzchalsk 2009, Larsson and Simonsen 2014 and Hinnenthal and Günther 2010), which rely on meteo-oceanographic forecasts (i.e. wind, waves or currents predictions). There is a large number of ship-weather routing algorithms, but the algorithm used for evaluation of SSS routes is the brand new SIMROUTE v2 algorithm (Grifoll et al. 2016). Currently, its feasibility is based on spot checks on very specific routes. The present work aims to evaluate its feasibility for ship-weather routing by testing short-distance routes for different speeds and weather conditions.

## **Method**

The feasibility study was performed on the Western Mediterranean area. Comprehensive analysis of the weather conditions in this region at several periods of the year was carried out. A summary of the SIMROUTEv2 algorithm and its structural basis (route function and wave function) was also conducted.

Ro-Ro and Ro-Pax vessels were chosen due to the benefits provided by them in terms of environmental protection, transport safety and decongestion of roads. The research was focused on two existing routes and two possible new routes that could be important in the future for SSS (see Figure 1). These four routes covered most of the Western Mediterranean Sea. They had one port in common, the port of Barcelona (Port of Barcelona, 2017). This port was chosen for

its geostrategic position as well as the SSS growing process, which make it Spain's leading port in Ro-Ro and Ro-Pax as far as SSS is concerned (Ro-Ro & Ferry Atlas Europe 2014/2015). Several ship speeds were considered: 10 knots, 16 knots, 22.6 knots (SSS average speed) and 30 knots. In order to obtain all weather conditions, the Pilot Charts of the Mediterranean Sea (National Geospatial-Intelligence Agency, 2002) and several papers by Millot (1990) were studied. In addition, an extensive search through all scripts in the Spanish Port Agency (*Puertos del Estado* website) was done. For each route, wave scripts were searched considering the following significant wave heights ( $H_s$ ): Calm-Smooth sea (0 metres), Moderate-Rough sea (1.25-2.50m/2.50-4.00m) and Rough-High sea (4.00-9.00m), and the following wave directions: Following Seas (FS), Beam Seas (BS) and Head Seas (HS).



**Figure 1:** Tracks of the four studied routes: Barcelona-Civitavecchia (route 1), Barcelona-Taranto (route 2), Barcelona-Sousse (route 3) and Barcelona-Oran (route 4)

SIMROUTEv2 is based on the A\* pathfinding algorithm (Dechter and Pearl, 1985). The Dijkstra Algorithm (Dijkstra, 1959) was also tested but the A\* pathfinding algorithm was considerably faster (Grifoll, 2016). An optimal route was obtained from SIMROUTEv2. This route was compared with the minimum distance route considering the weather conditions. A simple formula including wave affected speed reduction was suggested by Bowditch (2002). Final speed was computed in function of non-wave affected speed ( $v_0$ ) plus a reduction in function of the wave parameters:

$$v(H_s, \Theta) = v_0 - f(\Theta) \cdot H_s^2 \quad (1)$$

where  $f$  is a parameter in function of the ship-wave relative direction. The values of coefficient  $f$  are shown in Table 1.

Ship-wave relative direction	Wave direction	f (in kn/ft <sup>2</sup> )
$0^\circ \leq \Theta \leq 45^\circ$	Following seas	0.0083
$45^\circ < \Theta < 135^\circ$	Beam seas	0.0165
$135^\circ \leq \Theta \leq 225^\circ$	Head seas	0.0248
$225^\circ < \Theta < 270^\circ$	Beam seas	0.0165
$270^\circ \leq \Theta \leq 360^\circ$	Following seas	0.0083

**Table 1:** Values of coefficient f.

The period of time from the initial to the final node of the optimal and minimum distance routes was calculated for each case by SIMROUTEv2.

## Results

This section presents an application of the above theoretical methodology. Travel times of the considered routes and travel time using the optimal route compared to the minimum distance route (calculated by SIMROUTEv2) are summarised in Tables 2 and 3. Since most of studied routes last from 1 to 3 days, differences in wave heights can occur. The wave height used in each case (Calm-Smooth sea, Moderate-Rough sea and Rough-High sea) is the main sea affecting the route for a considerable period of time.

Table 2 shows the results obtained considering Calm-Smooth sea. Wave directions are negligible in this case but were considered in the other cases (Moderate-Rough sea and RoughHigh sea).

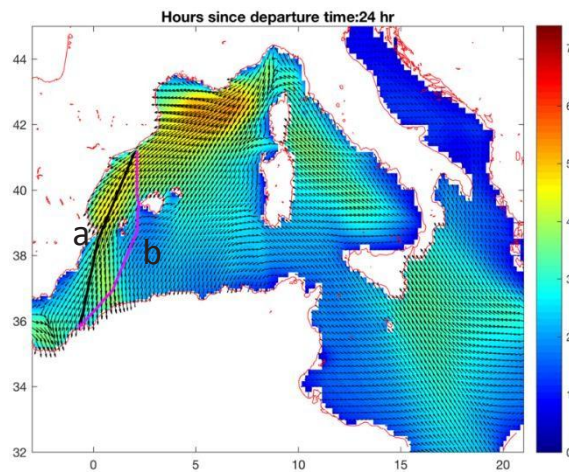
Route	Barcelona - Civitavecchia				Barcelona - Sousse				Barcelona - Oran				Barcelona - Taranto			
Ship speed (knots)	10	16	22.6	30	10	16	22.6	30	10	16	22.6	30	10	16	22.6	30
Minimum distance route (hours)	44.11	19.49	19.49	14.67	57.46	35.9	25.41	19.13	35.11	21.89	15.48	11.65	89.21	55.71	39.42	29.84
Optimal route (hours)	44.11	19.49	19.49	14.67	57.46	35.9	25.41	19.13	35.11	21.89	15.48	11.65	89.21	55.71	39.42	29.84
Saved travel time (hours)	0				0				0				0			

**Table 2:** Simulation results of travel time saved using the optimal route in comparison to the minimum distance route for all cases with Calm-Smooth sea (0-0.5m) and ship speeds of 10 knots, 16 knots, 22.6 knots and 30 knots.

Table 3 shows results considering all the routes, wave directions with Moderate-Rough sea and ship speed of 10 knots.

Route	Barcelona – Civitavecchia		Barcelona - Sousse		Barcelona – Oran			Barcelona - Taranto		
	Wave direction	Head Sea	Beam Seas/ Following Sea	Beam Seas	Beam Seas	Beam Seas	Following Sea	Following Sea / Beam Seas	Beam Seas/ Head Sea	Following Sea / Beam Seas
Wave height average (meters)	1.50	1.58	1.11	2.0	1.48	2.45	1.69	0.76	1.27	1.34
Minimum distance route (hours)	44.94	48.39	58.1	60.47	37.14	38.64	44.58	89.59	92.84	91.70
Optimal route (hours)	44.94	48.30	58.1	60.35	36.70	38.07	41.48	89.59	92.57	91.47
Saved travel time (hours)	0	0.09 (0.17%)	0	0.12 (0.19%)	0.44 (1.19%)	0.57 (1.47%)	3.1 (7.21%)	0	0.27 (0.29%)	0.23 (0.25%)

**Table 3:** Simulation results of travel time saved using the optimal route in comparison to the minimum distance route for all cases with Moderate-Rough sea (1.25-4m) and ship speed of 10 knots.



**Figure 2:** Minimum distance route (a) and Optimal route (b) from Barcelona to Oran on 21/01/2017. Estimated Time Departure (ETD): 20h. Initial speed: 22.6kn. Colour bar represents wave height.

As can be seen in the above tables, the travel time saved using the optimal route depends on the route, ship speed, wave direction and significant wave height. Some of the most outstanding results are presented as follows:

**Barcelona-Oran route (21/01/2017).** Rough-High sea: 4-9 metres. Predominant wave direction: Following sea. Initial speed: 22.6 knots (see Figure 2). This case provided the most remarkable results. Although head sea is the most critical wave direction, the following sea on that day altered the speed of the vessel substantially. The following sea had a negative effect on speed because the height of the waves was between 4 and 7 meters. The shortest path, without

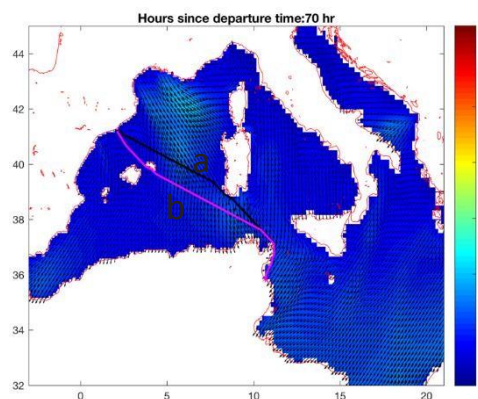
added wave resistance, took 15.44 hours. Travel time changed when the wave field was taken into account. Considering added wave resistance, travel time increased to 23.73 hours. However, most of the large high sea period was avoided with the optimum path. Thus, travel time decreased to 20.03 hours. This demonstrates that the algorithm optimisation leads to a 3.70-hour time saving.

Table 4 shows results of the Barcelona–Oran route on 21/01/2017 considering several ship speeds and maximum wave height encountered.

Speed (knots)	Maximum wave height (metres)	Minimum distance route (hours)	Optimal route (hours)	Saved travel time (hours)
10	6.91	The ship cannot sail because of maximum wave height conditions	50.47	The ship cannot sail because of maximum wave height conditions
16	7.29	35.66	30.03	5.63
22.6	7.04	23.7	20.03	3.7
30	6.99	16.21	14.45	1.76

**Table 4:** Barcelona–Oran (21/01/2017).

**Barcelona-Sousse (Date: 20/12/2016).** Rough-High sea: 4-9 meters. Predominant wave direction: Beam/Following seas. Initial speed: 10 knots (see Figure 3). At the start of the route between Palma de Mallorca and Barcelona, the weather conditions were challenging, with waves from 4 to 4.90 metres. The predominant beam seas had a negative effect on the stability of the vessel, leading to a reduction in speed. When the vessel was passing the area of sea surrounded by North Africa, Palma de Mallorca and Sardinia, following sea (waves from 1.50 to 3 metres) prevailed. The waves during this period had a positive impact on speed. The minimum distance route, without added wave resistance, took 57.26 hours. Travel time changed when the wave field was taken into account. Considering added wave resistance, travel time increased to 69.57 hours. However, most of the large high sea period was avoided with the optimal route path. Thus, travel time decreased to 67.41 hours. This demonstrates that the algorithm optimisation leads to a 2.16 hour time saving.



**Figure 3:** Minimum distance route (a) and Optimal route (b) from Barcelona to Sousse on 20/12/2016. ETD: 13h. Initial speed: 10kn. Colour bar represents wave height.



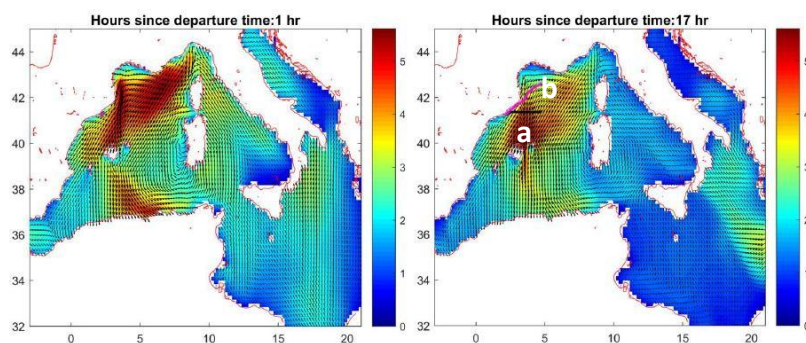
Table 5 shows results of the Barcelona–Sousse route on 20/12/2016 considering several ship speeds and maximum wave height encountered.

Speed (knots)	Maximum wave height (metres)	Minimum distance route (hours)	Optimal route (hours)	Saved travel time (hours)
10	4.90	69.57	67.41	2.16
16	5.21	39.16	39.12	0.04
22.6	5.30	27.06	27.06	0
30	5.30	20.07	20.07	0

**Table 5:** Barcelona–Sousse (20/12/2016). All cases.

**Barcelona-Civitavecchia (Date: 20/12/2016).** Rough-High sea: 4-9 metres. Predominant wave direction: Beam/Head seas. Initial speed: 10 knots (see Figure 4). This case was surprising because the track of the optimal route differed significantly from that of the minimum distance route. In the area of sea surrounded by Barcelona, Palma de Mallorca, Corsica and Sardinia, following sea prevailed. The height of the waves (4 to 4.80 metres) had a negative impact on speed. The minimum distance route, without added wave resistance, took 43.96 hours. Travel time changed when the wave field was taken into account. Considering added waves resistance, travel time increased to 50.70 hours. However, most of the large high sea period was avoided with the optimal route. Thus, travel time decreased to 49.72 hours. This demonstrates that the algorithm optimisation leads to a 0.96 hour time saving.

Table 6 shows results of the Barcelona – Civitavecchia route on 20/12/2016 considering several ship speeds and maximum wave height encountered.

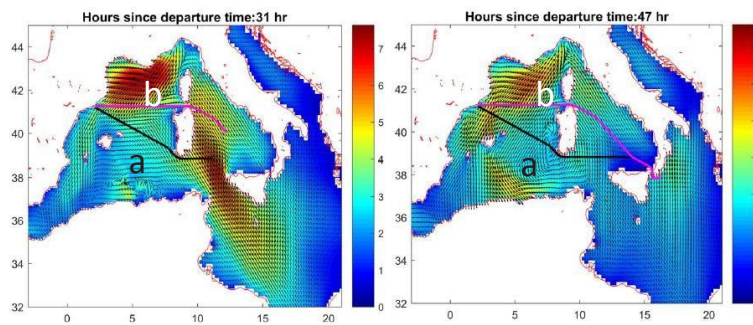


**Figure 4:** Minimum distance route (a) and Optimal route (b) from Barcelona to Civitavecchia on 20/12/2016. ETD: 21h. Initial speed: 10kn. Colour bar represents wave height.

Speed (knots)	Maximum wave height (metres)	Minimum distance route (hours)	Optimal route (hours)	Saved travel time (hours)
10	4.78	50.70	49.72	0.96
16	5.43	31.44	30.96	0.48
22.6	5.48	21.44	21.26	0.18
30	5.40	15.64	15.60	0.04

**Table 6:** Barcelona–Civitavecchia (20/12/2016). All cases.

**Barcelona-Taranto (Date: 18/12/2016).** Rough-High sea: 4-9 metres. Predominant wave direction: Head seas. Initial speed: 16 knots (see Figure 5). In this case, the vessel altered the course and changed the direction entirely when passing between Corsica and Sardinia. This change of course was necessary due to the extensive high wave field (maximum wave height of 5.53 metres) in the area of sea surrounded by Tunisia, Sardinia and Sicily. The critical head sea had a negative effect on the vessel taking the minimum distance route because of high wave resistance. The minimum distance route, without added wave resistance, took 55.44 hours. Travel time changed when the wave field was taken into account. Considering added wave resistance, travel time increased to 60.86 hours. However, most of the large high sea period was avoided with the optimal route. Thus, travel time decreased to 58.37 hours. This demonstrates that the algorithm optimisation leads to a 2.49 hour time saving.



**Figure 5:** Minimum distance route (a) and Optimal route (b) from Barcelona to Taranto on 18/12/2016. ETD: 20h. Initial speed: 16kn. Colour bar represents wave height.

Table 7 shows results of the Barcelona–Civitavecchia route on 18/12/2016, considering several ship speeds and maximum wave height encountered.

Speed (knots)	Maximum wave height (metres)	Minimum distance route (hours)	Optimal route (hours)	Saved travel time (hours)
16	4.40	60.86	58.37	2.49
22.6	2.97	40.72	40.28	0.44
30	2.23	30.09	29.92	0.17

**Table 7:** Barcelona–Taranto (18/12/2016). All cases.

## Conclusions

The present work studied the feasibility of the SIMROUTEv2 algorithm using a large number of cases. It was observed that if the wave field was not so wide, it was possible to avoid it and save time. Additionally, if the wave field extended along the route, the time difference between the optimal route and the minimum distance route was still more considerable. On the other hand, if the wave field was very wide and/or with a few extensions along the route (1 or 2 hours), the time saving percentage was 0%.

In the case of Calm-Smooth seas (almost negligible wave height), the optimal route was exactly the same as the minimum distance route. In consequence, the difference in time saving percentage was 0 in all cases and for all the routes. This means that the algorithm is not useful in Calm-Smooth sea conditions. In the case of Moderate-Rough sea, the algorithm can be feasible at ship speeds between 10 and 20 knots; in these cases, if the wave field is wide, time savings with the optimal route are considerable (between 0.25 and 2.5 hours). If high speed vessels (>23 knots) are considered, waves between 1.5m and 3m do not affect speed, and therefore time savings are negligible.

Finally, in Rough-High sea conditions, waves were more powerful than the vessel in most cases (maximum wave height >6 metres) for a speed of 10 knots. In this situation, the vessel is forced in reverse, which is ultimately detrimental to the engine. In some cases, the minimum distance route could not be taken by the vessels whereas the optimal route was always feasible by taking a different route while also adding travel time. For a speed of 16 knots, travel time savings varied considerably, i.e. ranging from 0.35 hours to 5.35 hours (in the extreme case of the Barcelona-Oran route), except for those cases where savings were 0 hours due to the wide wave field. In this situation, the vessel would not have taken a redirected route to avoid the waves because this would result in a significant increase in travel time. For speeds between 22.6 and 30 knots, time savings tended to be 0 hours, not including the Oran case, where the wave field extended along the route. In the Barcelona –Oran route, the optimum path avoided this field, leading to time savings between 3.70 hours and 1.76 hours, respectively.

To conclude, Table 8 shows general results of the feasibility of SIMROUTEv2 for Short Sea Shipping routes:

	10 knots	16 knots	22.6 knots	30 knots
<b>Calm-Smooth</b>	No	No	No	No
<b>Moderate-Rough (FS)</b>	No	No	No	No
<b>Moderate-Rough (BS)</b>	½	½	No	No
<b>Moderate-Rough (HS)</b>	½	½	No	No

Rough-High (FS)	Yes	Yes	½	½
Rough-High (BS)	Yes	Yes	½	½
Rough-High (HS)	Yes	Yes	Yes	Yes

**Table 8:** Feasibility analysis considering all cases. FS (Following sea); BS (Beam seas); HS (Head sea). Yes (feasible); No (not feasible); ½ (meaning that not all cases were feasible).

Future work will include the implementation of dynamic wave systems, implementation of a multi-criteria algorithm (e.g. NAMOA or genetic algorithm) including safety restrictions due to wave conditions (surf riding or rolling motions) in the methodology and the influence of currents and winds in optimum ship routing.

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## ONTOLOGICAL SYNTHESIS OF STRATEGIES FOR MARINE CATASTROPHES CONTROL IN EMERGENCIES

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**Abstract.** The ontological synthesis of strategies for marine catastrophes control on the basis of an emergency computing center (ECC) are discussed. Functioning of ECC in real-time mode is provided by the system integration of ontological synthesis of information, algorithmic and software on the basis of database of dynamic measurements and structured knowledge base. The focus is on providing support for decision-making in complex dynamic environments with the use of the modern theory of catastrophes.

**Keywords:** emergency computing center, an intelligent system, high-performance computing, real-time mode, dynamic theory of catastrophes.

### 1. Ontological synthesis of ECC models

Integrated development environment (IDE) of ontological synthesis for modeling and visualization of vessel behavior in an emergency situation is formalized on theoretical results [1] - [15] and uses the following models [5] - [7]:

$$Ont = Ont(M) \cup Ont(U) \cup Ont(R) \cup Ont(S) \cup Ont(D), \quad (1)$$

where Ont (M) - metaontology; Ont (U) - ontology for management calculations and modeling; Ont (R) - ontology for restrictions of the role of terms and relations between them; Ont (S) - domain ontology; Ont (D) - ontology of data for calculations and modeling.

With the formalization of the ontology model for domains Ont (S), which are general domain of problem of emergency control Ont (P), the following definitions are used [5], [7]:

**Definition 1.** Domain ontology

$$Ont(S) \rightarrow \langle Q, C \rangle \in Ont(P) \quad (2)$$

defines a number of terms Q (objects, processes and phenomena) and a plurality of relations C between them:

$$Q = \{q_k | k = 1, \dots, K\}, C = \{c_l | l = 1, \dots, L\} \quad (3)$$

**Definition 2.** Evaluation model of vessel behavior in an emergency is an interpretive theory in which framework various complex ontology formalisms are developed depending on the problem. The concept of space and time allows to define the basic concepts of the interpretation of vessel behavior on the basis of a dynamic model of catastrophes in the form of mapping [5]:

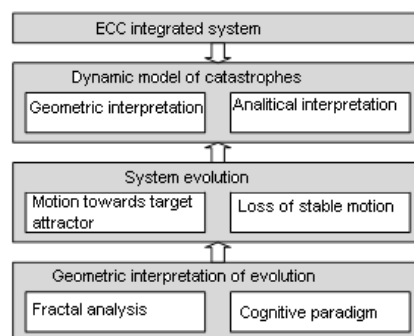
$$Ont[Cat(D)] = \langle Ont[Cat(B)], Ont[Cat(E, DO)], Ont[Cat(F, DO)] \rangle, \quad (4)$$

where Ont [Cat (B)] - ontology that describes the bifurcation set, Ont [Cat (E, DO)] - ontology of sets that defines the interaction of the system elements "vessel - environment"; Ont [Cat (F, DO)] - ontology of sets of features of interaction dynamics.

**Definition 3.** The construction of ontological system for the dynamic model of catastrophes within mapping (4) is carried out using the principle of competition [5] - [7]:

$$Ont[Com(PR)] = \langle Ont(ST), Ont(FLM), Ont(ANN) \rangle, \quad (5)$$

where Ont (ST) - ontology of the standard model which describes a state of emergency on the basis of the achievements of classical mathematics; Ont (FLM) - ontology model implemented in the framework of fuzzy logic basis; Ont (ANN) - ontology formalizing neural network model.



**Fig.1.** Ontology defining the dynamic model of the interaction system of ECC elements on the basis of the modern theory of catastrophes

Figure 1 presents an ontological system formalizing a dynamic model of the modern theory of catastrophes. It highlights aspects of the ontology defining features of the system behavior and its geometrical interpretation.

**Metaontology for interpretation of the evolution of the vessel in an emergency situation.** Among the possible conceptual metabasis corresponding to level of metaontology "space - time" in the interpretation of an emergency under the dynamic model of catastrophes can be distinguished [5] - [7]:

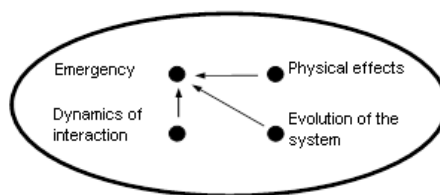
$$Ont[META(t)]: Ont - A[W, V, DO], Ont - B[W, V, DO], \quad (6)$$

where, Ont-A [W, V, DO] formalizes features, ratio, mapping; Ont-B [W, V, DO] - state, process, time, and the structure of W, V, DO - environment (interaction space), and a dynamic object.

With the formalization of a dynamic model of catastrophes as evolutionary potential of a self-organizing system the following assertion is justified

$$\forall C \in Ont - A[W, V, DO], [c] is - a [ob] \quad (7)$$

This means that the elements of the concept of "dynamic interaction"  $Cat \in C$  (Ont-A [W, V, DO]) are assigned to C-category "object of study", and a generalization of the problem of realization at W, V-model level leads to metadiagramme of interpretation system "Vessel - environment" methods of modern catastrophe theory shown in Fig. 2.



**Fig. 2.** Metadiagramme defining the generalization of the problem implementation of management strategies in the formalization of the interaction system

Thus, the natural metabasis Ont-A [W,V,DO] sets the object metaontology which language  $L(Ont-A [W, V, DO])$  has a logical model in the form of a given implication. The conceptual basis of the Ont-B [W,V,DO] is called "natural" and contains concepts "process", "state" and "time". Therefore, the model structure metabases Ont-B [W,V,DO] are *dynamic* and ontology Ont-B [W,V,DO] is an information system that focuses on the modeling of the



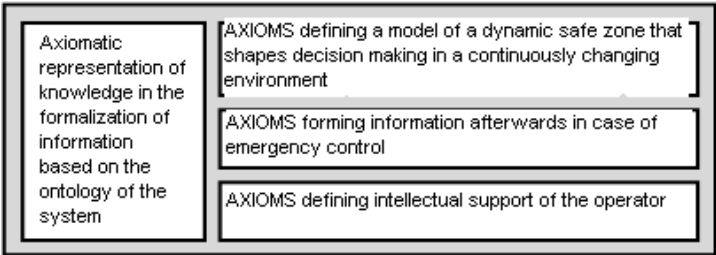
system of interaction of objects in a complex dynamic environment, which determines the state of emergency.

The dynamic system "ship - environment" in a state-space is a model structure that can be made on the basis of the algebraic system so that the logic model of this type of language will be one of the forms of action logic [3].

Thus, formal ontology model of the integrated ECC complex that defines the operation of the dynamic model of catastrophes allows to describe ontologies at different levels of abstraction. Based on this integration intelligent technology of knowledge integration is implemented with the use of ontological system [5]. The formalization of a system of knowledge consists is in the interpretation of the domain S(ES) in the form of structures having a certain semantic location - the spatial, temporal and functional. Considering the semantic space structures of investigated domain knowledge S(ES), it is necessary to carry out their semantic localization [5] - [7].

**2. The axiomatic basis of the interaction system dynamics**

The main operations which are performed in the ECC software package within information processing paradigm in multiprocessor computing environment [5] - [7] are based on an axiomatic basis [7], which allows to describe the behavior of the interaction system "vessel - environment" in an emergency situation at the level of structural and functional configuration (Figure 3).



**Fig. 3.** The axiomatic basis of the system

The principal advantage of this technology is the view of the system evolution on the implementation interval  $[t_0, t_k]$  in the form of fractal structures, and the view of interaction dynamics interpretation – using entropy analysis [4]. The result is simplicity and clarity of the mapping an emergency development process in a complex dynamic environment.

*Axiomatic knowledge representation.* General concepts of axiomatic study of the domain are specific to each applied ontology. In the investigated area axiomatic

representation of knowledge in the interpretation of the system is determined by formalization of information flow through a comprehensive ontology [5], [7] in the following axioms.

Identification axioms are the description of all types of variables and relationships of formalized structure of interaction system:

$$Axiom(Ident) = \langle Var, Rel \rangle \in \Omega(Str), \quad (8)$$

where Var, Rel - variables of the problem and the relationships between them;  $\Omega(Str)$  - knowledge of the structure.

planning axioms set the rules of calculations (the order and accuracy conditions). The basis of calculation in the phase space is the interval arithmetic property that allows for the convergence of the iterative procedure of calculation of interval values of parameters for localizing certain intervals containing the required decisions in the interpretation system:

$$Axiom(Plan) = \langle Evol(PH), Int(Cal) \rangle, \quad (9)$$

where Evol(Ph) - the evolution area of the phase space, Int(Cal) - interval arithmetic procedures.

Calculations axioms set the rules for calculating the relationship in the phase space of the system. Calculations axioms also include the optimization axiom.

$$Axiom(Calcul) = \langle Rule(Cal), Axiom(Opt) \rangle, \quad (10)$$

where Rule (Cal) - calculation rules; Axiom (Opt) - optimization axioms to ensure optimal decision-making research tasks, the structure of which is represented as logical axioms tables (Logical Axioms Table).

Thus, axiomatic knowledge representation allows to have modeling procedures support while the interpretation of the evolution of the vessel in a complex dynamic environment of an emergency.

Interaction system "Ship - environment" is developed on the time interval  $[t_0, t_k]$ , as a sequence of discrete states:

$$S(t) \in S[t_0, t_k] \quad (11)$$

which are formalized under the quasi-stationary hypothesis [6] - [7].

The state space of a fractal system  $S(t)$  is defined by an ordered set of fractal mappings. These mappings are a self-similar structure developing in the process of evolution of the system. In general, the fractal ensemble is portrayed as a compact set, presented on the basis of the interpretation of the dynamics of the system in an emergency. The sequence of cycles of evolution takes a fractal system  $S(t)$  of the current configuration, which determines the

beginning of its operation in the next state, defining its dynamics in the studied time interval  $[t_0, t_k]$ .

Stable development system stages  $S(t)$  determine the motion of a system of interaction to a target attractor. In this situation, the system remains in a state close to equilibrium, and its organization is undergoing significant changes. At a steady state of the system the external influences are described by means of streaming load, changing the fractal structure  $F_R$  depending on the characteristics of the situation. The movement towards the target attractor  $S(G, Attr)$  is determined by configuration in such a state of the system:

$$S(G, Attr) \rightarrow Stab(F_R). \quad (12)$$

Stage of the critical state (occurrence of the disaster) is characterized by the release of the test parameters of the system from the specified range and the emergence of bifurcation - the loss of stability of the system which is connected with the formation of alternative options for its organization. Cycles of functioning interaction systems define the process of self-organization  $S(G, SO) F_R$  fractal structure in continuous changes to the system dynamics. The system configuration when a loss of stability (the phase transition and the formation of the disaster) is characterized by the condition:

$$S(G, SO) \rightarrow Cap(F_R). \quad (13)$$

Thus, the conditions and their implementation within the framework of a dynamic model of disaster allow to formulate an axiomatic basis and present an emergencies interpretation ontology. Developed on the basis of such a formalization of the ontology model are regarded as components of the overall system problems ontology "vessel - environment" and defines the criteria for CR truth (True) to meet the requirements Dem completeness (Full) and consistency Dem (Non-Contr)] formulated axioms and inference rules:

$$Ont(SAU) = \langle C_R(True) [Dem(Full), Dem(Non - Contr)] \rangle. \quad (14)$$

### 3. Implementation of the axiomatic approach in the analysis of emergencies

Within the framework of the axiomatic approach recognition of abnormal behavior of the ship in an emergency is implemented using the following procedures:

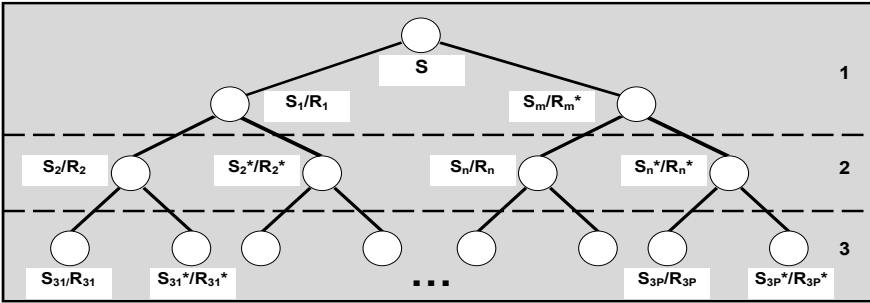
**Procedure 1.** Classes of abnormal behavior are defined and appropriate reference trajectory with unprecedented knowledge base are investigated.

**Procedure 2.** The analysis of the observed trajectory which is formed on the basis of fragments close to the classes of non-standard behavior is carried out.

**Procedure 3.** For selected trajectory fragments the sequence of axioms corresponding to the reference trajectories is defined.

Thus, the problem of recognition of abnormal behavior of the ship in emergency situations, based on ECC is reduced to the problem of fuzzy search of fragments of reference trajectories in the observed system trajectory.

The mathematical theory of the ECC computing system is defined by an object system and a system of relations within the ontological basis, and the logical structure of the interpretation of the dynamics of vessel - based on the fundamental provisions (axioms), determining *the evolutionary complexity* of the system. In such an analysis the analytical structure of the dynamical theory of catastrophes is represented by patterns of behavior and control spaces or a modified system of iterated functions (SIF) [7] and a geometric one – different visual models in the form of cognitive fractal images and maps. The problem of space-time is considered taking into account *the complexity of the measure* in respect of the interaction the ECC elements, communication concept analytical synthesis with physical laws of interaction dynamics.



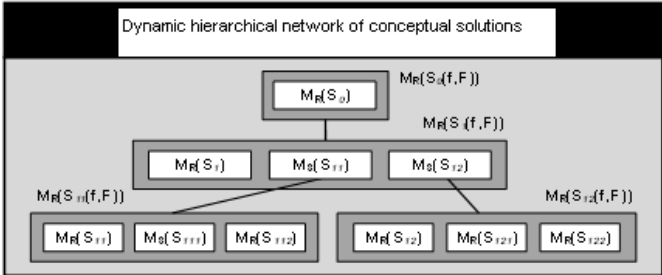
**Fig. 4.** Wood states of a complex system: S - system components; R - the result; 1 - system; 2 - subsystem; 3 - element

As a result of the processing of information about the dynamics of the vessel with the definitions set forth above, statements and axioms on the interval  $[t_0, t_k]$  carried out the operation of interpretation. System approach to the interpretation of the current situation of catastrophe theory methods allow to formalize the process of modeling the dynamics of the vessel and to the interaction space network in a *tree of states* of a complex system (Fig. 4). The forecasting task for the behavior of the ship in an emergency is a chain of transformations:

$$X_1(T, S) \Rightarrow Y_1(Out), \dots, X_n(T, S) \Rightarrow Y_n(Out), \tag{15}$$

where the components  $X_1(T, S), \dots, X_n(T, S)$  determines the interpretation of the function at each step of the operation of interpretation and management of the dynamic theory of catastrophes or a modified SIF using the control function, and  $Y_1(Out), \dots, Y_n(Out)$  – results of the study of the system specification forecast.

One of the ECC features – *hierarchical organization* which determines the conditions of management in time delays, noise and uncertainty. Strategic planning of operations and conceptual solutions in a hierarchical organization is represented in the form of a dynamic hierarchical network [11] (Figure 5) that displays the result of the integration of a fundamental component of a dynamic model of catastrophes and modified on the basis of the SIF intelligent technology and high-performance computing [7].



**Fig. 5.** Structure of the dynamic hierarchical network

The hierarchical model allows us to describe the dynamics of a vessel in an emergency situation at various levels of abstraction: the reflection elements, properties, performance, determining the management and interpretation in the process of development of the situation. When the decomposition is implemented *connectivity concept*, defines a representation of the original model  $M_R(S_0)$  in the form of a set of sublevels models of tree-like attitude. Formation of hierarchy is carried out using standard decomposition bases. At any level of the hierarchy ECC subsystems are defined and the relationships between them, while providing the level of the whole, and not lost the finest levels of analysis.

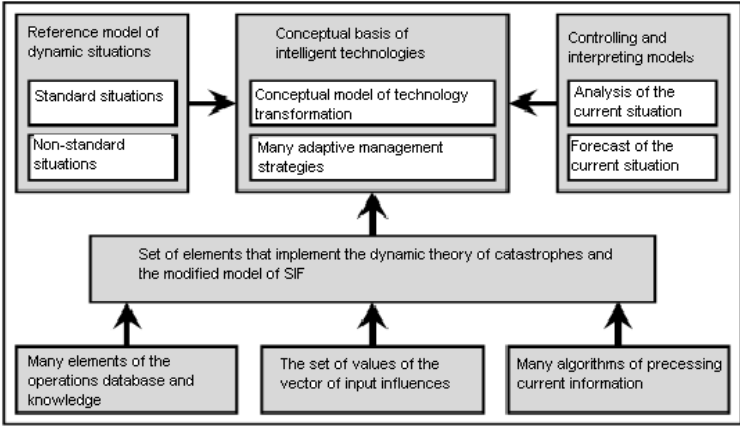
This interpretation of the data shows *the principle of subsidiarity*. According to this the conditions in which a continuous change in the behavior of the vessel are provided. A formal model of information transfer opens up opportunities to find solutions with the use of hierarchical structures characteristic of the investigated tasks. This model does not depend on the contents and the task analysis and is a versatile apparatus for analysis and search for solutions. This opens the possibility of "compression" of information, because of the dynamic measurements only the data is obtained which is required during emergency control.

Thus, the ECC computing complex is regarded as ADS [9] which operates in a complex dynamic environment. System control is in formation of procedures minimizing the objective function for maximum efficiency of the control in the current situation. ECC objects are considered as active elements which functions are aimed at modeling and visualization of vessel dynamics. When generating alternatives, and the development of control actions the

collective strategy selection is carried out, based on the active elements of the strategy of the system. The hypothesis of the independent behavior of active elements of ECC is considered within the paradigm of information processing in a multiprocessor computing environment. Synthesis of the ECC optimum active elements management ensures maximum efficiency of information processing procedures. Many ongoing activities is determined by the decision making procedures. Planning activities in the assessment of the system status and forecasting its development is the choice of effective planning procedures based on optimality criteria.

<b>Model of information transformation in ECC</b>	
<p><b>VECTOR OF CONDITIONS</b> A set of conditions for the existence of solutions <math>X = \{X_1, \dots, X_n\}</math> The components of the vector are the data of dynamic measurements of the parameters of the objects of the external environment (wind and waves)</p>	<p><b>MATRIX OF CONFORMITY</b> The model of the relationship between conditions and solutions</p> <div style="text-align: center;"> </div>
<p><b>VECTOR OF DECISIONS</b> Many possible solutions <math>Y = \{Y_1, \dots, Y_m\}</math> The components of the vector are non-standard (non-standard and extreme) situations</p>	<p>Each cell of the matrix characterizes a clear and fuzzy match between X and Y</p>

**Fig. 6.** Model of information transformation in the analysis of the behavior of ship emergency



**Fig. 7.** The conceptual basis of intelligent technologies the interpretation of the behavior of the ship in case of emergency

Figure 7 presents a conceptual basis of intellectual technologies which implements the information transformation procedure in the interpretation of the behavior of the ship on the basis of the dynamic theory of catastrophes [5] and the modified model of SIF [7].

Model of interpretation of the situation is presented in the form of the interaction field in which the transformation and geometric mapping are carried out allowing to understand the learning and development processes and to identify "subtle effects" of the phenomenon under

study. The cognitive process provides a "compression" of the processed signal and the maximum possible code of abstraction contained in the signal description in order to achieve a higher degree of predictability [5] - [7].

## **Conclusion**

The ontological synthesis of vessel behavior control models in the event of maritime catastrophes provides a solution to the problem of increasing the effectiveness of the decision making process in the operation of the ECC which implements the methods of the dynamic theory of catastrophes. Presented decisions determine a problem of interaction of the ship with the environment on the basis of the axiomatic approach formalizing achievements of intelligent technology and high-performance computing. An adequate description of the hierarchical organization and the identification of the physical laws of the process of interaction in emergency situations is achieved by identifying the essential elements of functionally significant interpretive ECC system. This analysis makes it possible to develop mechanisms of formation of administrative decisions and to module calculations in emergency mode. [14]. Compression of information and the construction of interpretive models are achieved on the basis of the matrix of conceptual solutions, dynamic hierarchical network and the formal apparatus of analysis and forecasting of the behavior of the ship in emergency situations. [5] - [7], [11], [13], [15].

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# CYBER THREAT IN MARITIME INDUSTRY – SITUATIONAL AWARENESS AND EDUCATIONAL ASPECT

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**Abstract** This paper examined a variety of important educational issues, management practices, and information technologies related to cyber security. The field of cyber security is more important than ever for any one maritime organization and related companies in the supply chain. As well government organizations and law enforcement agencies have to work with private companies to share, communicate, and collaborate in solving technical and human issues in this field. If all the personnel are well prepared in the cyber security domain according to the responsibilities and duties this will raise the level of cyber security awareness, alert, and readiness for action.

Based on the content analysis of the curriculum of the specialties at Maritime University NVNA, Varna and identified cyber threats and means to impose them in maritime domain the authors suggested new approach to enhance not only the education of cyber security expert and manager but all the personnel involved as an users of communication and information systems supporting the business processes of the maritime companies/infrastructures.

Exploring the statistics of cyber incidents, such as information losses, theft, and malware propagation causes business failure the authors bring their attention to the human factor in cyber security. For solving the issue with the highest percentage of cyber incidents causer they reach the conclusion that it is vital to stress not only to the technical part of cyber security and prepare well educated administrators and managers but to pay significant attention to every one user of the information systems used in navigation and maritime business.

**Key words:** Cyber security, cyber threat, human factor, education, curriculum

## Introduction

Today's modern cyber commerce-based industries such as the navigation and maritime industry are faced with increased global competition and increased physical and cyber security threats, while simultaneously striving to increase value in the value chain. Since the 1970s information

and telecommunication systems have provided business many benefits in the field of commerce, such as:

- Increased efficiency of core business process (e.g., human resources/staffing, payroll, accounting, etc.);
- Improved information sharing between trading partners (e.g., importers/exporters, shipping companies, charterers, agents/representatives, custom brokers, and government authorities); and
- Enhanced communications between administrative employees, manning organizations, and vessel personnel.

The field of cyber security and assurance is complex and challenging, as it involves many human and technical aspects of security. To strengthen the cyber security is not only technical but mainly human issue.

The authors raise the thesis that to enhance the level of cyber security it is necessary to stress on human factor and particularly to conduct proper education of all the regular users of the information systems implemented in the navigation and maritime business.

### **1. Human factor in a maritime company cyber security**

The history of cyber security is closely linked to the field of computer security and has its roots in World War II. During this conflict, the British and U.S. militaries had various programs to intercept and crack the communications of the German and Japanese forces. In fact, some historians argue that this was the only way that the United Kingdom and the United States gained an advantage over its adversaries.

In the mid-1990s, one of the major results of the Year 2000/Millennium Bug crisis was the growth of *enterprise resource planning* (ERP) systems. Instead of rewriting or otherwise fixing thousands of lines of programming code in their various applications, many organizations found it more efficient to replace their legacy systems with ERP systems. During this time, products such as SAP R/3, PeopleSoft, JD Edwards, Baan, and Oracle Financials became very popular, particularly in large global companies.

One of the concerns with ERP systems is the tight integration of the individual software modules (e.g., human resources, payroll, accounts payable, etc.). Practically, to implement these systems before January 1, 2000, some of these projects were done very quickly. ERP systems are known to be highly complex. Therefore, the security aspects of these systems are complicated.

Database security is yet another facet of cyber security. The main issues within this area typically involve restricting access control and limiting file updates and retrieval mechanisms and powerful user privileges. Individual user rights need to be appropriately restricted based on

job duties. Retrieval methods should also be tightly controlled to prevent accidental or intentional data corruption and theft.

Application security is concerned with detailed security configuration and parameters within a specific software product such as the International Maritime Organization’s Global Integrated Information System. This type of security is highly dependent on the security features and capabilities that were built into the software when it was developed. For instance, some applications allow for detailed security settings, whereas others do not. Application security typically covers such important features as access controls, transaction processing, and file permissions (i.e., read/write, modify, read only, delete, etc.).

Maritime organizations operating in the electronic commerce environment face various vulnerabilities. The first common vulnerability is errors which are intentionally mistakes by personnel. For example, an employee might accidentally input the wrong financial figure in an electronic spreadsheet, and a manager then uses this information to make an incorrect business decision. The second common vulnerability is fraudulent acts, which might involve collusion with other employees (e.g., both information systems and non-information systems) as well as outsiders. Reputational risk is another important risk to address. One information security incident such as defacement of the company’s website could have an important impact on the company’s general reputation in the industry. Business interruption is the final common technical threat which deals with the financial consequences of a cyber security incident. This should be analyzed in a *business impact analysis study*, which can be performed by a cyber security officer or consultant, which in turn is then integrated into a risk management plan by the CSO and other executives.

Human threats arise from both intentions and unintentional errors. Some sociologists have studied the field of human behavior to formulate ideas as to why people intentionally deceive other people and carry out malicious activities. A summary of these threats is provided in Table 1.

<b>Threat</b>	<b>Internal</b>	<b>External</b>
Current Employees	XX	
Contractors and Facility Managers	XX	
Customers/Clients		XX
Service Providers		XX
Former Employees		XX
Former Consultants		XX
Hackers		XX
Organized Crime Groups		XX
Terrorist Organizations		XX
Competitor Firms		XX
Social Action/Pressure Groups		XX
Rogue Nations		XX
Other (s)	XX	XX

**Table 1.** Summary of Human Threats to Cyber Security

Current employees may intentionally attempt to alter systems or steal data in retaliation for some type of work-related conflict. This situation may occur due to a missed promotion, low compensation structure, or workplace conflict. In fact, the most recent survey on cyber criminality indicated that most malevolent activities related to IT are actually perpetrated by insiders, with 70% of the organizations responding that they were aware that security breaches occurred in their organizations (Gordon, L., et al. 2006, CSI/FBI computer crime and security survey. Available online at <http://www.gosci.com/2006survey>).

External threats evolve from former employees, contractors, and consultants, as well as various groups of *cyber warriors*. Hackers and organized crime rings are the most popular groups of outside threats that most cyber security officers consider.

Organized crime is another external threat to cyber security in the maritime sector. Through influence and pressure, these groups seek to take advantage of others in order to benefit themselves and their associates and sympathizers, profiting from such illegal activities as extortion, money laundering, drug sales, prostitution, and gambling. Today, they can also stalk people online, send threatening e-mail messages, and post messages on websites and blogs.

Terrorist organizations, rogue nations, and political/social action groups also pose threats to the critical infrastructures. Cyber terrorists normally fall into two categories: nationalists/extremists or foreign terrorists. The Internet is an attractive training ground, information dissemination tool, and group-think platform for these groups. No matter where they are physically resided, the Internet provides an inexpensive tool for destruction. In addition, rogue nations are classical enemies of a nation in both a traditional warfare context as well as from a cyber-warfare perspective. Finally, political and social action groups motivated by their own agenda also pose threats, some of which are physical threats.

In terms of the transportation infrastructure, a large denial of service attack could have devastating results. For instance, what would be the impact of a ship that explodes in a large port facility whereby emergency response systems are temporarily or permanently disabled? Today's government information systems store vast amounts of important information, and in the maritime industry some of these systems are available to the public at large, whereas others are accessible only to commercial companies that participate in selective government programs. There is also a wide variety of additional general business threats and risks that are also relevant to the maritime industry. Although they are common to other traditional organizations, it is worthwhile to acknowledge that these risks are also evident. They include sociological, criminal, political, economic, and legal issues (Alexander, Y. and Swetnam, M.S. *Cyber terrorism and information warfare: Assessment of challenges*, vol. 1. Dobbs Ferry, New York: Oceana Publications. 1999, p.38).

Ethical consideration in cyber security includes such issues as employee e-mail monitoring, acceptable use of policies, and disciplinary action plans that an organization must consider. Often, these are controversial issues in the workplace. For this reason, it is important to have a strict set of company policies including a corporate *code of conduct*.

## **2. Means of cyber actions**

Information is a vital asset to every maritime organization. Any accidental or deliberate destruction or theft can cause damage to the company in a variety of ways. Depending on the criticality of the information, this could have dramatic effects on the organization.

*Malware* is a comprehensive term covering a variety of malicious forms of computer software. Included in this category are *computer viruses*, *worms*, and *Trojan horses*. Computer viruses are the most popular form of malware, and popular viruses have received a lot of discussion in the information systems field.

There have been a number of pervasive, powerful, and destructive computer viruses. Some of them have interesting names, such as ILOVEYOU, Melissa, Naked Wife, and WannaCry, which help make them appealing to the user when they appear as e-mail subject lines or file names. These viruses spread rapidly through the Internet due to the virus file being attached to e-mail messages. Computer viruses are not only common but also very costly in terms of their impact on business organizations. For instance, total costs of the ILOVEYOU virus were estimated to be \$7 billion (Ghosh, A. K. Security and privacy for e-business. New York; John Wiley & Sons, Inc. 2001, p.87).

Denial of service attack is particularly important to web-based business. In essence a denial of service attack is overflowing of a computer system with more data than the system itself has the capacity to manage. This situation often forces system administrators to shut down their e-commerce systems and websites until the proper protection can be implemented.

Due to the diversity of network architectures, such as wide area, local area, virtual private, and various others, an organization needs to make various considerations. This is due to the underlying protocols being used. Two common risks in network security include sniffing and spoofing.

*Sniffing* involves an unknown party “listening” on the network using a hardware or software tool. This listening can involve undetected e-mail transmissions, free-text user ID and password details, and other valuable communications. A sniffer can be placed at a single location or in various locations within the company’s network. This also makes the detection of such activities difficult for cyber security officers and network administrators.

*Spoofing* is also known as masquerading. In this attack, one user impersonates another user or pretends to be an external party such as a customer, vendor, or other third party. This type of attack can be easily complicating the cyber security enforcement and detection processes.

Organizations can implement various countermeasures to fight computer viruses. First, antivirus software should be installed on all PCs, file servers, and mail gateways. While it is critical to have this software loaded on workstations and servers, it is also important to make sure that this software is updated regularly. Second, companies should educate employees about the dangers of downloading software that has not been tested, approved, and licensed. For instance, shareware (i.e., software that is based on a liberal software distributed license) and freeware (e.g., software available without charge) can easily contain spyware and adware, which in turn can be used for computer zombies and botnets (Backhouse, J., et al. Risk management in cyberspace. In R. Mansell and B. S. Collins (Eds.), Trust and crime in information societies, Cheltenham, United Kingdom: Edward Algar Publishing. 2005, p.156).

### 3. Scope of the maritime cyber education at NVNA

Maritime University NVNA Varna has accredited specialties with developed curriculum in bachelor and master degree in the area of navigation, engineering, shipping and ports, maritime logistics, ICT, all of them civil and part of them - military oriented.

Specialties	Curriculum	
	Bachelor degree	Master degree
Navigation	XX	XX
Marine engineering	XX	XX
ICT in marine industry	XX	XX
Inland water navigation	XX	
Fleet and port management	XX	XX
Water transport management	XX	XX
Shipping	XX	XX
Ship electrical engineering	XX	XX
Ship repair	XX	XX
Ocean engineering	XX	
Marine safety and security		XX
Cyber security		XX
Logistic		XX

**Table 2.** Summary of NVNA curriculums

Scrutinizing all the curriculums, taking in mind the complexity of the information systems implemented in shipping and maritime business, and the promoted cyber security measures it could be summarized that:

- All the students are educated and trained to work their future jobs as users of information systems. The characteristics of seafarers and maritime business professions are to use a big

amount of information that modern companies/infrastructures acquire, process, store and share using computers/consoles organized in local/global nets

- The cyber space domain is presented in curriculums as environment where the users benefit from connectivity, integrity and huge capacity
- The cyber security is not presented in bachelor's degrees
- There is no educational program for education of the students for the management security issues in the cyber area – for the positions ‘Cyber Security Officer’
- The master program ‘Cyber security’ is oriented to educate students for the security issues in the cyber area – for the positions ‘Cyber Security Engineer’
- The bachelor and master degree of the specialty ‘ICT in marine industry’ is dedicated to educate students for the positions: network engineers, systems administrators, application programmers, and system programmers
- There are no subjects in the bachelor and master programs that to support cyber security education of regular users of the information systems

Could be conclude that *the adapted at NVNA educational system is partly capable to prepare leaders, experts and users for the maritime cyber security domain.*

### **3. How to improve cyber awareness and cyber security in maritime domain by proper education and training**

Based on the analysis of the identified threats and means of cyber attacks and existing curriculum in the NVNA the following suggestions for improving education and training for enhancing the cyber awareness and cyber security in maritime domain are elaborate:

- To establish curriculum for education of the students for the management security issues in the cyber area – for the positions ‘Cyber Security Officer’ – master degree program ‘Management of cyber security’. The curriculum must bear two core fields – management and business courses (Information Technology Project Management; Security and Privacy of Information; Information Systems Legal Framework; Information Systems Strategy and others) and technical courses (Knowledge Management; Systems Integration; Systems Development; Incident Response Systems; Cybersecurity and others) (See: MBA in Information Systems, Georgia State University, <http://www2.cis.gsu.edu/cis/program.mbasic.asp>).
- To introduce in the curriculum of all the specialties of the bachelor degree a subject ‘Cyber security fundamentals’ which can include:
  - = The key principles of cyber security: *Ease to Use, Need to Know, and Least Privilege* (Whitman, M. E. and Mattord, H. J. Principles of information security. Canada: Thompson Course Technology. 2005, p. 54).

= The primary objectives of the information technology security - *confidentiality, availability, integrity, nonrepudiation, and authentication*.

= The categories of information system cyber security - *physical controls* and *logical security* (Barber, R. The evolution of intrusion detection systems – the next step. *Computers & Security* 20 (2), 2001, p. 138).

= The organizational policies:

- Document classification schemes - supported by the organizational policies about how information and related documents can be shared within and outside the company. Information classification scheme with three major categories: *Public/Non Confidential, Secret/Proprietary, Top Secret/Highly Confidential* (Bosworth, S. and Kabay, M. E. *Computer security handbook* (4<sup>th</sup> ed.). New York: John Wiley & Sons, Inc. 2002, p.245).

- The company's culture on what types of information are allowed to be viewed and shared between various employee groups.

- Organization of security personnel in the company with a cyber security functions that can promote and enforce the company's cyber security policies and procedures. (Cyber systems and physical security department, chief cyber security officer, Cyber Security Officer, Cyber Security Engineers, network engineers, systems administrators, technicians, application programmers, and system programmers).

- Outsourcing some or all of organizational network management processes to a service provider to provide adequate information security.

= trusted user and his responsibilities.

### **Summary**

The legal issues related to information and cyber security are diverse and often complex. For instance, global regulation of the Internet has often been cited as one of the major obstacles to further development of this important technology. Finally, we can expect that the field of cyber security will continue to expand and mature as information systems and communication technologies become more prevalent in the maritime and transportation industries.

Improving the cyber security in maritime domain is achievable through establishment of clear situational awareness having well-educated end experienced expert and managers in cyber security domain and basically informed 'trusted' regular information system users.

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# **A STUDY ON MARINE POLLUTION PROBLEMS IN BLACKSEA AND MITIGATION OF THE DEFICIENCIES**

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## **Abstract**

Environmental Pollution in particular Marine Pollution is an international problem which seriously threatens human life and nature. As the pollution increase gradually and its negative impacts are understood by society, awareness and concerns on environmental protection increases. This study presents the main sources and/or reasons of maritime pollution, investigates the current situation in Turkey in the light of national and international acquis and level of implementations in order to define problem areas and gaps concerning governance. The Study involves mainly the Turkish maritime environment and neighbouring areas and focuses on the Black Sea region which is the most affected part of Turkey. It also investigates the level of the shipboard pollution and related issues. The purpose of this study is to investigate the legislation related to Maritime Environment Protection and problem areas on the application which directly affects Maritime Environment to define the measures to be taken for mitigation of the deficiencies.

**Keywords:** Environmental Pollution; Marine Pollution; Protection of the Environment; Pollution in the Mediterranean and Black Sea.

## **Introduction**

Oceans occupy 71% of the world's surface and contain 97% of the earth's water. Ocean water is 96% pure water. They present outstanding sources to sustain the life of the human, fauna and flora as well as worldwide lines of communication for sharing foods, goods and any other kind of products. That is the reason why it is sensitive to protect the maritime environment.

It is clear that all international and national measures or solutions to prevent pollution at sea are not sufficient. Whereas lands are under the sovereignty of a single nation, sea areas are shared by many nations and there is not an authority which has full control on the seas. Reluctance of a single neighbouring country may cause a serious damage to adjacent sea areas as the others are keen to protect the environment. The Black Sea is a good example which is seriously polluted by rivers which rise in different basins and pass through different countries.

The source of marine pollution is mostly generated by neighbouring land areas. Unfortunately many countries discharge their land origin pollution into seas. And as a result of the nature of the water, the pollution expands moving by winds or water currents. That is the reason why we need international regulations and intervention systems which have been fully supported by each individual nation to protect the marine environment.

Although we have many international organizations and national or international nongovernmental organizations which focus on environmental protection and there are many regulations, conventions, laws, codes etc. we are still not able to prevent the pollution. Current researches prove that the main problem is the insufficient implementation of the international regulations and national legislation accordingly, especially in the developing countries. If we have the perfect regulations concerning prevention of maritime pollution but we are not able to implement them, there is no possibility of success. Therefore, concrete measures to implement rules and regulations are strictly required in protection marine environment.

The shipping which transports 90 per cent of global trade is statistically the least environmentally damaging mode of transport when its productive value is taken into consideration. Moreover, set against land-based industry, shipping is a comparatively minor contributor, overall, to marine pollution from human activities” (IMO 2014).

### **Method**

The aim of this study is to look through the acquis related to marine environment protection and define problem areas and the missing points on application of the procedures which directly affects marine environment and measures to be taken for mitigation of the deficiencies in the Black Sea which is polluted actrousciosly.

The study starts with a comprehensive literature quest which is intended to gather detailed information on the sources of pollution which affect the maritime environment negatively, the current situation of maritime environment protection in the light of national and international acquis. The second step is based on an investigation which may help to solve the problem areas met and proposals to mitigate the deficiencies. The third and last part of the study covers the most reliable and applicable proposals to find remedies for existing and future problems.

### **Research**

The discussion is based on the evaluation of the pollution sources and effects. It covers a comprehensive study on the existing situation, legislation and applications in the world.

Major threats to marine environment are; Unplanned Coastal Development, Land Based Sources of Pollution, Marine-based Activities, Overfishing, Habitat Destruction, Climate

Change, Invasive Species and Nuclear Power Plants and Pollutant type of Ammunitions. Major environmental impacts of the pollution to oceans are ‘Loss of Biodiversity’ and ‘Damage to Sea Life’. Table-1 below provides an idea concerning to the sources of oceanic oil pollution. It is noticeable that the biggest source is natural seeps mainly derive from land.

Table-1: Sources and Percentages of Oceanic Oil Pollution (Source: GESAMP 2007)

SOURCE	PERCENTAGE
<b>Natural seeps</b>	<b>49</b>
<b>Ship activity related</b>	<b>39</b>
<b>Coastal</b>	<b>10</b>
<b>Offshore production discharges</b>	<b>2</b>

Marine based activities include operations of huge merchant fleets especially in dense shipping areas also creates negative effects. In the last ten years, the dimension of world fleet increased 53 percent. International Seaborne Trade is developed 10 times (from 2.005 B tonnes to 9.842 B tonnes) between 1970 and 2014. The most important part of the sea sourced pollution is the oil spill and the major oil spill accidents occur in the Atlantic Ocean and the Mediterranean which have condensed sea traffic. These accidents create harmful and long duration pollution in the adjacent shore lanes.

2011 was a record-breaking year for extreme climate and weather events. Leading scientists are investigating the relationship between such events and climate change. According to the latest insights, climate change is leading to changes in the frequency, intensity, length, timing and spatial coverage of extreme weather events. New studies also suggest that the combined impacts of higher sea temperatures, ocean acidification, lack of oxygen and other factors could lead to the collapse of coral reefs and the spread of ocean dead zones (UNEP 2013).

The long term effects of nuclear disasters can often spread over thousands of years. It is estimated that Chernobyl won't be inhabited for at least another 20,000 years. But Nuclear Power Plants are prominent and provide approximately 5.7% of the world's energy and 13% of the world's electricity. With 437 Nuclear Power Plants worldwide, there are bound to be incidents every now and again (Process Industry Forum 2012). Nuclear decommissioning refers to safe handling, at the end of life, of nuclear power reactors and nuclear facilities. After the Fukushima accident, the number of reactors to be decommissioned in the next ten years is set to increase significantly (UNEP 2012).

***International Acquis on Marine Environmental Protection***

UNEP established in 1972, is the voice for the environment within the United Nations system. UNEP acts as a catalyst, advocate, educator and facilitator to promote the wise use and sustainable development of the global environment. UNEP has close relations with IMO's MEPC (Marine Environment Protection Committee) concerns with marine pollution from ships. UNEP's Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal) adopted in 1989. Basel obligations are mainly imposed on or directed to state parties.

IMO as the custodian of the 1954 OILPOL Convention assumed responsibility for pollution issues. As a consequence, it has, over many years, adopted a wide range of measures to prevent and control pollution caused by ships and to mitigate the effects of any damage to the environment that may occur as a result of maritime operations and accidents. IMO's area of interest concerning marine environment includes; Pollution Prevention, Pollution Preparedness/ Response, Ballast Water Management, Bio fouling, Anti-fouling systems, Recycling of ships.

In 1973, IMO adopted the International Convention for the Prevention of Pollution from Ships (MARPOL) which is an international convention for the prevention of pollution from ships. SOLAS, STCW 78 (2010), ISM and ISPS are also major instruments of IMO for safety. IMO also recognises that some areas need additional protection and the MARPOL Convention defines certain sea areas as "Special Areas" in which the adoption of enhanced special mandatory measures for the prevention of pollution is required. The Mediterranean Sea and Black Sea are declared as special areas against oil and waste dumping. But the special area requirements are not in effect in the Black Sea. MARPOL defined limits of Sulphur Dioxide and Nitrogen Oxide emissions from ship exhausts and prohibits deliberate emissions of ozone depleting substances in 2005. IMO adopted mandatory measures of energy efficiency to reduce Green House Gases (GHG) emitted by the ships in 2011. The Lower global sulphur cap in the Emission Control Areas (ECA) will be reduced to 0.50% max as of 1 January 2020.

IMO Assembly has adopted Guidelines for the designation of Particularly Sensitive Sea Areas (PSSAs), which are deemed to require a higher degree of protection because of their particular significance for ecological, socioeconomic or scientific reasons, and because they may be vulnerable to damage by international maritime activities. To this date, fourteen PSSAs have been designated by the IMO (MEPC 2012). The "London Convention" of 1975 which has been replaced by London Protocol in 2006, is one of the first global conventions to protect the marine environment. International Convention on Oil Pollution Preparedness, Response and

Co-operation 1990 (OPRC 90) and the Protocol on Preparedness, Response and Co-operation to Pollution Incidents by Hazardous and Noxious Substances, 2000 (OPRC-HNS Protocol) are the major international instruments. Figure-1 below shows the relations between the ship source pollution and related instruments.

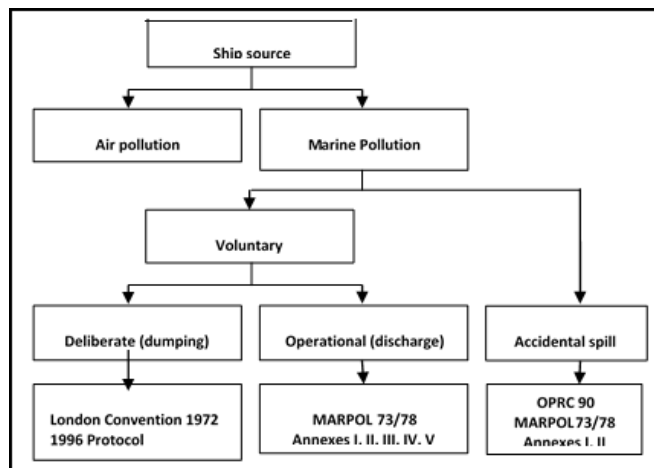


Figure-1: Ship Source Marine Pollution (Source: Mukherjee 2010)

### ***Discussion on the Situation in the Black Sea***

The Black Sea is one of the most remarkable regional seas in the world having over 2,200 m deep and receives the drainage from a 1.9 million km<sup>2</sup> basin covering about one third of the area of continental Europe. It carries about 300 km<sup>3</sup> of seawater to the Black Sea from the Mediterranean along the bottom layer and returning a mixture of seawater and freshwater with twice this volume in the upper layer through the Turkish Straits. Every year. About 350 km<sup>3</sup> of river water enters the Black Sea from an area covering almost a third of continental Europe and including significant areas of eighteen countries. Europe's second, third and fourth largest rivers (the Danube, Dnipro and Don) all flow to the Black Sea (BSC 2008). The Black Sea is the most polluted area in the Mediterranean. Black Sea being a most isolated from the world oceans, has the most eutrophication, and is the most poisonous (hydrogen sulphide), the most anoxic and the most environmentally endangered sea and she requires more attention. Proliferation of pipelines and oil terminals, increased offshore activities for exploration and exploitation of hydrocarbon resources increased the risk of accidental spills; risk of operational/illegal discharge and risk of introduction of harmful alien species through ballast waters. Beginning point of the mitigation looks like the dirty inland rivers which pour to the Black Sea. All river coastal states must stop pumping/leaking of the pollutants into the rivers (Oral 2008).

### ***Pollution Protection Efforts in the Black Sea Area***

In April 1992 six Black Sea countries (Bulgaria, Georgia, Romania, Russian Federation, Turkey and Ukraine) signed and shortly thereafter ratified the Bucharest Convention on the Protection of the Black Sea against Pollution with its three integrated protocols. Convention obligates the contracting parties, in particular, to prevent pollution; by hazardous substances or matter; from hazardous wastes in trans-boundary movement and the illegal traffic, from land-based sources; from vessels; resulting from emergency situations; by dumping; caused by or connected with activities on the continental shelf, including exploration and exploitation of natural resources; from or through the atmosphere. The Black Sea Commission (BSC) is the intergovernmental body for promoting the implementation of the provisions of the Bucharest Convention, its protocols and Strategic Action Plan and the regional focal point for any aspects of the coastal and marine environment of the Black Sea. The Black Sea Environmental Programme (BSEP) launched in 1993, included a number of interventions by the GEF (Global Environment Facility), including the development of the first Black Sea Transboundary Diagnostic Analysis (TDA), finalised in 1996. The Black Sea Strategic Action Plan (BS-SAP), signed in the same year. Following the signature of the BS-SAP, GEF funding was sustained in order to enable countries to complete National Black Sea Strategic Action Plans and for the negotiations on the institutionalisation of the BSC Secretariat at Istanbul to be completed. Further GEF Full Project funding was secured in 2002 with the commencement of the Black Sea Ecosystem Recovery Project (BSERP) handled between 2002 and 2007. As a result of this project development of a revised Black Sea TDA and SAP is actualized which will embody specific actions (policy, legal, institutional reforms or investments) that can be adopted by nations. Black Sea Strategic Action Programme (BS SAP) addresses the major priority to transboundary problems in the TDA. Black Sea Integrated Monitoring and Assessment Programme (BSIMAP) established the monitoring /sampling stations along the Black Sea coast.

The system is good enough in theory and hopeful for a sign of a late awareness but current reports notifies deficiencies as; Gaps in countries' monitoring programs, the monitoring is mainly not integrated, mandatory parameters are often not covered, recommended frequency of observations is not always observed, difference in sampling and sample analysis techniques, different approach in assessment of environmental status, pure coordination between responsible authorities, insufficient financial support of monitoring (Myroshnychenko 2011).

After integration of Romania and Bulgaria in 2007, EU's borders extended to the Black Sea Coasts. Both Mediterranean Sea and Black Sea were covered in the EU Marine Strategy

Framework Directive (2008/56/EC) in 2008). And thanks to UN and EU many environmental protection projects were executed and completed in the Black Sea. In December, 2013 the BSC PS signed the Letter of Grant Agreement with the United Nations Development Program (UNDP) and became a partner of the joint EC/UNDP Project “Improving Environmental Monitoring in the Black Sea (EMBLAS)”. The Project aim is to strengthen capacities of the Georgia, Russian Federation and Ukraine for biological and chemical monitoring of water quality in the Black Sea, in line with EU acquis. The Project is completed between 2013 and 2014 contributes significant achievements on technical cooperation for data collections. ‘Clean Sea’ is a large continuing European research project for BSC aiming to provide instruments and tools to keep European seas clean, healthy and productive. Bucharest Declaration concerning Danube River Protection Convention and the Black Sea Protection Convention is a critical cornerstone to prevent the river load which is important sources of pollution in the Black Sea. Black Sea Littoral States Border/Coast Guard Agencies began with the initiative of Turkey in 2000. “The Black Sea Cooperation Forum (BCSF)” was established in 2006, aiming development of the cooperation between these authorities also prevent marine pollution.

### ***Situation in Turkey***

Turkey is a peninsular country surrounded with four seas with coastline over 8,400 KMs. The BSEC Headquarters - the Permanent International Secretariat of the Organization of the Black Sea Economic Cooperation (BSEC PERMIS) and the Black Sea MOU on Port State control are located in Istanbul. It facilitates to reach information in these organizations for authors.

Turkey has accepted 24 International Conventions, 32 IMO Conventions, 39 Regional Conventions, 5 Bilateral Maritime Agreements and European Union Directives related to the environment. Turkey has 36 Laws, 1 Decree Law, 19 Guidelines, and 1 Decree of the Cabinet of Minister, 38 Regulations, 1 Communiques in her national acquis on the same issue. The Main responsible institution concerning environment and pollution is the Ministry of Environment and Urbanization (MoEU). The Environment Law covers national environmental policies, pollution penalties, waste control, waste reception facilities, measures to prevent sea and inland water pollution caused by any kind of source. MoEU works in coordination with the Ministry of Transport, Maritime Affairs and Communications (MTMAC), Coast Guard, Metropolitan Municipalities. The responsibilities for reacting and taking necessary measures including intervention/response against environmental pollution in Turkey, the ‘Law



Pertaining to Principles of Emergency Response and Compensation for Damages in Pollution of Marine Environment by Oil and Other Harmful Substances’ is published in 2005.

Turkish government plans that half of ports will be certified as “Green Port” by 2023. Turkey has issued a Prime Ministerial Circular regarding IMO Strategy in 2010 to harmonize its laws with the IMO conventions and regulations and volunteered for IMO VIMSAS (The Voluntary IMO Member State Audit Scheme). Seven projects amounting to 10.2 m € have been successfully implemented by the MTMAC since 2004 in the fields of maritime safety, control of the ship-based emissions and training of seafarers (MTMAC 2013).

Currents statistics show that Turkey discharges almost 20 % of its total sewage water (812,167 thousands m<sup>3</sup>/year) into water land from land and other areas without being treated (TUIK 2014). Water land includes; seas, lakes, artificial lakes, rivers and dams and unfortunately some of them are used as the sources of potable water or agricultural watering. Figure-2 below shows successful trend of sewage treatment goes on.

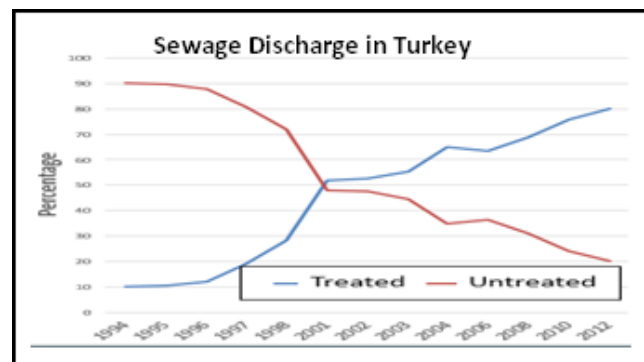


Figure-2: Annual Percentage of wastewater discharged from municipal sewerage

## Conclusion

The main sources of the marine pollution are land based; maritime activities are also contributors of marine pollution. Preventing land based pollution should be more focused. Sea has no physical borders and most marine problems are trans-boundary. Therefore measures applied by any coastal state may not be effective enough; regional approach including collective actions is required in order to mitigate marine environmental problems. It is pretty clear that the environment is the easiest area of cooperation. Marine pollution can be prevented only with international cooperation and collaboration. The close cooperation between the coastal states and countries associated with the inland seas such as the Black Sea is highly important.

Any gaps in implementation like “defining responsible authorities and areas of responsibility” must be filled. The establishment of a continuous and adequate pollution monitoring system is required for the application of deterrent measures.

The regulations have provided considerable benefits in reducing the amount of the pollution events and the areas affected. Thus we can say that legislation on pollution prevention is sufficient in many countries and in the framework of the IMO. But at the same time there is excess of regulations which all refers to same topic, creates complexity in application. We need less, simple but more operational regulations both national and international.

Almost all of the regulations are well designed and fit to purpose, serious problems are met at the implementation phase. Unfortunately the implementation of regulations is more effective in developed countries comparing with developing under- developed countries. Karim (2011) states that ‘The reason of the problem is the states’ reluctance in complying with and enforcing globally agreed standards contained in the international conventions defending lack of financial sources. Considering the financial constraints of under-developed and developing countries, expects to take serious measures on environmental pollution in these countries will be very unrealistic. Establishment an international financial assistance fund for these countries for this purpose would be a more realistic approach.

The Government of a State Party to a mandatory IMO instrument must be in a position to implement and enforce its provisions through appropriate national legislation and to provide necessary implementation and enforcement infrastructure (Curtis, 2010). The Black Sea countries have problems to fully comply with the IMO Regulations.

Some preventive measures for the ships may be; taking measures to prevent oil spills and dangerous goods leakages, pumping clean water, exhausting according gases, and applying waste management. Although regulations of MARPOL, London and Basel Conventions etc. are considered sufficient, there are many deficiencies in the implementation.

Recently different parts of the world suffered unordinary climate and weather events. There are some indications that signs to the relation among these events and climate change. Combined impacts of the pollution and climate change are higher sea temperatures, ocean acidification, lack of oxygen and other factors could badly affect the sea life. As the potential enemy of the environment, nuclear plants will continue to be used at least in the midterm to meet the need of energy. As a safer solution alternative energy production methods should be considered. There are many international arrangements to prevent environment but there is not a legal authority to enforce the countries to comply with these regulations. It is strongly recommended that an international enforcement authority supported with a jurisdiction system

based on 'Polluter Pays Principle'. Pollution does not recognize borders, so it is a problem for all, not just the coastal state- shared responsibility. Increasing awareness, continuous monitoring, immediate reaction, precautions relating to decreasing accidents, sanctions against conscious events without tolerance, are the key preventive measures.

Considering special status and situation of the Black Sea an effective cooperation and coordination between adjacent and related (the Danube trans-boundary) countries should be established.

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# CRUISE SHIPPING ACCIDENTS IN ASIA: THE TRENDS, CAUSAL FACTORS AND IMPLICATIONS

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## Abstract

Since the ‘Titanic’ disaster in 1912, safety in cruising has attracted international concerns. A number of shipwrecks have highlighted high frequencies of human failures in the cruise industry over the last century. The safety regulations and ineffective cultures of safety reflected weaknesses on increasing risks of losing lives in cruise ship accidents, notably in Asia. The paper undertakes a critical review on the trends and causal factors in cruise ship accidents using information on marine casualties and incidents since 1912. It shows how human and organizational factors contribute to cruise shipping accidents and raises issues on how to develop comprehensive safety measures and policies in Asia, where the cruise industry is rapidly growing.

**Keywords:** Cruise shipping; Shipwrecks; SOLAS Convention; Maritime Safety Committee; Asia

## **1. Introduction**

In the context of passenger transport, cruising is recognized as a safe method of taking vacation (Lois et al., 2004). Over the past century, scientific and technological advances have led to major breakthroughs in power supply, design, catering facilities, and accommodation of cruise ships (Lois et al., 2004). Indeed, since the ‘Titanic’ disaster in 15 April 1912, safety in cruising has attracted international concerns and academic world. A number of shipwrecks have highlighted relatively high frequencies of human failures in the cruise industry over the last century. For instance, there were 580 cruise shipwreck events recorded from 1989 to 2013, especially for the major disaster of Costa Concordia in 2012. Tremendous cruise ship accidents, notably, 2006 Star Princess have attracted global attention to the cruise industry and resulted in investigations and legal actions on safety concerns (Mileski et al., 2014). The National Transportation Safety Board (NTSB) found that 37% of the marine accidents from 1988 to 2014 were related to passenger vessels. The Cruise Line International Association (CLIA) has investigated the causes and deficiencies of serious accidents and managerial practice of the industry to highlight potential regulations on cruise ships (Mileski et al., 2014). In this case, Gossard (1995, p. 157) noted that “although most critics acknowledge that the cruise industry in general has an excellent safety record, serious losses can and do occur. Fire may be the biggest danger to a cruise ship but collision and grounding may also have serious consequences. In most instances, the ship’s crew has responded professionally”. Maritime safety analysis concentrates on qualitative analysis on the enforcement of safety regulations, training of seafarers, the health of seafarers at the high sea (Mileski et al., 2014), assessment of the safety of individual vessels, as well as ship designs, structures and backwards (e.g. Stiehl, 1977; Pate-Cornell, 1990; Guedes Sorars, 1997). After the 1990s, maritime safety analysis focused on methodological, rather than conceptual or theoretical, issues (Zohar, 2010) and underwent transformation in operational research with a variety of advanced techniques including fuzzy logic (e.g., Yang et al., 2009; Gaonkar et al., 2011), evidential reasoning (e.g. Wang et al., 2004; Liu et al., 2005), Bayesian networks (e.g. Eleye-Datubo et al., 2006), genetic algorithm (e.g. Montewka et al., 2010; Nwaoha et al., 2010), Markov chains (e.g. Kolowrocki and Soszynska, 2011), to name but a few. However, few research efforts have been put to cruise ship accidents in Asia (Lau et al., 2017). Recently Asia has witnessed increasing demand for cruising, the newly-developed cruising destinations, as well as the competition between cruise lines. Understanding such, this papers aims to understand how

various factors may enhance cruise liners to develop comprehensive safety measurement for future research and policymaking for Asia. It presents a historical account on 48 cruise ship accidents in Asia between 1972 and 2015.

## 2. Cruise traffic in the Asian region

Once being a preferred mode of travel for the social elite (Johnson, 2002) in the 1920s, cruising was challenged by air transport in the 1980s (Mileski et al., 2014). Cruising revived after reshaping into leisure mode of traffic. Currently, it is a fast-growing and dynamic sectors of transport (Castillo-Manzano et al., 2014) with 100 million passengers worldwide between 2005 and 2012 (Mileski et al., 2014). Broadly speaking, cruise markets have divided into three main regions, namely North America, Europe, and Asia, spreading from Alaska to Asia (Castillo-Manzano et al., 2014).

In this regard, Asia is a key maritime region with a strategic role in international shipping activities and 20 countries classified as maritime nations with long coastlines (Zhu, 2006). The region increased its attractiveness as a result of new cruising destinations with their cultural, leisure and touristic offerings (Castillo-Manzano et al., 2014; Lau et al., 2014). By the end of this coming decade, Asian passengers will accumulate one in every five cruisers (Lau et al., 2014). Indeed, Asia has a dominating trend in terms of cruise travelers for the last 15 years (Table 1), while a similar phenomenon can be found in terms of cruise fleet (Table 2).

**Table 1: Trend in Asian cruise travelers (millions of cruise passengers)** Source: Ocean Shipping Consultants (2012)

Regions	2005	2010	2015
Japan	0.23	0.27	0.32
East Asia (China, South Korea and Taiwan)	0.44	0.72	1.00
South East Asia	0.04	0.55	0.07
Sub-total (Asia)	1.07	1.54	2.02
Total (Global)	13.6	18.0	22.6
The proportions of Asia region to global	8%	9%	9%
Growth rate global		29.5%	11.1%
Growth rate of Asia regions		43.9%	31.2%

**Table 2: Cruise growth and deployment trends in major regions (2008-2013)** Source: CILA (2013)

Region	Growth of capacity (2008-2013)	Share in 2008	Share in 2013
Asia	302%	1.20%	3.60%
Australasia	155%	2.20%	4.10%
South America	57.0%	2.90%	3.40%
Mediterranean	57.0%	8.30%	9.80%
Caribbean	49.0%	17.60%	19.90%
Europe	33.0%	37.20%	37.30%
Alaska	-5.40%	7.60%	5.40%

### **3. Safety regulations**

The history of maritime safety can be traced back to a series of maritime accidents followed by regulatory responses, with a good example being the UK with its courts of marine inquiry (Schroder-Hinrichs et al., 2012; Schroder-Hinrichs et al., 2013). The faith on Titanic raised the attention on cruise safety and provoked international dialog (Yang et al., 2013; Mileski et al., 2014). Results are the international maritime safety convention – Safety of Lives at Sea (SOLAS) – adopted in 1914, the International Convention for the Prevention of Pollution from Ships (MARPOL) adopted in 1978, and the formation of the International Maritime Organization (IMO) in 1948 (Knudsen and Hassler, 2011; Wu, Jeng, 2012). A resolution of IMO in 1993 introduced the International Safety Management (ISM) Code that aims to provide a holistic and integrated approach for cruise shipping companies to develop the Safety Management System (SMS) so as to reduce human error in cruise ship accidents and align with the interests of the public good (Mukherjee, 2007; Tzannatos, Kokotos, 2009; Batalden, Sydnes, 2014; Li et al., 2014). In 2010, the new IMO Casualty Investigation Code mentioned that safety investigations should be on top of the agenda for administrations (Schroder-Hinrichs et al., 2012). The Costa Concordia grounding has brought significant impact on cruise ship industry. In response, IMO's Maritime Safety Committee (MSC) launched a resolution recommending operational measures to enhance the safety of large cruise ships.

Cruise ships are subject to much higher risk of human casualties due to the nature of cruising services (Gemelos, Ventikos, 2008; Mileski et al., 2014), and the growth of the Asian market raises the question on cruising safety within the region. In fact, the region has different maritime regulatory regimes and levels of economic development across the countries (Zhu, 2006). In a competitive market, the cruise lines are pressurized to cut costs by recruiting less qualified (and lower cost) labors, re-flagging vessels to circumvent regulations by flag states (Batalden and Sydnes, 2014). Some Asian countries even have a lack of training, awareness, expertise, and resources in the implementation of the ISM Code.

While the human aspect is vital for cruise ship safety (Ek et al., 2014), 80-85% of all the recorded severe cruise ship accidents are related to human errors (Barnett, 2005; Tzannatos, Kokotos, 2009). These stem from cruise seafarers working for long hours with insufficient recuperative rest, thus causing ill-health conditions (Barnett, 2005; Gemelos, Ventikos, 2008). However, the IMO stresses that the root cause of human errors is the lack of professionalism of cruise seafarers,



being influenced by performance and attitudes (Ek et al., 2014). Human error in cruise ship accidents seems to sustain despite technological progress made in the cruise industry for the past three decades.

#### 4. Factual information of cruise ship disaster

To analyze this question in a systematic way, this paper discusses the factors of cruise ship accidents in Asia by evaluating 48 cruise ship incidents between 1972 and 2014. A comprehensive dataset was built with 9,000 records from 1900 to 2014 from the Global Integrated Shipping Information System: Marine Casualties and Incidents of the IMO. The cruise ship casualty records in Asia are 48 in the final dataset. All unspecified type of casualties are excluded as they fail to provide sufficient key data and information. The dataset contains descriptive variables, e.g., date, location, cruise ship events (collisions, contacts, fires/explosions, foundered, hull/machinery damage, wrecks/stranded, groundings), type of casualty (very serious, serious, less serious, unspecified).

**Table 3: Types of cruise ship accidents in the Asian region from 1972 to 2014**

Year	Foundered	Capsizing/Listing	Collision	Fire/Explosion	Poor Weather	Contact	Stranding/Grounding	Hull/Machinery	Total	Year	Foundered	Capsizing/Listing	Collision	Fire/Explosion	Poor Weather	Contact	Stranding/Grounding	Hull/Machinery	Total
2014	1	0	0	0	0	0	0	0	1	1992	0	0	1	0	0	0	0	0	1
2013	0	1	1	0	0	0	0	0	2	1991	0	0	0	0	0	0	0	0	0
2012	1	1	1	1	0	0	0	0	4	1990	0	0	0	0	0	0	0	0	0
2011	0	1	2	1	1	0	0	0	5	1989	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	1988	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	1987	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	1986	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0	1985	0	0	0	0	0	0	0	0	0
2006	0	0	0	1	0	0	0	0	1	1984	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	1	1	1983	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	1982	0	0	0	0	0	0	0	0	0
2003	0	1	1	0	0	1	1	0	4	1981	0	0	0	0	0	0	0	0	0
2002	0	1	0	3	0	0	0	1	5	1980	0	0	0	0	0	0	0	0	0
2001	0	0	1	1	0	0	1	0	3	1979	0	0	0	0	0	0	0	0	0
2000	0	3	2	3	0	0	0	0	8	1978	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	1977	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	1	0	0	3	4	1976	0	0	0	0	0	0	0	0	0
1997	0	1	3	2	0	1	1	0	8	1975	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	1974	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	1973	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	1972	0	0	0	1	0	0	0	0	1
1993	0	0	0	0	0	0	0	0	0	<b>Total</b>	<b>2</b>	<b>9</b>	<b>12</b>	<b>13</b>	<b>2</b>	<b>2</b>	<b>3</b>	<b>5</b>	<b>48</b>

Analyzing the cruise ship accidents in Asia by cause from 1972 to 2014 (Table 3), it is evident that the most common cause is collision (25%) and fire/collision (27.1%) that contributes the cruise ship accidents, followed by capsizing/listing at 18.8%, hull/machinery at 10.4%, stranding/grounding at 6.3%, foundered, contact and poor weather at 4.2%. The cruise accident caused by human error is 95.8% of all recorded during the period of study. Human errors are mainly due to the psychological and physiological characteristics of seafarers (Schroder-Hinrichs et al., 2012), and it could affect the seafarers' behaviors at work (Gemelos, Ventikos, 2008). Nevertheless, it is noted that cruise ship accidents are not evenly distributed in the past 42 years with clusters in 1997, 2000, and 2011 (Table 4). In this case, The Philippines, Indonesia, and Japan demonstrate higher frequencies in serious cruise ship accidents, contributing to a total of 64.6% of all recorded cruise ship accidents. Among the rest, China and Malaysia contribute 14.6% and 6.3%, respectively. Other countries and regions, including Thailand, Hong Kong, Burma (Myanmar), and South Korea contribute a total of less than 5%.

**Table 4 List of cruise ship accidents of the Asian region from 1972 to 2014**

Year	Indonesia	Thailand	Philippines	Hong Kong	Burma	South Korea	Japan	China	Malaysia	Total	Year	Indonesia	Thailand	Philippines	Hong Kong	Burma	South Korea	Japan	China	Malaysia	Total
2014	1	0	0	0	0	0	0	0	0	1	1992	0	0	0	0	0	0	0	0	1	1
2013	0	1	1	0	0	0	0	0	0	2	1991	0	0	0	0	0	0	0	0	0	0
2012	1	0	1	1	1	0	0	0	0	4	1990	0	0	0	0	0	0	0	0	0	0
2011	1	0	1	0	0	1	2	0	0	5	1989	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	1988	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	1987	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	1986	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0	0	1985	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	1	0	0	0	0	1	1984	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	1	0	1	1983	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	1982	0	0	0	0	0	0	0	0	0	0
2003	1	0	0	0	0	0	1	2	0	4	1981	0	0	0	0	0	0	0	0	0	0
2002	2	0	1	0	0	0	2	0	0	5	1980	0	0	0	0	0	0	0	0	0	0
2001	0	0	1	0	0	0	0	2	0	3	1979	0	0	0	0	0	0	0	0	0	0
2000	1	0	4	0	0	0	3	0	0	8	1978	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	1977	0	0	0	0	0	0	0	0	0	0
1998	1	0	1	0	0	0	1	1	0	4	1976	0	0	0	0	0	0	0	0	0	0
1997	2	0	1	0	1	0	1	1	2	8	1975	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	1974	0	0	0	0	0	0	0	0	0	0
1995	0	0	0	0	0	0	0	0	0	0	1973	0	0	0	0	0	0	0	0	0	0
1994	0	0	0	0	0	0	0	0	0	0	1972	0	0	0	1	0	0	0	0	0	1
1993	0	0	0	0	0	0	0	0	0	0	<b>Total</b>	<b>10</b>	<b>1</b>	<b>11</b>	<b>2</b>	<b>3</b>	<b>1</b>	<b>10</b>	<b>7</b>	<b>3</b>	<b>48</b>

4.2 Case study – 2006 Star Princess

We discuss in detail the 2006 Star Princess as a representative cruise ship accident. Brief summary report of the event is generated from Marine Accident Investigation Branch (MAIB) (2006):

- On 23 March 2006, at 0309h, fire was detected at the Bermuda cruise ship Star Princess.
- The ship was on passage between Grand Cayman and Montego Bay, Jamaica, with 2690 passengers and 1123 crew on board.
- The fire began on an external stateroom balcony sited on deck 10 in the center of main vertical zone 3, on the vessel's port side. It was caused by a discarded cigarette and heating combustible materials on a balcony, which smoldered for around 20 minutes before flames developed.
- The fire spread along adjacent balconies and assisted by a strong wind over the deck, it spread up to decks 11-12 and on stateroom balconies in fire zones 3 and 4 within 6 minutes.
- After further 24 minutes, it had spread to zone 5. The fire also spread into the staterooms as the heat of the fire shattered the glass in stateroom balcony doors, but was contained by each stateroom's fixed fire-smothering system, the restricted combustibility of their contents, and their thermal boundaries.
- Large amounts of dense black smoke were generated from the combustible materials on the balconies, and the balcony partitions. This smoke entered the adjacent staterooms and alleyways, and hampered the evacuation of the passengers, particularly on deck 12.
- The captain immediately sounded the general emergency signal. Total of 7 short blasts were followed by 1 long blast on the ship's whistle (over the PA) and the ship's horn. All passengers were waked up over the ship.
- Passengers were stationed in muster stations, theatres, restaurants and other public areas for around 7 hours. Some passengers who needed regular medication required crew members to go into their suites and retrieve their medication.
- 13 passengers suffered from smoke inhalation and 1 passenger died from asphyxia secondary to inhalation of smoke and irrespirable gases.

The incident caused 6 fires on the balconies of cruise ships during which either beach towels or plastic chairs had caught alight. According to the UK's Marine Accident Investigation Branch (MAIB) and the International Council of Cruise Lines (ICCL), the main issue was to allow the

fire to spread quickly because: (1) balconies' polycarbonate partitions, polyurethane deck tiles, and the plastic furniture were highly combustible that created excessive very thick black smoke; (2) the strong wind over the deck and its direction; (3) the balconies crossed main zone fire boundaries both horizontally and vertically, and were without structural or thermal barriers at the zone or deck boundaries; (4) no fire detection or fire suppression systems were fitted on the balconies. Since the balconies were classified as 'open deck spaces', SOLAS II-2 has not covered any prevailing fire protection regulations (i.e., the use of non-combustible materials, smoke generation potential, toxicity of materials used) in external deck spaces. In response to Star Princess fire incident, the MSC approved draft amendments to SOLAS chapter II-2 aimed at ensuring that existing regulations 4.4 (Primary deck coverings), 5.3.1.2 (Ceilings and linings), 5.3.2 (Use of combustible materials), 6 (Smoke generation potential and toxicity) are also applied to cabin balconies on any new passenger ships. Also, the Sub-Committee on Fire Protection (FP) should review the fire safety of external areas on cruise ships and develop draft guidance for the approval of fixed water-spraying, fire detection, and fire alarm systems for cabin balconies.

## **6. Discussion and Conclusions**

This paper critically reviews safety in cruise liners in Asia between 1972 and 2014. We identify some general trends of cruise ship accidents. 95.8% of cruise ship accidents were caused by human errors. To reduce similar errors, seafarers should be required to enhance their knowledge and work attitude towards cruise ship operations. By understanding these factors of cruise ship accidents, cruise liners operating in Asia should develop some more comprehensive safety measures. In this case, our findings offer the appropriate direction for future research and policymaking of the cruise industry in Asia.

Compared to ships dedicated for cargo transport, the design for cruise ships are more complex. In practice, cruise ships are floating hotels and sophisticated ship design leads to more complex maintenance (Lau et al., 2014; Mileski et al., 2014). On average, cruise ship typically carries over 4,000 passengers during any particular trips, thus making it very hard for crew members to look after cruise ship operations while simultaneously paying attention to every single passenger. Moreover, cruise ships face various operational challenges, such as quick port turnaround (less than one day) and timely service (Rodrigue, Notteboom, 2008). The stated challenges do not only exhaust crew members in terms of physical strength, but also contribute to the failure to conduct

proper maintenance and check-ups. The long working hours with ill-health conditions, notably during peak seasons, are likely to increase human errors by crew members (Gemelos and Ventikos, 2008; Mileski et al., 2014).

Training could improve crew members in terms of knowledge and work attitude. Yet, cruise liners often face intense competition and are often forced to recruit less qualified (and lower cost) seafarers. Some cruise ship accidents were due to insufficient manpower in the driving area. Crews from some Asian countries have a general lack of education, safety awareness, sense of expertise, and legal resources in the implementation of the ISM Code (Tunidau, Thai, 2010). In some cases, cruise ship operations still rely on outdated shipping technologies without proper equipment (e.g., light, radar, night vision). Some crew members do not even receive complete training in every aspect of the job before commencement, nor conducting physical test regularly. It is thus not surprising that some crew members do not understand how maritime assets integrate their skills particularly during a crisis (Mileski, Honeycutt, 2013). From the perspective of cruise liners, safety plan implementation occupies lower priorities due to profit maximization and infrequent cruise disasters. Hence, they have not actively participated in pre-planning for prevention and post-disaster follow-ups (Mileski et al., 2014). Besides, crew members and passengers come from different countries and regions, facing barriers of language and culture that cause miscommunication and deviation from the instructions in a crisis (Mileski et al., 2014).

Since economic development, legal systems, and size are significantly different among different Asian countries and regions, each country or region adopts diversified maritime safety standards and rules regardless of the IMO requirements (Zhu, 2006). Some countries set up tight regulations to ensure compliance with the Convention and the documentation as a proof of compliance, whereas some simply establish loose regulations, inadequate safety control systems, and lower safety standards. Due to the favorable situation of lower standards in terms of capital inputs, some cruise liners tend to re-flag their vessels to circumvent regulations imposed by the lower-standard flag states (Batalden, Sydnes, 2014). These cruise ships have indeed posed the greatest likelihood of disaster when passing through key locations in Asia, such as South East Asia, particularly the Coral Triangle area (MSC, 2014). All these have highlighted the urgent need for further research on this area.

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# “THE BODY” MATTERS IN MARITIME EMPLOYMENT CONTRACTS

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**Abstract** Despite various efforts to promote women seafarers in the maritime sector, the number of women seafarers has not been significantly improved in the last 25 years. In 1992, when the International Maritime Organization (IMO) made an estimation of the percentage of women seafarers, it was reported as only one or two percent of the total seafaring population (Belcher et al., 2003). The latest manpower report from BIMCO and ICS (2016) indicates that only one percent accounts for women officers and cadets in deck and engine departments. Over the years, the maritime education and training (MET) sector has been observing some increase of female student enrolment in nautical and engineering courses. Nevertheless, the employment of women seafarers/cadets is still a challenge in many countries. It is known that some shipping companies prefer male seafarers to females due to their perceived risk factors in relation to their gender. For example, having a woman in the male-dominated workplaces, both on board and in port, may be regarded as disruption or disorder to their work due to the woman’s “body” being a part of the work environment. Shipping companies may possibly consider it as a risk that women bring sexuality and, consequently, social disorder into the ship environment. However, what makes this generalised assumption that women are considered risk factors as well as possibly being at risk themselves? The paper argues how “the body” matters when shipping companies employ women seafarers in terms of their morals and responsibilities over women on board ships. Based on Pateman’s (1988) sexual contract theory, the concept of “the body” helps us to understand why women have more difficulties than men to access to work on vessels. This paper discusses such employment barriers due to risk perceptions about women seafarers/cadets from a feminist perspective by linking between “the body” and “employment contracts”. To understand why some shipping companies are reluctant to employ women seafarers, the paper argues how women’s “body” is considered to be an important element of their employment contracts, to be managed by those companies. Starting with three different



categories about “the body”: the body as nature, the body as socially constructed, and the body as subjectivity, common perceptions towards women seafarers are revisited. The paper points out the issue of how gender could influence the generalised understanding of risks in the maritime employment contracts. It concludes with the suggestions to the maritime industry on how to transform towards gender-inclusive employment.

**Keywords:** Body · Social contract theory · Sexual contract theory · Maritime employment · Risk

## 1. Introduction

The sea has been regarded to be the place for men’s work for a long time. This notion is largely shared in many parts of the world, creating stereotypes for maritime professions, including seafarers. The International Maritime Organization (IMO) launched the programme for the Integration of Women in the Maritime Sector (IWMS) in 1988. The vision of equality enshrined in the United Nations (UN) Charter was the core of the strategy in this programme (Tansey, 2015). In the process of developing the programme, other major UN’s initiatives were born, such as the 1995 Beijing Declaration and the Millennium Development Goals (MDGs). Later, the Manila conference of the International Convention of Seafarers’ Training, Certification, and Watchkeeping, 1978 (STCW) issued a resolution to recognise women as important maritime human resources (IMO, 2010). In 2013, IMO supported the Regional Conference on the Development of Global Strategy for Women Seafarers, in Busan, Republic of Korea. The outcome of this conference was to publish the Busan Declaration to call for a cooperation among stakeholders to support women seafarers. Another conference was held by the World Maritime University (WMU) in 2014; the 2<sup>nd</sup> International Conference on Maritime Women: Global Leadership (MWGL 2014) was concluded with the MWGL Declaration, advocating women’s leadership in the maritime sector. In 2015, the UN’s Sustainable Development Goals (SDGs) replaced the MDGs to further elaborate the importance of gender equality (SDG Goal 5) as a cross-cutting issue to achieve all the other SDGs.

Despite these political engagements and instruments to advocate gender equality in the maritime sector for almost 30 years, the number of women seafarers has not been improved as expected. In 1992, IMO estimated the population of women seafarers as approximately one or two percent of the total seafaring workforce and this includes those who work in hotel and

catering sections (Belcher et al., 1992). The recent statistics from the manpower report (BIMCO/ICS, 2016) identify women seafarers in marine sections approximately one percent of their dataset. An overall picture of women's representation in seafaring has not significantly changed in the last 25 years. The reason behind is considered to be remaining stereotypes about women seafarers who tend to be regarded as not physically and mentally strong enough to work on board (Kitada, 2010, 2013). In fact, some shipping companies are still hesitant to recruit women seafarers (Belcher et al., 2003; Zhang and Zhao, 2015). So why are some companies not motivated to employ women seafarers? This paper presents an account of the obstacles for women seafarers in terms of women's "bodies". We want to look into possible explanations for this, focusing on women as "bodies". Simultaneously, we want to emphasise that men also have "bodies" and are as gendered as women. The differences between these gendered processes – the male and female ones – and their implications for work life at sea lie at the core of our discussion.

## **2. Gender, Bodies, and Organisations**

### **2.1. Gender-imbalanced organisations**

In gender-imbalanced organisations, for example, a ship which mostly is strongly male-dominated, social bonds will naturally forge between those of the majority gender (Aronson and Kimmel, 2004). The gender identity which is developed becomes more accentuated than identities in more gender-balanced organisations. Stereotypical gender expressions become the norm within such a context. The majority of gender expressions are looked upon as the "normal" (Rosenberg, 2002). The gender norms and expressions will build an organisational culture which tends to be one-linear and quite strong.

### **2.2. Bodies and sexuality**

Bodies are more than "mere" bodies, and they are also bearers of sexuality. This is an unescapable fact even in situations when it is emphasised that sexuality is of no consequence, for example, when it comes to life in work organisations (Alvesson and Billing, 2009). There are no "sexuality free" organisations; latent sexuality will always exist and may surface at times and occasions to different degrees in different organisations. Expectations concerning bodily and sexual behaviour in organisations are socially constructed and might be different for men and women. Such expectations might also differ between organisations.

### **2.3. The enclosed social organisation: the total institution**

In a specific context of shipboard work/life, we consider Erving Goffman's classic definition of a total institution to be a useful framework for the analysis of the ship organisation:

“A total institution may be defined as a place of residence and work where a large number of like-situated individuals cut off from the wider society for an appreciable period of time together lead an enclosed, formally administered round of life.”  
(1961:11).

A ship may be looked upon as a laboratory where organisational issues due to the physical isolation from the wider society become specifically distinct. The previous mentioned issues of gender imbalance, bodies and sexuality will thus be illuminated, strengthened and highlighted in this enclosed social organisation.

### **3. How do “bodies” matter in the maritime sector?**

When social organisations become gender imbalance, in this case, a male-dominated organisation in the maritime sector, women's “bodies” can be considered as “unusual” in the work environment. Firstly, “the body” may be understood as nature, focusing on biological differences between men and women. The reproductive capacity of women can be understood as almost the only worthy role that women can play, by contrasting a man's world on board ships.

Secondly, what we understand male and female today can be constructed through a socialisation process. “The body” as socially constructed provides us an account that male-dominated occupational and organisational cultures have shaped the idea of male and female “bodies”. Butler (1999) argues that “the body” is not “being” but a variable boundary, making cultural friction of gender apparent as if they are real. Most of gender biases argued in the maritime sector requires a careful examination of whether they are real or just imaginary.

Thirdly, Connel (1987) states that cultural practices of defining the differences of male and female by a distinct set of fashions, for example, is a way of achieving “the body” as subjectivity. In this way, fashions have successfully distinguished between the bodies of men and women. For example, women's clothes and accessories, such as skirts, high-heels, and handbags, are symbolic to female bodies whereas men's ties, shirts, and flat shoes are established by masculine styling for male bodies. It is also obvious that the designs of shipboard workplaces and clothes assume that seafarers are male.

Pateman (1988) argues in her sexual contract theory how women's "body" is considered to be an important element of their employment contracts. She identifies the problem in the classical social contract theory, which is not just contracting a person's labour or abilities, but also a person's entire body and mind. This anticipation matches how the shipping companies see the risk of women seafarers as their employees and do not want to take a responsibility over women's "bodies" at possible risks at work. In seafaring, women's "bodies" are considered to be riskier than men's. As a matter of fact, men's bodies are also exposed to various risks if women are protected. But why is it ok for men to take risks and not being protected? Is it ok not to give the same level of attention to men's safety in terms of gender equality? We might want to question what is normally accepted in the maritime sector from a gender lens.

#### **4. Women as risk factors in the work environment on board**

Based on the general considerations discussed so far, we will look into whether women's bodies per se can be considered as a risk factor for the work environment on board. Since all organisations will try to eliminate risk factors, this might illuminate why so few women are employed at sea. The question of risk and femininity may be approached from different angles:

- 1) Are female seafarers and their bodies more likely to represent risk factors in the work processes than male seafarers and their bodies? In other words: Is there anything workwise connected to the female body that could be a barrier for hiring more women? For example, are they more involved in work accidents and do they have difficulties in participating in work processes due to their physical bodies? The question of gender and risk has been discussed by several researchers (see for example, Ertac and Gurdal, 2012; Mather and Lighthall, 2012). When a difference in risk behaviour between men and women can be noticed, it seems to be a general observation that women take fewer risks than men.
- 2) Women as well as men are bearers of their bodies in the work place as well as out of work. In a total institution like the ship, work time and time off work take place within the same physical context. Such an organisational situation will highlight the gendered bodies and the gendered expectations – including sexuality – towards men and women. Due to this, the question of risk can be looked upon as the social and cultural risks of integrating women, women's bodies and women's sexuality in a work environment where the male is the "normal" (Rosenberg, 2002). Included in this discussion is also the question whether women are at greater risk of sexual abuse in strongly male-dominated organisations. We

choose to concentrate upon these social and cultural risk aspects of women and female bodies within a maritime work environment. Possibly, vital barriers for an increase of female employment at sea lie here.

#### **4.1. Social and cultural risks inherent in female seafarers' bodies**

Alvesson and Billing (2009) argue that the shared male identity in a male-dominated work place may weaken when women enter. The risk of disruption of the organisational culture by women can be considered to be particularly strong in a total institution like a ship.

Women enter the ship work place with their female bodies. Their bodies become obvious reminders of the existence of a hetero-normative sexuality (Rosenberg, 2002), the most widely accepted form of sexuality in general. Without women on board, the hetero-normative sexuality is evident through pictures, films, books, and talk. It is widely acknowledged that sexual artefacts of different kinds are alive and well at ships (Kajser, 2005; Bolsø, Langåker, Mühleisen, 2017). Such artefacts – calendar girls, porno movies, “teenager talk”, sexist jokes – can be looked upon as manifestations of a male culture in which it may be difficult for organisational members not to partake. Also, these male artefacts will function as exclusion mechanisms vis-à-vis women (Acker, 1990). A sexual emphasis can be argued to be a token of a male culture in which men's bodies with their integral heterosexual desires have to be placed “on wait” until they reach known or unknown shores again. Whether or not there exist homosexual mini-cultures behind the visible expressions of a heterosexual culture we do not know much about. What is known, however, is that it is the male heterosexual culture which is “exhibited” within the normal and more or less stable life of the ship culture.

When women enter a ship organisation, things change. The female bodies are living reminders of gender and sexuality, and gender roles and identities – which previously were of no apparent concern due to only the male gender being represented on board – become important. It is often presented as if it is the women and their bodies that introduce sexuality onto the ship, notwithstanding the numerous examples of existing sexual artefacts previously mentioned. In accordance with such a view, there are norms and rules for women and their bodies in order not to disturb the existing culture. At the same time, though, “double” expectations can be found in that women are expected not to appear as women and also to live out their femininity as women, at least partially, on board. The complexity of this social process is described by Kajser (2005) who talks about clear norms for female seafarers' behaviour. What is important to notice is that it seems to be the responsibility of the newcomers – the women – to manage the “sexual

climate” on board. It is as if the women and their bodies are the sole bearers of sexuality and that men and their bodies in a rather peculiar way can be seen as being mentally “attacked” by the inherent sexuality in women’s bodies. Women are told – or not told, but get the understanding – that they ought not to provoke the surroundings by their femininity and inherent sexuality. There are dress codes, codes for sun bathing, etc. in order to prevent the female bodies to become sexualized in a work setting which is supposedly difficult to keep stable, quiet and efficient if energy is used in sexual play, intrigues, emotions, and so on (Kitada, 2010; Bolsø, Langåker, Mühleisen, 2017). And a stable work environment – as far as any work environment can be stable – is probably even more important aboard a ship than it is in a land-based work place. The totality of the institution accounts for this.

#### **4.2. When a woman – or a man – is hired, her or his body is also hired**

According to Pateman (1988), a person’s body as well as their mental and physical capacities are contracted in a work relationship. What is a point of interest is that at times organisations seem to forget that this relates to both men and women. Men’s bodies and minds as well as expectations towards their behaviour are as gendered as women’s are, although often in different ways.

We have argued how a ship work environment in the vast majority of instances is male-dominated and, accordingly, male gender roles and gender expectations constitutes normality. We have also argued that a ship organisation is vulnerable when women and their bodies enter – and that the women who enter might be vulnerable as well. We have pointed to a set of imagined risks that may enable us – at least partly – to comprehend why it seems difficult for women to become employed at sea: a perceived risk of more accidents and work difficulties, the possible risk of sexual abuse, and the risk of a destabilization of the work environment.

Kajser (2005) argues that issues about sexuality and bodies in organisations can be visible, non-visible or secret. It is our impression that these issues can be considered to be both visible, non-visible and secret within the maritime sector. As far as we know, these are topics that are not often talked about within the industry in a formal way. In their discussion of managerial moral muteness, Bird and Waters (1989) argue that ethical questions often are avoided due to perceived threats of harmony, threats of efficiency and threats of power and effectiveness. It is not difficult to suppose that such “threats” – consciously or subconsciously – may prevent managers/captains in the maritime industry from raising the issues of women and men as bodies

onto the organisational agenda. If the maritime industry has an interest in employing more female seafarers, then this muteness has to be overcome.

## **5. Coping the challenges – Conclusions and Suggestions**

In order to move towards a more gender-inclusive employment situation at sea, an openness relating to the mentioned gender issues has to be accomplished. Shipping companies and their managements have to find the organisational bravery to lift the discussed gender issues onto the formal agenda, thereby recognising their importance within the specific organisational context. The existing muteness has to be conquered.

Given the maritime industry's very international profile, resulting in different nationalities being represented on board a ship, it is not unreasonable to assume that cultural and ethnic aspects are inherent in the ways gender is looked upon and enacted within the organisations at sea. Tolerance towards different culture and ethnicity in the organisations can be learned through gender-sensitive training from managers to employees at all levels.

We need more research to illuminate these and other questions concerning gender in the seafaring environment. Up till now, there seems to have been limited interest within the research society to explore ships as gendered organisations. In its role as a societal actor, the maritime industry is able to encourage and ask for such research. There is a reason to believe that improved knowledge is the essential tool in order to improve the present-day situation.

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## SPECIFIC ASPECTS OF MOTIVATION OF SEAFARERS

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**Abstract:** Motivation is a voluntary and consistent effort to act in a certain way or to achieve some goals. It is essential and even critical for solving contemporary problems of the human element at sea. Especially those of attraction, recruitment, and retention in the profession, wastage and turnover rates, safety, security and efficiency of the sector. The study reports on the surveys in other countries as well as in our own country Bulgaria, investigating factors that motivate the attraction and retention in the maritime profession. The analyses of results defend the hypothesis that the maritime industry relies on external motivation, both instrumental and positioning. The instrumental motivation to work comes from the level of wages and fringe benefits, job security and regularity of remuneration, working conditions and time for rest, opportunities for on the job training, professional development and promotions. Positional motivation is related to the perception of work as a source of prestige and public recognition, good organizational environment, and professional relationships. This most important empirical conclusion is in line with the normative theoretical recommendations on the topic. In some specific cases - maritime ecological organizations, maritime education, as well as in the Navy - intrinsic motivation should dominate. The reason for this in the case of maritime education is the creative nature of teaching and research. In other examples, utopian ideas, altruistic concern for others, patriotic, social, religious or political beliefs that private actions should achieve broader goals play a significant role. In conclusion, the paper summarizes the results of the research and makes recommendations how to improve motivation in the maritime industry.

**Keywords:** external and internal motivation, seafarers' incentives, maritime industry

## **Introduction**

Staff motivation has always been a major problem for the maritime business. This is a result of the great importance of the human factor for the safe and cost-effective fleet operations. The crews are entrusted with technical aids that cost millions of dollars and errors are costly and have unpredictable consequences. Ships sail at great distances from the company's office, in adverse weather conditions, under the threat of piracy and terrorism. Tens of thousands of dollars are invested in the qualification of each staff member. (Lambert, 2009) Under these circumstances, no company wants to have unmotivated ship personnel. Mistakes in the selection, high turnover rate and low efforts are not acceptable for the maritime sector. In this sector people must be motivated to work hard, to achieve the best they can, to be loyal, and to adopt and transmit the corporate values and culture.

The purpose of this report is to analyze the motivation of seafarers and to seek new empirical facts about the factors determining the effective motivation of seafarers.

To achieve this goal, we have the following three tasks: (1) to present the results of previous empirical surveys on motivation in the maritime sector; (2) to present the methodology and the results of our own empirical study, confirming in an adaptive form the classical studies in the field and carried out in 2016-2017 with the participation of students from the "N. Vaptsarov" Naval Academy; (3) to analyze the motivational factors in order to build more effective management techniques, programs and policies in the maritime business.

Some limitations of the study should be outlined in advance. The lack of systematic theoretical knowledge and the applied statistical methods for collecting information – surveys, which do not give sound grounds to claim that the results obtained are representative and valid for all conditions. In addition, it is difficult to claim that the results of our own and those of the original research are comparable due to factors such as time difference in the studies, differences in the samples studied, the tools used to process the results, the cultural specificity of the studies. However, the comparative studies are a good way to extend the knowledge of the issues concerned with new arguments for the motivation in the maritime business. This would allow for more accurate predictions to be made and more effective tools and policies to be formulated for personnel management in the maritime business.

The analysis will be structured as follows. Firstly, the theoretical framework of the study and major research on the motivation in the maritime business will be presented. Then, the methodology of our empirical research and its main results will be clarified. Finally, theoretical and applied conclusions will be drawn for the management practice in the maritime business and some recommendations for further research will be outlined.

## **Theoretical framework and previous empirical studies on the motivation of seafarers**

Behavior is a function of many factors, depending both on individual characteristics and on the social environment. They are related to the satisfaction of two fundamentally different types of motivation defined initially by Edward L. Deci in 1975. (Deci 1975)

The first is external motivation in which the source of motivation is external to the person, and the stimuli are formed by impacts not related to the activity itself. External source motivation can be regarded as instrumental and positional. The instrumental labor motivation arises from the level and regularity of payment and the additional benefits, promotion and career prospects, working conditions, employment security, and the expectation of receiving on the job training or the acquisition of valuable information. The position motivation, in turn, is related to the perception of work as a source of prestige, the organizational environment, the relationship with the colleagues and management, the desire to gain social status. The second type of motivation is the internal motivation based on perceiving the work as interesting, pleasant and attractive because of its important goals, content and means, the existence of a sense of realization in the work and the full use of the skills and abilities of the personality. (Ryan and Deci 2000)

These two types of motivation are not addictive. External incentives have good results when the work is routine, repetitive, boring, and not very socially important. In activities that are of social importance or require creativity, the external motivation restricts and replaces the internal motivation. In these conditions, external motivation does not work, or it is counterproductive, and worsens the performance. (Etzioni 2011)

The largest empirical study of motivation in the maritime sector "Life at Sea" is conducted in 2012 by the English company "Shiptalk Ltd." in collaboration with "The Sailors Society". (Shiptalk Limited 2012) This survey involves more than 40 000 sailors from a wide background from countries across the global. United Kingdom, India and USA make-up 41.39% of the results. Bulgarians are in the same group with seafarers from Indonesia, New Zealand and Spain, which represents 1,64% of the survey. The results prove the strong predominant importance of the external instrumental motivation in shipping. The leading motives for choosing the seafaring profession are purely instrumental - payment, career opportunities, visiting different parts of the world. The question "Why did you choose to sail," was answered by 42.01% in the following way: "I wanted the maritime career" and 15.78% answered - "Better career opportunities"; 34.02% choose "Better pay than on the coast" and

33.61% - "For the money". Those who have chosen the answer "To see the world" are 34.22%. "The salary" was selected by 76.23% of those who answered the question "Which aspect of the maritime career is most important to you". The same study proves that instrumental motivation is also leading to retention in the seafaring profession. To the question "Why do you continue to sail" 50.20% answer "I get a salary I cannot get on shore", and to the question "What would keep you in the seafaring profession" 62.09% answer "More money", 59% - "Better financial benefits, incl. Pensions, etc." and 39.14% - "Better benefits from work".

Another study on motivation in the shipping business in Taiwan (Kiriaki and Chang 2008) also confirms the role of the instrumental motivation. It finds out that the strongest motivator is the high payment. A second important factor is the ability to build new skills. The cash bonus takes the fourth position and the possibility of promotion – the sixth. The results do not show great differences depending on age, gender, position in the company, and family status. Given the importance of the instrumental incentives for seafarers, the material incentives take the main place in the structure of incentives. Of these, the emphasis on monetary compensations is the strongest. Compared to other sectors, payments are considerably higher, both in the form of wages or bonuses for attraction, retention, performance, or for completing the contract free of accidents. According to the 2010 Marine Business Survey, in many cases the remuneration received depends directly on the periodic assessments of performance at the end of the voyage or every six months. (PwC 2010, 8) In addition, the study proves that employment security and low unemployment are relevant to the attraction and retention of seafarers.

Another observable motivator are non-monetary working conditions: free food aboard the ship, decent living conditions and a balance between working and resting hours on board, managing workload, pace of work, working time, weekly rest, long coastal breaks. In the field of health and safety at work, ship and port medical care, sports facilities, as well as serious measures ensuring the safety and security of the ship are provided. Measures are taken to offset social exclusion and distance from the family, such as regular communication and on-line contact with family and friends on the shore, including the possibility of family members being allowed to get on board. In support of this, polls of the English company "Shiptalk Ltd." prove that nearly 7% of the respondents define working conditions as a serious reason for choosing the seafaring profession.

The motivating role of the on the job training, covering the cost of education, clear career plans, opportunities for ship hierarchy promotions, professional shore mobility and other

factors should not be omitted as well. The cited study of motivation in Taiwan proves the role of career development as one of the most important reasons for choosing job at sea. (Kiriaki and Chang 2008) In the study of “Shiptalk Ltd.” 7.58% determine the prestige of the seafaring profession as the main reason for choosing it. (Shiptalk Limited 2012) Much of the preference for career growth is also likely to have a positional character. In the quoted study of motivation of Taiwanese marine companies, the positional motivation is most strongly represented by the factor "good working atmosphere". This factor occupies third position and is important for nearly half of the respondents. (Kiriaki and Chang 2008)

The practice of position motivation is primarily directed to the Master of the ship. The phrase "The First after God" is clear enough to express the respect for him and for the social status he holds on board the ship. For the crew, a traditional mechanism of positional motivation is to build a culture of recognition in which those who are doing well are recognized and well-respected: respect for the work and contribution of others, concentration on success, offering and receiving gratitude, praise and recognition of good work, giving a positive attestation for work and offering for promotion. An effective instrument for positional motivator is also to support the activities of others, both during the ship's work and in personal problems or in preparation for exams. Employee care, attention to personal and service issues, corporate solidarity, moral incentives, shortening the distance between master and crew, including authorizing direct access to a report without following the hierarchy, also have a strong motivating role. And last but not least, the celebration of professional success, birthdays and other personal events play role in creating a good organizational environment. Due to the above-mentioned factors that characterize positional motivation, about 20% of Shiptalk's respondents want to work at sea until they retire.

The internal motivation, though not prevalent in these studies, is also present. The study of “Shiptalk Ltd.” as the 5th most important factor points to the possibility of personal development. The other factors related to internal motivation - the ability to take responsibility during work and the variety of tasks - occupy the last places in the priorities of the respondents. The study on internal motivation can be judged by the fact that it is important for 54.71% of the respondents to receive satisfaction from their work, and 32.58% declare that they are satisfied with their work at sea. The questions, however, do not allow direct conclusions to be drawn on internal motivation as they do not explain the source of satisfaction - the work itself or what it brings as a benefit.

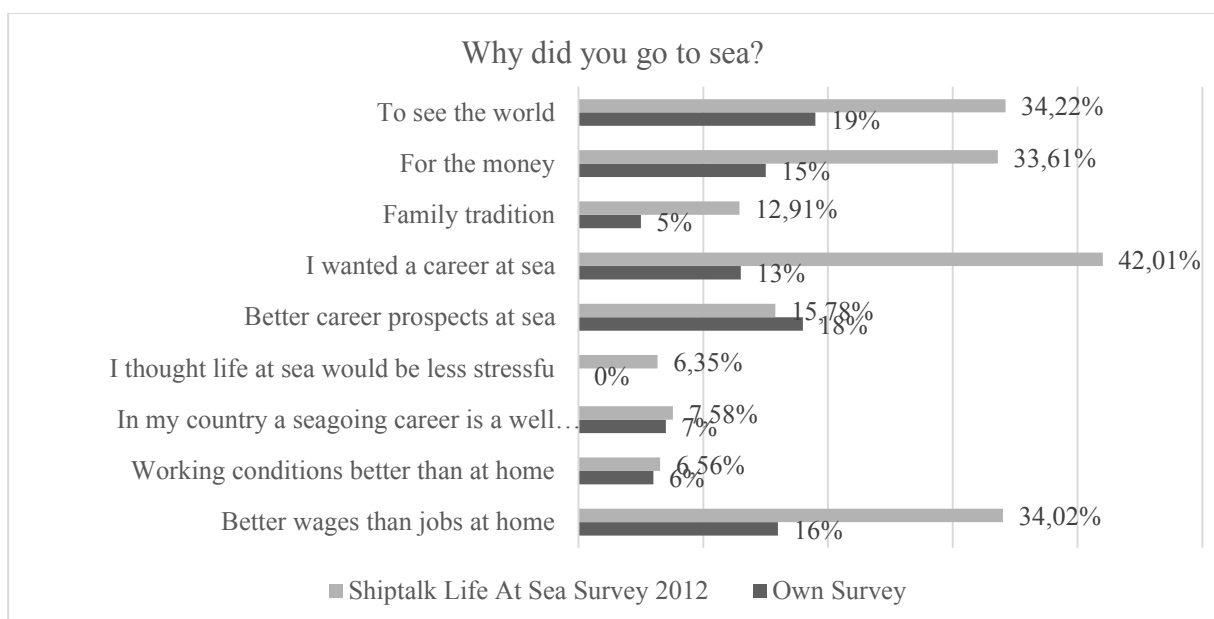
#### **Study at the Nikola Vaptsarov Naval Academy - Varna**

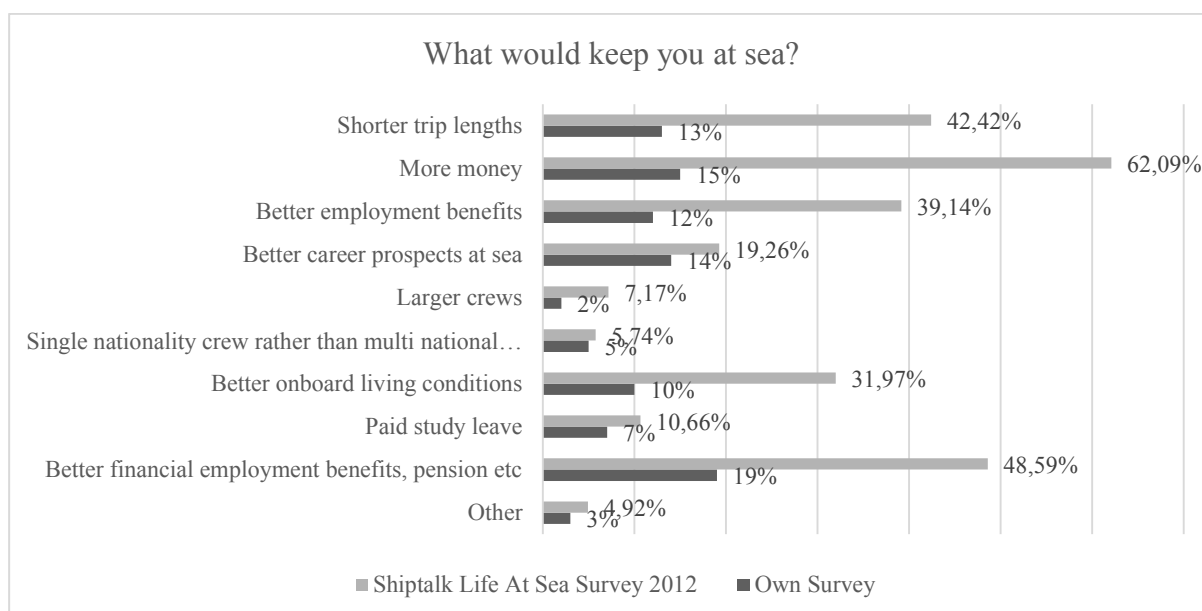
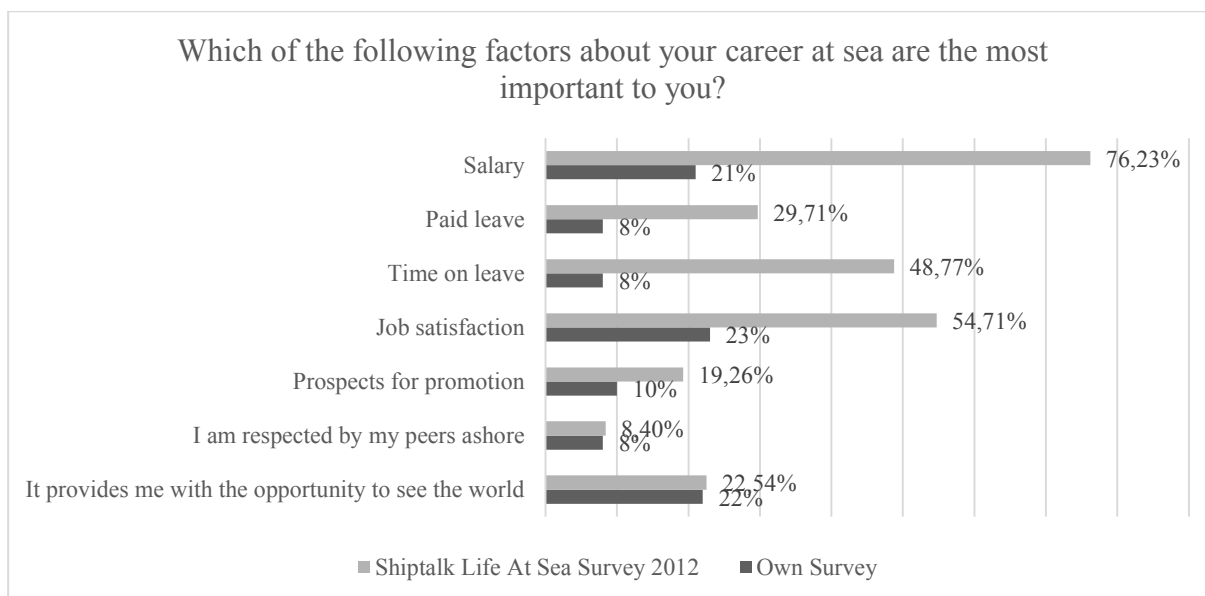
**Data.** Object of the empirical study are students of the first year, full time education, trained in the civilian specialties of Nikola Vaptsarov Naval Academy, Varna. The sample is formed on a voluntary basis and involves 139 people, which is 64% of the total population. The sample reproduces sufficiently well the characteristics of the general population and is representative of it. The poll was conducted between November 2016 and January 2017. Before taking part in the survey, participants declared their informed consent to participate.

**Statistical analysis.** The statistical method used is an online survey. The online form of the survey does not affect the representativeness of the sample as all students, part of the general population, have free access to the Internet and the online survey. The research task of the study is to verify the characteristics of the distribution of answers to the questions asked. The statistical method is the frequency analysis of the statistical indicators number and percentage. The coding and analysis of the results was done by exporting them from MOODLE and processing them in EXCEL.

**Empirical results.** Our research puts out three questions borrowed from “Shiptalk Ltd.”: "Why did you choose to sail?", “Which of the aspects of the maritime career is most important to you?” and "What would retain you in the seafaring profession?” The suggested options for selecting the respondents also repeat those from the study of "Shiptalk Ltd.". The only difference in our research is that respondents should choose only one answer, whereas in the original research they can choose multiple answers. The results of the study and their comparison with those from the study of “Shiptalk Ltd.” are presented in the figures below.

Figure 1. Empirical results





**Conclusions from the study.** The results of the survey are in line with those from the original study of “Shiptalk Ltd.” and reveal a motivational structure with the predominant importance of external motivation. The most widespread motives for choosing the seafaring profession among Bulgarian students are the ability to see the world (19%), better career opportunities (18%), better payment than ashore (16%) and money (15%). After these answers is only the desire to follow the maritime career (13%), based on internal motivation. The strongest motives for retention in the seafaring profession are also instrumental - better financial benefits (19%), more money (15%), better seafaring opportunities (14%), better work benefits (13% %) and favorable working conditions - shorter trips (13%) and better ship life (10%). As

to what factors are perceived to be the most important, our research reveals one important specificity. The answers to the question "Which of the aspects of the maritime career is most important to you", 23% put "Job satisfaction" in the first place. This factor is perceived as important for the "Shiptalk Ltd." survey, but it occupies a second place and is outpaced by the Salary factor. The weight of the "opportunity to see the world" factor is also greater in our study. Probably the reason is that young people have romantic expectations of the seafaring profession. However, the answers to other questions testify that in their actual choices they are not driven by them but by the real external stimuli of the monetary and non-monetary working conditions in the sector.

## **Conclusion**

The revealed specificity implies the formation of two fundamentally different approaches to the motivation of the people in the maritime industry – internal and external motivation.

The first one should be targeted at experienced sailors. Given the objective characteristics of the maritime profession - routine, low level of creativity, the need of high discipline and of following a predefined set of rules, precise schedules and goals - the external motivation has advantages. For this reason, the maritime sector should continue to focus on relatively better payment and improving the working conditions.

The second approach should be targeted at potential candidates and people at the beginning of the maritime career. The attracting to the seafaring profession must consider and exploit the existing romantic and utopian ideas in young people. To avoid disappointment and leaving after the first confrontations with reality, the maritime education system as well as the training onboard periods should gradually adapt them to the realities of the seafaring profession.

The internal motivation is not a main drive for maritime profession, but must be a priority in some other specific cases. For example, in maritime education, maritime non-profit organizations, and in the naval forces. Unlike the merchant navy, in those spheres, the internal motivation is more productive than the external motivation. In the case of maritime education, the reason is the creative nature of teaching and scientific activity. In the maritime non-profit organizations and in the naval forces the utopian ideas, altruistic concern for others, patriotic, social, religious or political beliefs, the idea that private actions should achieve broader goals, also have a significant role to play. In these and other similar structures, people are ready to work, not because they expect any utilitarian benefits, as with external motivation, but because they value the job itself and receive work satisfaction. In order to stimulate their innovativeness, rather than rely on rewards and punishments, it is better to create favorable



conditions for people to work and then rely on their reciprocity. These favorable conditions include (1) giving them a goal and understanding about the importance of their efforts; (2) be autonomous in their decisions about what and how to do it; and (3) to offer them opportunities for personal and professional growth and accumulation of expertise in dealing with new challenges and responsibilities. (Pink 2011)

Given the limitations of the study, its conclusions and recommendations should not be generalized. Their task is to broaden the knowledge about motivation in the maritime business and to stimulate future research and scientific discussions in the field.

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# MARINE INSURANCE AND THE POLAR CODE

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## Abstract

Climate change and technological enablers are contributing to increased shipping in Arctic waters. Sea ice extent in the Arctic region during 2016 was below what was typical of past decades and on 7 March 2017, Arctic sea ice reached its maximum extent for the year, the lowest in the 38 year satellite record [1]. This in light of growing demand for the Arctic's natural resources, increasing cruise and adventure tourism, exponential population growth, and the quest for more efficient shipping routes feeds the growing global interest in the Arctic. As activity increases so will the risks to people, the environment, and shipping. In basic terms, risk means uncertainty. Insurance is one way to transfer risk from the vessel operator to the underwriter and its practice dates back to Lombardy, Italy around 1250AD [2]. Insurance premiums are high when there is uncertainty, minimal empirical data, a lack of accepted industry standards and best practices, and a lack of regulatory oversight. Risk mitigation measures producing fewer insurance claims will lower insurance premiums. The Polar Code, a risk mitigation measure, came into effect on 1 January 2017, as a means to address and protect against the significant risks to people, shipping, and the fragile ecosystems in Polar regions. From a regulatory perspective, the Polar Code deals with navigation, ship design and equipment, education and training, search and rescue, and environmental concerns. A key element of the Polar Code is the requirement for a ship specific Polar Waters Operational Manual detailing how the ship personnel will respond to a worst-case scenario in light of the anticipated conditions for the planned voyage. Under current rules, vessels operating above 72 degrees north had to agree on a separate policy with its insurer with unique conditions negotiated for each vessel and voyage. Protection and indemnity (P&I) liability insurance is compulsory for Arctic trade. P&I policies generally do not include trading limits. However, P&I Club rules generally require members to notify the Club if a ship is to perform an Arctic voyage on the basis that this can represent an alteration

of risk. The Club needs to assess whether and on which conditions it may agree to cover the risks involved, and its member will have to provide a full risk assessment for planning a safe voyage. Hull and Machinery insurance generally excludes Arctic waters as a trading area unless prior permission is obtained from the insurer. Assureds are expected to have a well-prepared and equipped ship and competent crew to perform a safe voyage. An insurer insures against the risks that its assureds encounter in their trading activities. These risks are based on an evaluation of the probability that the insurer will have to pay a claim. In the past, a small cohort of well-prepared, specialized, and experienced operators having only minor incidents has performed Arctic voyages. Insurance challenges will arise when less experienced players enter the market. The Polar Code aims to level the playing field.

**Keywords:** Marine Insurance, Risk, Polar Code, IMO

### **Introduction**

Global attention towards the Arctic is increasing, especially in the exploitation of its waters and hence in maritime transportation. Some of the main drivers of this increase include a decline in the coverage and thickness of multi-year ice, longer open water periods during the Arctic summer, increase in demand for renewable and non-renewable resources in the area, improvements in technology, potential gains in business efficiency via shorter shipping routes, and population growth of native and non-native people requiring greater consumer choice and more services. Regardless of the global growth in interest, the Arctic remains a very challenging environment in which to safely and effectively operate as it is a remote, isolated, geographically vast, sparsely populated, environmentally sensitive, climatically harsh, poorly charted and meagerly serviced region with extensive periods of total darkness and waters that are ice covered or ice-infested.

On a global comparison, Arctic shipping is relatively small. In 2014, Arctic shipping comprised 9.3% of global shipping traffic with most of this comprising of fishing vessels and passenger vessel expeditions in the Svalbard region of Norway [3]. In light of the small volume of cargo ships operating in Arctic waters there is consequently far less statistical information on losses from which to base insurance premiums. In addition, the cost of doing business in remote and unpopulated Arctic regions is significantly greater than in more accessible and highly populated southern regions. The most common type of marine occurrence, both globally and in the Arctic, is grounding [4]. Dispatching a tugboat or salvage resources from southern latitudes to tow a grounded vessel or remove a shipwreck in

the Arctic will be of substantial loss. Further, environmental cleanup cost in the Arctic are on average ten times more expensive than in southern waters [4]. These risks and others associated with Arctic shipping add to the potential for significant financial loss and therefore are captured and reflected in much higher insurance premiums than similar operations in southern waters. The basic tenet of insurance is that the premium shall commensurate with the risk.

The Polar Code identifies ten hazards having potential to elevate levels of risk during polar navigation [5]: ice, topside icing, low temperatures, extended periods of darkness and daylight, high latitude, remoteness, potential lack of experience, potential lack of suitable emergency response equipment, severe weather, and sensitive environment.

### **Risk identification methods**

The Arctic presents many hazards and risks to maritime transportation and thus effective risk management is a vital component of safe and successful business operations. To help drive the need for risk management, the International Maritime Organization (IMO), through its International Safety Management (ISM) Code, requires owners and operators to “assess all identified risks to its ships, personnel and the marine environment and establish appropriate safeguards”[6]. To expand on the work of the IMO in the area of risk management, a Formal Safety Assessment (FSA) concept has been developed and credited with prompting numerous initiatives and regulatory changes [7]. The goal of the FSA is to predetermine need so that measures can be established in an attempt to prevent tragedy. The FSA methodology has several of the characteristics common to many risk management approaches and is a five-step process with feedback loops. The steps include hazard identification, risk assessment, risk control options (RCOs), cost-benefit assessment (CBA), and decision-making recommendations [7]. While the FSA methodology is not without its critics, it is felt that with appropriate application tailored to numerous challenges, it is a suitable risk management tool for use in Arctic maritime transportation [4].

### **Risk definitions and financing**

Risk management definitions relevant to Arctic shipping and insurance:

Risk - potential variation in outcomes;

Operational Risk – the possibility of loss due to business, operational, credit, hazard (accidental), and reputational risks;

Operating Risk – the possibility of loss due to the malfunction or breakdown of existing technology or support systems;

Hazard (Accidental) Risk – the possibility of loss arising from property, liability, net income, and human resource loss exposure;

Loss Exposure - anything that presents a possibility of loss;

Loss - an outcome that reduces an organization's financial value;

Risk Financing - obtaining funds to pay for or offset an organization's losses.

Frequency – the number of occurrences of a loss over a specific time period, usually an annual basis; and

Severity – the size of losses in terms of the dollar amount that must be paid to recover the losses.

The funds to pay for or offset an organization's losses can come from internal or external sources. An example of an internal source would be cash. An example of an external source would be insurance. Property-casualty insurance is commonly used as a method to transfer hazard risk rather than retain it [8]. In the maritime sector, such insurance would typically fall under hull and machinery (H&M), protection and indemnity (P&I), and cargo insurance [2, 8].

### **Assessing the risk**

As stipulated by The Chartered Insurance Institute [9], the principle risk assessment factors taken into account when underwriting a navigating hull risk and determining a rate to charge the vessel include three main areas:

- 1) Vessel factors:
  - a) type and tonnage of vessel;
  - b) trade type the vessel is involved in and trading area(s);
  - c) classification society in which the vessel is entered including any changes;
  - d) flag of vessel for registration;
  - e) type of machinery including main, auxiliary and refrigeration;
  - f) repair costs particular to vessel type and its trade;
  - g) underwriting experience of similar vessels;
  - h) age of vessel; and
  - i) loss record of the particular vessel.

- 2) Ownership and management:
  - a) claims experience of owner and manager;
  - b) crew experience and nationality; and
  - c) owner's operating history.
  
- 3) Insurance factors:
  - a) conditions of insurance being sought;
  - b) valuation of vessel for insurance purposes; and
  - c) level of deductible.

### **Ice navigation management systems**

Ice is one of the most challenging impediments to managing Arctic navigation. Like all management requirements, a system of measurement is needed before successful management can occur. To minimize risk of damage to vessels, navigation in the Canadian Arctic is controlled by two ice monitoring systems, the Zone Date System and the Arctic Ice Regime Shipping System (AIRSS). Similar to AIRSS is the Polar Operational Limit Assessment Risk Indexing System (POLARIS). POLARIS has been developed as a risk mitigation tool to accompany and strengthen the Polar Code. The Zone Date System consist of the Canadian Arctic divided into 16 shipping safety control zones in which vessels are permitted to navigate depending on the time of year and the vessel's ice strengthening [10]. Typically, Zone 1 is the most challenging to navigate in terms of ice while Zone 16 is the least challenging. AIRSS combines information on the observed ice conditions and the vessel's capability in ice to generate a class-dependent ice multiplier (IM) and subsequently an ice numeral (IN). The vessel can only proceed in the existing ice regime if the calculation results in a zero or positive ice numeral. POLARIS is similar to AIRSS with the addition of potential speed limitations. It uses a risk index value (RV) that helps determine a risk index outcome (RIO). Depending on the value of the RIO, a vessel may be permitted to proceed with or without a speed limitation or it may not be permitted to proceed at all [11]. All three systems are risk mitigation tools to help prevent the vessel from becoming stuck in or damaged by ice.

### **Findings**

As part of the research for the paper, four Canadian Arctic shipping operators were interviewed to inquire on the impact that the Polar Code is or may have on insurance

premiums for their Arctic vessels. The four companies are well-established Arctic operators, have been working in Arctic waters for decades, and are cognizant of the hazards identified in the Polar Code. The operators include Fednav, Coastal Shipping, Desgagnes, and Nunavut Eastern Arctic Shipping (NEAS). Vessels belonging to these companies are required to operate under stringent Canadian regulations, namely the Shipping Safety Control Zone Order, Arctic Shipping Pollution Prevention Regulations, and Navigation Safety Regulations that are pursuant to the Arctic Water Pollution Prevention Act [12]. The Act and its regulations provide guidance on what is required for vessels to operate in the Canadian Arctic and consequently provides insurance underwriters with a level of confidence and comfort when deciding on insurance policy conditions and calculating premiums. The consensus from the open-ended interviews concluded that the Polar Code has no immediate impact on current insurance conditions and premiums. The rationale being that these companies have been working in the Arctic region for decades, long before the Polar Code. These companies have significant experience, well established operating procedures, and subjected to a very stringent Canadian regulatory regime. They also reported they are finding it easier to secure insurance coverage that is less restrictive than previous policies.

In addition to interviewing Canadian shipping companies, a London based marine insurance broker, working with Canadian shipping interest in the Arctic, was interviewed with respect to the impact of the Polar Code on insurance. A summary of the interview highlighted that underwriters have limited sources of knowledge as relatively very few ships operate in the Arctic. Consequently, underwriters do not have the history, knowledge or experience to assist them. However, they realize that in light of the various and numerous differences in the relatively small number of Arctic ship operators, a “one size fits all” pricing scale would not be effective. For example, Fednav Ltd. operating all year round in hostile climates and having vast experience and knowledge as opposed to a Far East operator calling to the Arctic for the first time should be considered a higher risk and would attract a higher premium and restrictions/subjectivities in coverage. Further, during the last decade the insurance market has softened. Consequently, coverage has become considerably easier to find and underwriters are under pressure to reduce rates and not impose restrictions. With the combination of low freight rates and a soft market, the appetite to enforce new codes has been limited. In summary, although underwriters and various committees located in London are cognizant of the Polar Code, market conditions have resulted in very little reaction, as

they are not in a position to move and rely heavily on ship owners to adhere to regulations.

### Risk mitigation

Institute Warranty Limits (IWL) 1976, American Institute Trade Warranties 1972, and the International Navigating Conditions (INC) 2003 are similar risk mitigation tools used by insurance underwriters. All three, based on commercial, climatic and political conditions, provide geographical boundaries and dates, which wholly or partially restrict vessel movements [13, 14]. As illustrated in Figure 1, except for Western Europe, much of the area north of approximately 52°N is restrictive. Primary hazards for the Arctic, north of 70° North Latitude, as per the INC 2003 are: a) ice – November to March, b) fog – worst June and July, and c) reefs – depths of 4 metres or less [15]. In 2003, the IWL were revised, in light of climate change and current political conditions, and referred to as the International Navigating Conditions [13, 14, 15]. When calculating an insurance premium for a vessel, coverage to navigate in a Warranty area requires an additional premium. The additional premium is specific to the Warranty area and date, and based on gross registered tonnage (GRT) plus percentage on insured value [9]. For vessel having an ice class (IC) notation, the additional premium may be reduced by 70% for IC 1, 30% for IC 2, and 15% for IC 3 [9].



Figure 1. International Navigational Restriction Limits. Source: [14]



As per Lloyd's Market Association [15], vessels granted permission by their underwriters to operate inside of the excluded areas shall be fitted with and adhere to the following:

1. Two independent marine radars
2. A GPS receiver
3. GMDSS
4. Weather facsimile
5. Gyrocompass with latitude correction capability when North of 70°
6. Fully operational and manned by qualified personnel
7. Appropriate navigational charts corrected up to date, sailing directions and pilot books
8. Shall adhere to all pilotage requirement, traffic regulations and controls established by coastal authorities.

Typically, a vessel seeking to be 'fixed' in the charter market would look to secure insurance coverage with a minimum premium and consequently having full Institute Warranties restrictions. If the vessel was subsequently 'fixed' and required to operate outside of Institute Warranties as per the Charter Party, it would seek additional insurance coverage and pass the associated cost onto the Charterer.

## **Conclusion**

The Polar Code is an important step forward in mitigating the risks associated with polar navigation and consequently helping to ensure its goals of safety and reducing the potential for environmental pollution. The Code takes a goal-based standards framework and as such does not prescribe exactly how to achieve the goals [16]. How a vessel operator achieves the overarching goals of safety and pollution prevention will be depended on numerous variables such as vessel type, operating area in the Arctic and time of year. Consequently, a Polar Waters Operational Manual (PWOM) is to be tailored for each vessel. The PWOM is to be used by the owner, operator, master and crew to help support the decision-making processes during normal operations and emergencies. The PWOM shall also include a collection of risk-based operational procedure specific to the vessel's area of navigation and operations. The functioning of the PWOM is similar to the ISM Code in that it identifies risks that the vessel may expect to encounter and must plan to prevent or mitigate such risks. These risks will be associated with the hazards noted in the Polar Code. With respect to prudent, diligent and experienced Arctic operators, the intent of the PWOM will have already been met in Part

A-1.2 of the ISM code [6]. Consequently, the Polar Code appears to have no immediate impact on insurance coverage and pricing for seasoned Arctic operators.

Further research needs to be carried out with respect to interviewing novice Arctic operators and those planning to commence operations in the Arctic for the first time. This will allow for a comparative analysis. Further, additional interviewing needs to be conducted with a larger cohort of marine underwriters both experienced and inexperienced with Arctic operations.

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# **EXPLORING THE INTERCONNECTIVITY OF RISK MANAGEMENT, THE HUMAN ELEMENT, AND ACTION RESEARCH: A CANADIAN ARCTIC PERSPECTIVE**

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## **Abstract**

In recent decades, the shipping industry, described by the International Maritime Organization (IMO) [1] as “the most international of all the world’s great industries and one of the most dangerous” (p. 401) has undergone significant change and momentous growth, improved training, and substantial regulatory oversight. Extensive risk management (RM) protocol notwithstanding, accidents still occur [2, 3], with 75% deriving from human factors [4, 5]. In a fundamentally people-based industry, RM and the Human Element, and therefore potential Human Error (HE), are intrinsically linked. Maritime RM is highly regulated with the ISM Code, MARPOL, SOLAS, and the IMO’s Formal Safety Assessment (FSA) process all examples of the regulations and guidelines designed to proactively offset risk and prevent tragedy. Nevertheless, traditional maritime sector RM protocol relies heavily upon historical data which, in addition to the inherent undesirability of dependency, involves multiple other weaknesses. HE has been likened to a breakdown in technical reliability [7] where humans, in their susceptibility to inappropriate response in the face of disturbances to normal operations, act essentially as risk factors [6]. Recent perspectives on safety increasingly consider the Human Element as only one of a “network of errors” in a safety causation chain [7, p. 14]. In the Arctic, where unknowns are extensive and experience navigating them is not, this distinction is especially noteworthy. Strengthened and deeper connection with the Human Element, in conjunction with databank reinforcement and population, therefore appear fundamental to safety improvement efforts [6]. With particular focus on the Arctic, this paper explores whether Action Research is an appropriate methodology to (i) improve facilitation of tasks identified as necessary to mitigating the insufficiency of existing historical databases and (ii) contribute to safety improvement efforts and augment current RM protocol by bringing together the knowledge base of maritime stakeholders as representatives of the Human Element.

**Key words:** Action research, Data collection, Human element, Human error, Risk management, Arctic

### Introduction: Action research

Action Research (AR), considered a “powerful tool for industry-academia collaboration” [8, p. 1], is a proactive data acquisition strategy based on the mutual improvement and broadening of knowledge and practice through their interplay with one another [9]. AR’s problem-centered research approach merges ‘theory and praxis’, identifying a problem, postulating solutions, arriving at an action plan, executing that action plan, and then



Figure 1: Action research cycle [Adapted from 9,11,12].

reassessing in a continuous cycle [9,10]. See Figure 1. Traditional research models typically hinge upon empirical testing and inductive and deductive hypotheses derived from scientific theory, as well as from quantitative, often via mathematical means [11], resulting in a clear division between the research and (i) implementation process and (ii) the roles of researchers, participants, and practitioners. AR departs from this approach by instead

emphasizing the value of ongoing collaboration and the importance of group relations as a basis for research and problem solving [9, 12]. Moreover, AR participants are actively involved in the research process themselves and as such act as co-researchers as well as co-subjects [8, 9]. Ultimately, the Action Researcher is the principal investigator who facilitates dialogue to foster reflective analysis among participants to help achieve holistic understanding by all stakeholders. However, in addition to myriad roles including planner, listener, synthesizer, and reporter, the Action Researcher also provides the academic theory and methods necessary to suit a given research situation. Touted as the future’s dominant research methodology [14], AR’s inherent blend of real situations with experimental studies arguably produces the most ‘active’ researcher, i.e., one who is involved in the research process, has personal stake in problem resolution [10], and in turn more willingly embraces new ways of thinking and problem-solving through direct involvement in solution-creation [9, 11]. Studies in both the healthcare and software engineering contexts further support the AR approach as a bridge to the gap between theory, research, and actual practice [8, 12].

Since its inception in the 1940s, AR’s core tenets have broadened and proven productively transferable to common goal and consensus development in practical applications such as

strategic, action, and business planning; organizational efficiency improvement, as well as client group effectiveness within large corporations; education, healthcare and community initiatives; and even policy research and national governments [11, 13, 14]. Entire AR networks now exist, including the Boston University School of Management and the Cornell Participatory AR Network as well as various highly reputed AR groups such as Action Learning, Action Research, Project Management (ALARPM) and publications such as the *International Journal of Action Research*. Further, AR is emerging in industry-funded research domains such as transportation, tourism, engineering, and information technology [10, 14]. Therefore, while maritime-specific AR is currently lacking, as a research approach worthy of consideration for connecting RM to the Human Element, to organizational goals, and therefore to potential increased safety and to marine research-related knowledge bases, AR appears to have notable merit. Figure 2 illustrates a potential marine-context AR cycle.

### AR and proactive RM

Recognition of the need for a more proactive approach to RM and in turn to best practices' development and shipping governance in general is not a new one [15, 16]. Kingston's 2016 crown address to the IMO regarding the Polar Code (PC) and RM Insurance [17] reinforces what is now a commonly held view: that the traditional RM regulatory



Figure 2: Action research inquiry process as applied to shipping safety, risk management, and the human element. By Author.

process is usually slow, initiated by a triggering event and quite often not wholly implemented until another disaster reinforces recommendations made following the initial event [17]. Current protocol is further clouded by strong criticisms such as that of the US National Commission on the Deepwater Horizon disaster being the result of chronic industry and government complacency and inattention to safety [16]. This backdrop, in combination with the shipping industry's continued exponential growth curve trajectory [18] further emphasize the importance of a rigorously ongoing proactive approach to RM and maritime safety where knowledge gaps and inconsistencies clearly exist [5].

### *Data collection and flaw*

Proactive approaches to data acquisition include consistent seasonal reviews and near-miss reporting [6, 7]. Indeed, while dependence on post-accident historical data in RM is in itself a limitation, so is the data it yields since it represents what is overall a very small number of shipping events. While a post-accident safety investigation has undisputed value [20], critical incidents, or “near-misses” are in fact 600 times more likely to occur than accidents [19] and therefore offer even greater potential for learning [7, 21]. Studying critical events can lend insight into how accidents were avoided as well as provide a deeper understanding of the human decision-making process that accompanied dealing with the non-routine and potentially dangerous circumstances where a near-miss event could have become an accident [7, 22] and in turn prompt studies such as Overgard, Sorensen, Nazir, and Martinsen’s [19] whose assessment of human decision-making during DP operations, for example, informs of the importance of experience in critical decision-making as it affords more situational awareness and therefore more time to consider potential strategies for resolving the problem and thereby more optimally managing the situation. Grote’s 2007 [22] study on uncertainty management underscores the need to view disturbances as opportunities to learn and expand individual as well as organizational competencies, further indicating that the continued collection of such data is critical. Yet, according to the 2016 IAMU-FSA study [15], of 157 accidents which occurred north of 60 between 2000-2015, only 4 safety investigations by the Transportation Safety Board (TSB) were fully investigated. That is to say, while 4 occurrences met the requirement of *full* investigation, 154 did not, instead garnering only basic data collection status, and effectively translating to 154 missed opportunities to acquire more extensive and valuable data.

Benefits notwithstanding, near-miss report examination as a data-collection system has flaws. For example, Hilduberg [23] reports both an over-abundance of near-miss reports on everyday events, resulting in less meaningful data, and, due to fears of accountability, an under-reporting of events that have true learning potential such that distortion arises and serious systemic problems are not identified or addressed. As a result, lessons that should be conveyed are often not, instead becoming lost in the “information noise” associated with life at sea and putting into question whether anything has been learned from an actual near-miss incident [24, 20]. Studies also show an increased risk of communication failure among people who lack experience [21] which is in parallel with the intrinsic lack of experience with Arctic sailing. That is to say, while dependency on historical data is in itself flawed, in the Arctic where situations are generally new, prior historical data from which to draw important

safety considerations unique to that setting may not exist. Consequently, the application of Bayesian and other modelling techniques is often necessary. However, models and historical data are ultimately just tools to help make better decisions and “it’s dangerous to put too much faith in them” [25, p. 3]. Because of the risk of flaw, therefore, multiple methods of data collection are preferable [26]. Action Research has the potential to be an additional and effective tool for data collection and reporting as well as for levelling possibly flawed data, especially in the case of the historical-data deprived arena of Arctic shipping.

#### *Mitigating data insufficiency and flaw through AR*

Research shows an AR strength is its ability to curtail information loss through its systematic approach to the capturing and retention of data. Studies by Polo et al and Kauppinen [as cited in 8] found that in an engineering software-context, information loss was reduced due to the iterative AR stages of data collection, debriefing, reflecting, and recording. Additionally, the inherent AR components of structure and organization were found to better ensure process continuity and review [8, 34], points of significance in light of limitations such as manpower or resources amongst official bodies which may therefore limit the extent and breadth of reporting. Further, information retention is improved through the AR hallmark of effective information housing and organizing [12], akin to the Cloud concept of storing Big Data from a plethora of sources. In both cases, the goal is to retain, process and disseminate information so as to make it useful in practical applications and to also ensure, through iterations and a orderly approach to data management, that information does not stagnate. To that end, the cumulative goal to initiate action through information sharing with the relevant larger community, achieved through multiple means including reports, presentations, workshops, and steering committees, was asserted as an AR strength [8, 12, 34].

AR’s collaborative core approach meshed with what Psaraftis [as cited in 15] highlights as the vast knowledge and expertise that exist within the broader seafaring community presents another opportunity to widen the information-gathering net. By seeking out, initiating, and promoting discourse with players beyond the immediate scene of an accident, for example, the AR team, partly comprised of stakeholder participants, has the potential to be the connector of information that may otherwise exist only in pockets [10]. Meaningful dialogue with operators who found themselves in situations similar to those identified in an accident or near-miss situation combined with systematic record-keeping of their experiences can supplement findings derived from not only traditional post-accident RM participants such as superintendents and immediate crew but also from initiatives such as the Arctic Shipping Best Practice Information Forum and the Arctic Marine Advisory Board (AMAB), which aim



to assess use of the PC from initial stages, prior to incidents. Similarly, the October 2017 Canadian Marine Advisory Council (CMAC) conference includes a session on “ship operators’ experiences of using the Polar Code,” suggesting a strong and proactive focus to the PC [28] and attesting to the appropriateness of the equally proactive and collaborative AR methodology as a means of augmenting knowledge-sharing, beyond that derived from select gatherings. The Sustainable Transportation Action Research Team (START) [29] program in British Columbia is a further example of successful industry-relevant AR. Its blend of a variety of research methods, ranging from quantitative and qualitative statistical analyses to stakeholder interviews and discussion with a wide range of stakeholders, suggests that through the same interdisciplinary approach, AR also has the potential within the marine sector to harness the human in data acquisition so as to help identify trends and best practices.

### **AR and the human element**

*The human being is “at the center of the shipping enterprise from routine deckhand duties to IMO policy decisions” [21, p. 7].*

In 2014, Arctic shipping accounted for only 9.3% of global shipping traffic [30]. It can be deduced, therefore, that the majority of future Arctic-going seafarers lack adequate prior knowledge of operating in this new environment, characterized by unique and unpredictable challenges and the need for amplified environmental consciousness. Compounding this lack of experience, are changes in both vessel design and operations, which can lead to reduced situational familiarity and in turn negatively impact decision-making [19]. Additionally, while digitization in the maritime industry lags behind that of other industries, it is increasingly evident in many applications [31] with data driven decision-making (DDDM) fast becoming a vital tool for any industry’s success and the emergence of the Industrial Internet of Things (IIoT)-based safety-critical applications such as the Norway’s More Maritime Cluster changing the landscape of what many feel is a relatively traditional industry where use of technology in general is surrounded by skepticism [31, 32]. Not only is the technology learning curve increasing in both breadth and speed, but studies also show that the reduced active human involvement associated with automated systems contributes to increased error with the caveat that, innately, human beings are not perfectly rational decision-makers [19, 21]; studies demonstrate non-optimal decision-making and judgment even in situations where all the necessary information is available to do so [19, 22]. A variety of factors including limitations on resources and time; over-confidence and lack of appreciation of missing skills and knowledge; stress and fatigue; and individual differences in situational awareness and familiarity can all detract from the safety critical approach to

problem-solving [21, 22]. Moreover, even the perception of risk can differ, with Bailer et al's 2006 study [as cited in 21] finding that shore-based staff believed accident risk was twice likely as did crew, for example.

Recent RM views of "safety science" therefore slant away from traditional accident modelling approaches, such as the sequential or latent-failure model [7, p. 15] which tend to place HE and the individual component at the root of accident causation, and more towards a "no blame" culture that recognizes this variability in human performance and risk perception and the resulting need to predict changes in the shape of risk so as to pre-empt failures and harm [7, 21]. Because the HE catalyst is only one of many elements in a complex and inherently dangerous working environment, focusing on risk elimination to understand how we succeed is thought to be less beneficial than focusing on what is being done right and why people did what they did [21, 6, 7]. Subsequently, cultivating a connection with the Human Element so as to share potentially instructive, clarifying input that draws from the expertise of a variety of stakeholders, including that of the routine operator, is central to heightening awareness and improving understanding of both the "human out of the loop" issues connected with "disruptive" technologies as well as to variations in decision-making and risk perception. Studies show, however, that, while new training trends demonstrate the importance of instituting a "just" safety culture from senior management down and emphasize the serious injury or loss of life that can otherwise result, the fear of speaking up, or the "cover up culture," is an obstacle [7, 20, 23]. Thus, while input sharing is vital, trust also plays a significant role in the imparting of information as indeed, "People can bring together or push apart" [21].

#### *AR as collector and connector*

A recent PC commentary indicated the importance of "linking everything together" [17, p. 8), and of the value of the research community working with industry in a collaborative approach to gather knowledge. Similarly, the objectives of the AMAB's [33] Terms of Reference include the goal of functioning as a forum for open and transparent consultation and discussion with valid industry stakeholders. Likewise, AR is rooted in bringing together people who are mutually interested in solving or improving a situation [9] and engaging in meaningful dialogue to enable understanding at the "micro" level of those in the trenches whose voice may in turn find representation in the "macro" view of the wider industry, thereby expanding understanding of the issues as well as the range of relevant stakeholders. However, situations and parameters can influence perception and how an issue is approached and thus managed. A salient AR strength in this regard is that an effective Action Researcher

will carefully note findings from participants in *various* settings and go on to reflect on and consider linkages as well as disparities [9, Hironaka-juteau, et al , 2006 as cited in 27]. For example, an Action Researcher positioned at a conference where 20 operators are speaking on their experiences using the PC or new technology, would carefully observe and note the type of commentary put forth, but would then seek out opportunities to speak with operators in a smaller group setting and again at an individual level so as to ascertain whether setting, numbers, group composition, and level of privacy indicate differences in findings, as demonstrated in Breu and Hemingway's 2015 industry-based Participatory AR study [10].

While there are no maritime-transportation based studies to date which utilize AR in their methodologies toolkit, numerous studies exist which do recognize the AR approach as an effective catalyst for nurturing trust [11, 12]. Action Researchers are described as effective levelers who allay others' fears and invite participation in a "we're in-it together" approach so as to assuage fear amongst stakeholders [9], a point of significance given findings that even the promise of anonymity does not sufficiently encourage people to speak up about near-miss incidents, as the threat to an organization's professionalism is sometimes simply too intimidating. Yet, unless accountability is managed and seafarers can report without fear of blame, real systemic problems can go unaddressed [22, 23]. To this end, studies suggest that long-term industrial affiliation enriches the research process where an open-forum collaborative approach grounded in rapport fostered trust and encouraged discourse, as well as engendered the ability to pick up valuable information "on the fly" [10, sec. 5.2]. The AR methodology and setting, ideally an established hub, where information can be shared freely and anonymously in an environment underscored by trust and a mutual desire for improvement and growth would enable the possibility of uncovering commonality issues and needs as well as new research foci.

### **Conclusions**

AR is based on the active collaboration of researcher and stakeholder/co-researcher regarding practical concerns in a mutually beneficial situation of co-learning optimized by the establishment of trust and openness. Its goal is to improve a situation through collaborative efforts where the Human Element and the experience and input its participants bring to the research process is recognized and respected. In instances of meager or non-existent data, where multiple methods of information acquisition should be utilized, AR's interdisciplinary characteristics make it a reasonable strategy for adding to the existing knowledge bank used in both RM and safety protocol in general as well as for helping to offset data flaw. Additionally, AR's systematic approach to data collection and storage can lead

to efficiencies' identification through taking stock of, clarifying, and disseminating the input of the experienced so as to uncover new findings and trends. Moreover, because such information can be inadequately spread and instead remain in pockets with insufficient exploration, connectivity, and transparency and because such stagnation can in turn potentially skew data and therefore accuracy, discussions and the availability of a forum to share, maintain currency, and promote information and process continuity would be advantageous. As safety deserves all possible means of support, especially in new dimensions such as the Arctic, the findings of this paper suggests the need for (i) recognition of AR as a viable research methodology to promote both information-sharing and connection with the Human Element; (ii) more AR studies in industry, especially maritime; and (iii) ideally, the establishment of an AR nexus so as to offer an organized and fruitful environment dedicated to facilitating a maritime-focused research process and to better give voice to the collective and varied broader community of maritime industry stakeholders.

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# **EFFECT OF BULLYING ON MENTAL AHEALTH OF MARINERS**

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## **Abstract**

Due to unpredictable conditions, seafaring is depicted as the most hazardous occupation on the earth. In addition, working condition of sailors is brimming with stressors and unfriendly climate conditions, for example, disconnection from family and companions, high employment pressures and more work load. These stressors prompt poor mental health of Seafarers. Seafarer confront fatigue and stress, danger from piracy, bullying and harassment. They also work long hours without enough rest and also face fear of theft. These symptoms could lead to depression, nervousness, anxiety and to suicide in rare cases. Suicide have annihilating outcomes, for seafarer's families as well as for colleagues and the organizations who give them employment. The aim of an article is to review the data on the effect of bullying on mental health of Mariners, so to propose a suggestion to enhance the psychological wellness of seafarers.

**Key words** : seafarer, mental health, bullying and psychological problems

## **Introduction**

Seafaring is the most demanding profession among all vocations throughout the world which seafarers have unexpected task conditions (Håvold, 2007; Nielsen, Bergheim, & Eid, 2013). On the other hand, mariners work under unpredictable conditions and these stressors could be noise, aggression via bullying, dangerous weather, separation from closed ones, standard job expectations and shift timings (Nielsen et al., 2013). As a result these threats tend to poor psychological status.

Moreover, Mariners face isolation from their homes for a long period of time while they work many hours without taking care of themselves. Because of stress and tiredness they get lost their healthy attitudes to treat one another during duty times. There are more chances to get involved in criminalization, harassment and bullying, and dangers from piracy as well. Seaman's have high job demands, due to these they face high level of stress which lead poor physical and mental health (Dolmierski, Jezewska, & Leszczynska, 1990). Furthermore, they might face suicide in some cases. Suicide has adverse outcomes, not only for seaman's families but also for co-workers and ship companies.

This paper has objectives to review published and unpublished data regarding effects of bullying on mental health. Besides this, it will also review information about the welfare of seafarer with a specific end goal which gives a window into the current status of the psychological well-being of seafarers and build up whether the psychological wellness of seafarers much of the time keeps on being extremely poor and fatal. Other than this, to enhance the mental health mariners and recommend a far reaching push to enhance the psychological well-being of sailors.

## **Bullying and Seafaring**

### **What is bullying at work?**

Characterizing harassing or bullying, particularly on the off chance that we look for a definition which is common among specialists of the bullying. In any case, in spite of the many proposed definitions, we can certify that most known & common definition of bullying is that it's a specific conduct of aggressive behavior. It is evidenced by repeated acts and practices directed toward and unwanted by others. These acts are humiliating, affect individual performance, and contribute to an inhospitable or threatening work environment. However, bullying is defined as an event where it is difficult to protect oneself against negative action.

Therefore the idea of bullying at work alludes to all circumstances where at least one people feel pessimistic conduct from others in the work environment and in a environment where they cannot guard themselves against these activities.

One individuals feel subjected to cynical direct from others in the workplace and in a condition where they for different reasons can't protect themselves against these exercises.

Workplace bullying has not been widely investigated by researchers and bullying is also a most significant cause of stress in mariners (Mayhew & Grewal, 2003). Further, several mental health issues such as stress, depression, sleeping disorder and anxiety caused by workplace bullying. Moreover, the effect of bad working environment can reduce efficiency, productivity and moral values. It can also increase financial costs such as worker's compensation and legal time to resolve the bullying and harassment cases.

Mostly, a casualty is continuously insulted and offended, he or she thinks that they have less option to retaliate. We may recognize business related harassing for example work deadline and work perfections are the types of behaviors that make work place difficult for casualty. Example of personal bullying are bad remarks, teasing, rumors and social boycott. The idea of dispute related and predatory bullying to clarify the onset of two different types of bullying, suggested by Einarsen (Einarsen, 1996). In this type of bullying, mostly the social climate at work turns sour and creates more conflicts. In addition, when challenging work assignments combine with rational behavior it will create a very high bullying environment. Consequently, working with victims of long term bullying, the extreme and adverse health issues are displayed. Other than this, in perspective of the particular symptom constellation found in many reviews, it has been contended that several victims of long term bullying at work may in fact post-traumatic stress disorder. Subsequently, experiencing to one or a few other unpleasant life occasions may have added to their extreme medical issues.

Similarly such scenes can be seen on board, where working environment leads mental stress, as well as psychosocial factors are shared among people who work on the board.

When working with casualties of long term harassing, the exceptional and unavoidable medical issues they show is mental health problem. Particularly when seafarers who has been bullied for a long term, you will face extreme medical issues. Seafarer who has gone through intentional and systematic psychological harm by another person or company, seems to have severe emotional reaction such as fear, tension, powerlessness, depression and shock. Such exploitation appears to change the person's impression of his workplace and life all in all to one of risk, threat, frailty and self-addressing, which may bring about unavoidable fear thoughts, psychosomatic and psychiatric issues, as indicated by a large group of late reviews. In an investigation of male industrial laborers, we found a critical negative relationship between experiencing harassment at work and estimations of psychological health and well-being.



Work disability was associated with demanding and unpredictable atmospheric jobs (Eileen & Mark, 2004). Seafarers are used to face task and time pressure during their voyage. Although their stress level depends on the position and job work on board while their officers are responsible to face high level stress for personnel and material. According to the International Labor Organization (ILO, 2006), seafarers are bound to work the maximum working times of 14 hours per day. While it has not seen in seafaring to follow the given time slot.

Every cargo ship has the crew about 10 to 20 seafarers and where they has the privilege to work in a domain free from discrimination, harassment, bullying & violence. Under the Maritime Labor convention shipping companies and seafarers have a lawful duty to follow any measures that advance health and safety in the workplace. Under this obligation, employers have to take measures to reduce or eliminate the work place harassment and bullying. They all face physically tough and stressful job particularly on container ships during adverse weather. Additionally, crews on cargo ships or container ships are possibly exposed to dangerous and toxic goods. Besides these, the size of ships also influences the working situation via in smaller ships with less crews the stress level gets increased. In contrast, in larger ships mariners face mental issues because of long term voyage.

### **Conclusion**

According to Maritime Labour Convention 2006, seafarers have clear rights to free medical and psychological care. However, it has been observed that seafarers have fear for seeking mental health care to get the stigma of receiving the care. Researchers found significant associations between psychological distress and workplace bullying and mental health. According to the research the prevalence rate of occasional bullying among mariners is 10.1%, severe bullying 3.8%, whereas psychological distress is 9.3% (Malinauskaite & Bernotaite, 2014). It has been suggested that at ship industry level, effort should be done to facilitate the psychological well-being of seafarers. And should be provided them healthy work environment and effective counseling through proper channels.

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## OVERVIEW ON SOME POLITICAL AND ECONOMIC ASPECTS FOR BULGARIA IN THE CONTEXT OF THE NEW EURASIAN ECONOMIC CORRIDORS

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**Abstract:** The article examines the geopolitical and geoeconomical aspects of the new Eurasian economic corridors and their implications for Bulgaria. While establishing long-term energy- and commercial projects and continuous debates in Europe, influenced by the changing regional and international political and economic environment, and after the second forum in May 2017 the process of developing the most global project in the China's history One Belt, One Road (OBOR) continues. The major initiative will result in expansion of the Chinese economic influence in Europe. The related geostrategic and political opportunities for Bulgaria should be viewed and might be realised in the Union's context and by participation in the commercial and energy EU politics according to the main European political principles, for example diversification, anti-monopol politics etc. Currently there is no official EU political statement on the project. Of European and Bulgarian interest are the North and Central Trans-Eurasian economic corridors, as well as the South-Caucasian perspective and the Trans-Caspian transport corridor, including the Black Sea on the route China-Azerbaijan-Georgia-Black Sea. Whether the transport corridors reaching Azerbaijan and Georgia could reach Bulgarian coasts is a question which response requires a conceptual reconsideration of the country's economic priorities in the contemporary political environment. If such a scenario could be realized in the long run, then this possibility should be strategically and politically considered.

**Key words:** The New Silk Road, North- and Central Trans-Eurasian corridors, transport routes to Black Sea, Bulgarian perspectives in OBOR.

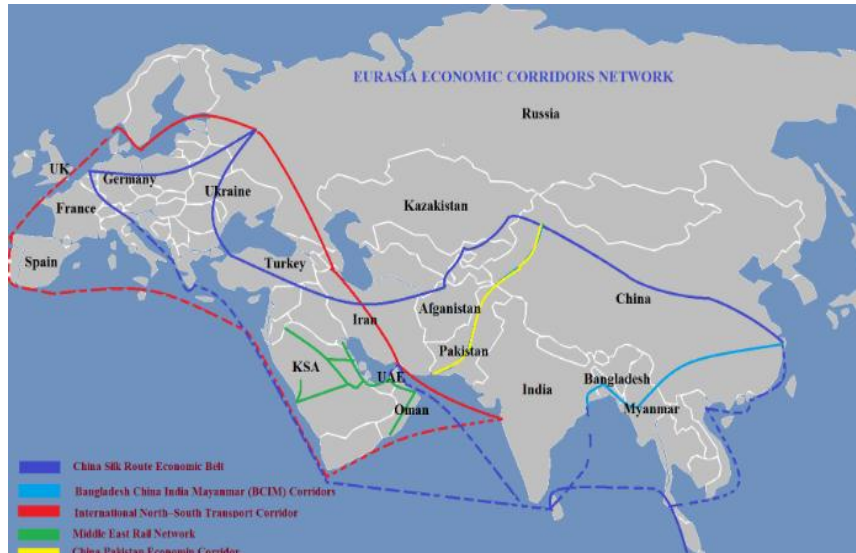
## Introduction

Following the geopolitical and economic changes in Central and Eastern Europe, Bulgaria has been increasing the importance of its geographic position. This indisputable fact, along with points like "transport energy corridors", "geostrategic status" have a magical power in all political and economic fora, defining guidelines at national, regional and global level. At the same time, in the Eurasian space, the geostrategic puzzle began to change sharply, including new key players such as China, India and Iran along with the traditional actors EU, Russia, the United States, and Turkey.

## Economic Transport Corridors in Eurasia

Economic corridors integrate infrastructure of roads, railways, ports, energy, telecommunication facilities, and oil and gas pipelines.

The Eurasian map of the 21st century features **five economic routes** that have the potential to connect new markets to over 65 countries in Asia, Africa and Europe (Fig.1). Two of them are of strategic importance: China's OBOR and the North-South Transport Corridor. The other three, such as the Pakistan-China Economic Corridor, the Gulf Cooperation Council Railway and Bangladesh-China-India-Myanmar Corridor (BCIM Corridor) are important linkages, however have a lesser meaning for the objectives of this article.



**Fig.1 Economic and trade routes, connecting Asia, Africa and Europe.**

Source: <https://www.linkedin.com/pulse/connected-eurasia-emerging-opportunities-expanding-corridors-masood>.

The "New Silk Road" – the initiative OBOR is one of China's most unprecedented economic and political indicators. From \$ 40 billion in 2014, the amount of investment rises to \$ 1 trillion. Dollars and plans for another 2 trillion dollars in the coming years. The

country's intentions to expand its geopolitical and economic influence from Pakistan to Serbia are impressive.

The ambitious idea is to build a large-scale transport infrastructure - motorways, power pipelines, airports, ports, high-speed rail infrastructure and telecommunication networks to boost trade, economic, financial and cultural cooperation between the Eurasian countries.

The initiative includes three Trans-Eurasian economic corridors - North (China - Central Asia - Russia - Europe), central (China - Central Asia - West Asia - Persian Gulf and Mediterranean) and South (China - Southeast Asia - South Asia - Indian Ocean).

The sea routes connect China, Indo-China, India, East Africa, the Middle East and Europe (Fig.2).



**Fig.2 The New Silk Road – the OBOR initiative and its maritime dimension.**

Source: <http://www.eurasiareview.com/13042016-one-belt-one-road-one-singapore-analysis/>

The OBOR initiative is primarily a Chinese national project aimed at expanding and even imposing the country's economic influence in Eurasia. So it is obvious that other regional Asian powers such as India, which definitely do not tolerate China's disputes with Pakistan about controversial areas are not present in the project.

China's efforts to attract European economic and political support for the project are in the main scope of the current research. Important is that Europe, in particular the EU, has no policy on the mega project. For China, the 500 mill. European markets, the richest at present, is a long-term goal that it tries to influence through economic instruments.<sup>1</sup> Since there is currently no EU political support at the Beijing summit, China has called for "more cooperation on concrete EU projects", to which Vice President of the European Commission, Mr. Katyanen, responded very cautiously. The European position is that every project between Asia and Europe must adhere strictly to a number of principles, rules and imposed

<sup>1</sup>The effects of Brexit and 65 millions market withdrawal are to be followed. – author's note.

international standards and policies of the market economy. Europe did not support the request for "economic status" under the provisions of the World Trade Organization. This status would reduce the level of sanctions in cases of price dumping. The situation is delicate - the huge flood of Chinese goods threatens the "healthy industrial base" that the EC considers to be key to economic growth, the working environment and competitiveness. In this sense, at the EU level, Bulgaria could be involved in proposing the introduction of a clearing system instead of policy of isolation.<sup>2</sup>

Along with efforts for the desired "economic status", China has increased its presence in Central and Eastern Europe. The change is that economic ties between China and Europe are no longer just a privilege for the big Western economies - Germany and the UK. In 2012, the "16 + 1" mechanism was set up, and the Chinese Prime Minister met the political leaderships of 16 countries once a year, EU members such as Poland, Hungary, Bulgaria, Slovenia and the Baltic and non-EU countries such as Serbia, Albania and Montenegro. The European Commission is admitted as an observer in the 16 + 1 group. Specific projects start without hindrance. The loans that Beijing gives to non-EU countries are not an appropriate option for countries with access to European funds. Moreover, such loans can often run counter to existing EU procurement rules, as is the case with the promised investment in a railway line across Hungary. A preliminary infringement procedure has begun against it launched by the European Commission.<sup>3</sup>

Another major infrastructure project in the EU is the port of Athens, Piraeus. Since 2016, it has been managed by the China Ocean Shipping Company (Cosco), holding a 51% stake, with an option to acquire another 16% by 2021 following large-scale investments. The idea is to turn Port of Piraeus into a starting point for Chinese goods and the base of many Chinese trading companies. Through the "Silk Road" and the expansion of the Suez Canal, China reaches the Mediterranean Sea. Cosco plans to turn Piraeus into one of the largest container transit ports. The overall idea implies the construction of the already mentioned

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<sup>2</sup>[http://www.capital.bg/biznes/pazari/2015/11/24/2656012\\_investitorite\\_i\\_kompaniite\\_shte\\_specheliat\\_ot\\_obshta/](http://www.capital.bg/biznes/pazari/2015/11/24/2656012_investitorite_i_kompaniite_shte_specheliat_ot_obshta/)

<sup>3</sup> James Kynge, Arthur Beesley, Andrew Byrne, EU sets collision course with China over „Silk Road” rail project, 20 Feb 2017, <https://www.ft.com/content/003bad14-f52f-11e6-95ee-f14e55513608?mhq5j=e3>. This is the planned high-speed route from Belgrade to Budapest. Brussels checks the economic feasibility of the 350 km long route worth almost 2.9 billion euros. The planned line should cut the trip between the two capitals from 8 am to 3 hours. It is considered a key element of the express link of Central Europe with Piraeus port in Athens, which is owned by a Chinese company. It will enable the travel to the West through Greece, Macedonia and Serbia. Without this railway line, Chinese companies will find it difficult to import goods into some rich EU countries and to export products to their EU businesses to Africa. Bartosz Kowalski, "China's foreign policy towards Central and Eastern Europe: The '16+1' format in the South cooperation perspective. Cases of the Czech Republic and Hungary," Cambridge Journal of Eurasian Studies, 2017, 1: #7R65ZH, <https://doi.org/10.22261/7R65ZH>, pp. 13-14.

high-capacity link between the Greek port of Piraeus and Budapest, from where cargo can continue in all directions.

Despite the increase in Chinese investment in Europe in 2016 by 77% over the previous year, it is worth noting the lack of reciprocity both in China's political and economic relations. There is no bilateral agreement at political level. Neither the EU Chamber of Commerce nor the US Chamber of Commerce in China has been able to influence the difficult access of European or American companies to the Chinese market. There is practically no good business climate for them. The lack of reciprocity in trade relations between China and the West is a major obstacle. Another problem is the huge trade deficits between a number of countries in Central and Eastern Europe and China.

A specially important role in the implementation of the OBOR is Iran. For centuries, the country has been a key transport link between the East and the West. In the context of the project, the importance of Iran will continue to grow.<sup>4</sup> In this context, different sites of the Chinese infrastructure network are being built in the country. Links between China and Iran are traditional, and they have developed particularly during the international isolation imposed on Iran for its nuclear program. Iran seeks to realize its geopolitical advantages and redirect as much route as possible over its territory, bypassing routes through Russia. Iranian leaders hope that the country's participation in the project will allow them to take advantage of China's big economic ambitions for its own prosperity.

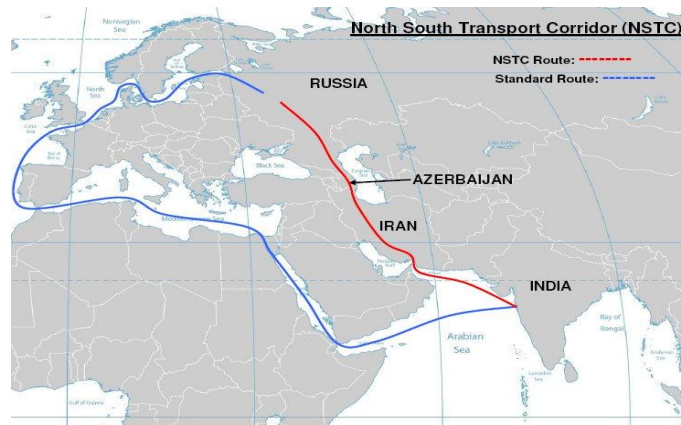
**The North-South Transport Corridor** covers land, rail and sea freight routes between India, Russia, Iran, Europe and Central Asia (Fig.3).

The route from Russia to Iran via Azerbaijan is an important part of the South-South transport corridor that should connect Russia with India. Its purpose is to ensure the transport of goods from India, Iran and the rest of the Gulf to Russian territory and from there to North and Western Europe. The project is of huge importance to India, as the traditional Suez Canal channel takes more time and costs.

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<sup>4</sup> According Thomas Erdbrink in his New York Times article „On the global ambitions of China” Iran is in the centre of all.,

[http://www.dnevnik.bg/sviat/2017/07/26/3012895\\_za\\_globalnite\\_ambicii\\_na\\_kitai\\_iran\\_e\\_v\\_centura\\_na/\\_centura\\_na/](http://www.dnevnik.bg/sviat/2017/07/26/3012895_za_globalnite_ambicii_na_kitai_iran_e_v_centura_na/_centura_na/).



**Fig.3 North-South Transport Corridor**

Source: <http://www.clearias.com/international-north-south-transport-corridor-instc/>.

Maritime traffic from the three transport corridors OBOR, North-South and China-Pakistan passes through **the Strait of Hormuz** to Iran and the United Arab Emirates. Strategically and economically, Hormuz's significance will reach an unprecedented importance after the sea flow from the corridors begins to pass through. Moreover, any political tensions in the region will have long-term economic effects on "key players" in China, India and Russia.

#### **Bulgaria in the context of the Transeurasian transport corridors**

Participation of Southeast and Central Europe countries incl. Bulgaria, in the OBOR economic project depends on their activities and the ability to combine the restrictions related to EU membership with the protection of their national interests. Unfortunately, Bulgaria has not secured its presence in any direction in the restoration of the Silk Road. However, the analysis of the situation in the Eurasian space and the potential of the aforementioned projects reveal certain opportunities for benefiting our country.

The realistic prospects for Bulgaria concern above all the interconnection of the Eurasian transport corridors in the Caspian Sea (Azerbaijan - Georgia) - the Black Sea.

It should be emphasized that in the context of the two major transport corridors OBOR and North-South the Caspian-Black Sea region, in particular Azerbaijan and Georgia, are becoming strategically important.

#### **Azerbaijan**

Azerbaijan invested \$ 520 million in the construction of a port and free trade zone of Alat (Fig.4). The new port complex will have a capacity of 10 million tonnes of freight per year and 40 thousand TEUs in the first stage, up to 17 million tonnes and 150 thousand TEUs in the second stage and 25 million tonnes and 1 million TEUs in the final third stage. The first



phase of three and a half years involves the construction of an international logistics center with an area of 109 hectares.<sup>5</sup>



**Fig.4 Port and FIZ Alat in Azerbaijan in OBOR and North-South.**

Source:

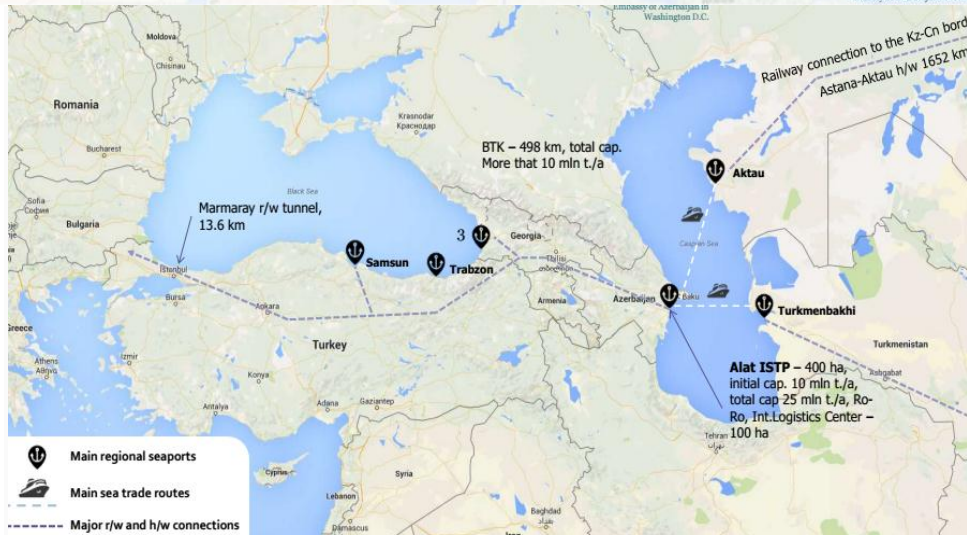
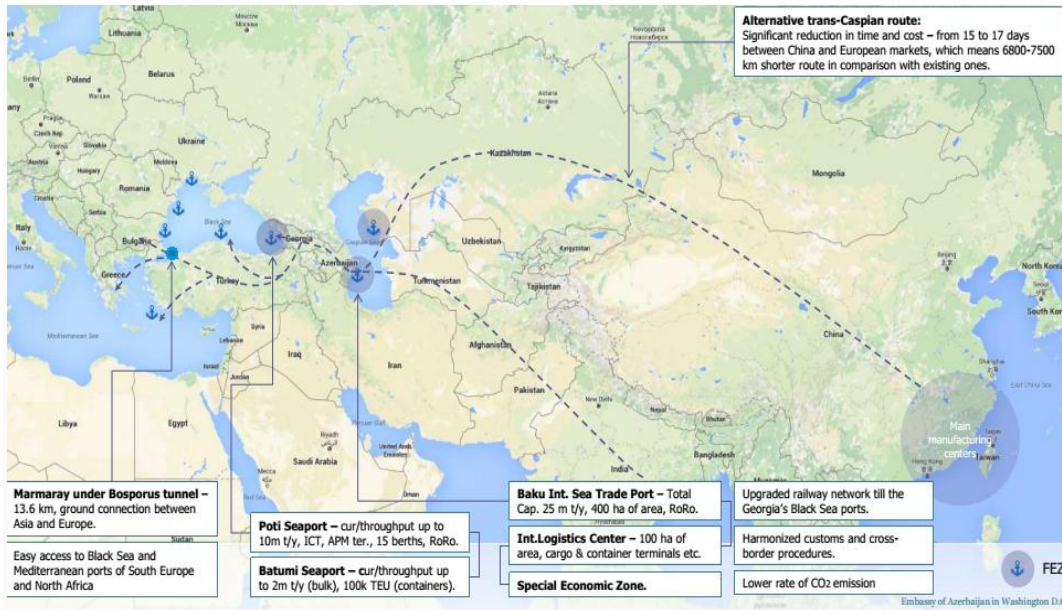
[http://azertag.az/en/xeber/Azerbaijan\\_is\\_a\\_transport\\_bridge\\_connecting\\_Europe\\_with\\_Asia-924814](http://azertag.az/en/xeber/Azerbaijan_is_a_transport_bridge_connecting_Europe_with_Asia-924814)

From a geopolitical point of view, Azerbaijan can act as a regional unifier or divider at the same time (Fig.5 and 6). The transport corridor from the port of Alat through Georgia to Eastern Europe is an alternative to the one-way route once through the land territory of Turkey, a route which, on the one hand, has a short length, and on the other hand it passes through areas with potential security problems. From this point of view, an alternative route through Georgia would definitely be of interest to Europe.

Additionally, such an alternative route could be part of the competing OBOR and North-South projects, with competition between the great Chinese, Russian, Turkish and Azerbaijani national interests.

In this context, Georgia has a strategically important geographic location as it serves as a gateway to the Caucasus and Central Asia and a link between transport systems in Europe and Asia.

<sup>5</sup>Dr. Vugar Bayramov, Christina Juan Carrion, The Silk Road EconomicBelt: Implications For Azerbaijan, CESD, [http://cesd.az/new/wp-content/uploads/2017/05/CESD\\_Presentation\\_the-Silk-Road-Economic-Belt\\_Implications-for-Azerbaijan.pdf](http://cesd.az/new/wp-content/uploads/2017/05/CESD_Presentation_the-Silk-Road-Economic-Belt_Implications-for-Azerbaijan.pdf).



**Fig.5 and 6 Azerbaijan in OBOR**

Source: TheRoleofAzerbaijanontheSilkRoad.pdf

## Georgia

Georgia's governments since 2004 have followed an extremely active policy in the transport sector. On May 14, 2017, Georgia and China signed a bilateral free trade agreement. Together with the Deep and Comprehensive Free Trade Agreement (DCFTA) of 2016, Georgia has a real chance to become a transport and logistics hub connecting China and Europe. In fact, Georgia is the only country in the region with free trade agreements with the EU, China, Turkey and the CIS. Moreover, the pro-European orientation of the country helps facilitate dialogue with the Black Sea countries, members of the EU. By attracting American and European economic interests, Georgia hopes to receive security guarantees in view of the Russian-Georgian events of 2008.

Along with very active political activities in Georgia, large-scale infrastructure projects are being built. It is planned to build a new modern intermodal port complex worth \$ 2.5 billion near Anaklia - a small resort town in the northern part of the Georgian Black Sea coast. It is planned to be implemented with US funding by Conti International, which will receive a concession for 52 years. This will be Georgia's largest deep-sea port with a capacity of 900,000 TEUs per year during the first construction phase starting in 2020, which is 50% more than the capacity of Poti harbor with a capacity of 600,000 TEU but actually realized 385 - 400 thousand TEU per year.

The first stage of construction of the port complex envisages a capacity of 7 million tons/year capable of handling Post-Panamax size vessels.<sup>6</sup> A growth of up to 100 million tons/year is expected, handling capacities up to 10,000 TEU and Panamax, Handymax, Aframax. Along with that, it is planned to build a Free Industrial Zone, open for production and trade, free of taxes for companies around the world.

Although Poti will remain a much smaller port center, Georgia does not underestimate it. In January 2017, China's "China Energy Company Limited" acquired 75% of Poti's Free Industrial Zone. This is an area of 300 hectares, opened in 2011, with a number of companies with a very wide range of activities - from wood production to IT services. The company plans to invest and expand the area in Poti.

Along with the development of the port infrastructure, rail and road transport networks are also developing. The Baku - Tbilisi - Kars railway project with a capacity of 15 million t / year was completed linking the Georgia and Azerbaijan railway infrastructure with the Turkish railway system. The construction of the motorway from Tbilisi to Poti and Batumi - E70 - is on go. To date, over 60% of it is built, with construction running parallel to different sections. The diversion of traffic from coastal resorts has been completed - a project involving the reconstruction, modernization and construction of new roads and bridges with a length of 33.6 km, financed by the Asian Development Bank (ADB).

### **Kazakhstan and Turkmenistan**

The development of transport infrastructure in the Caucasus region is directly linked to the infrastructure projects in Kazakhstan and Turkmenistan. The Aktau port (Kazakhstan) is also located along the Europe-Asia axis. It was built in 1963 and is the only international harbor for dry cargo, crude oil and petroleum products in Kazakhstan. It is located on two important transport corridors - TRACECA and the North-South corridor. In the context of the

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<sup>6</sup><http://www.anakliadevelopment.com/projects/anaklia-port>.

Silk Road Restoration project, a high-speed rail line was completed in the summer of 2014 to allow the development of the transport and logistics system in Kazakhstan and the expansion of transit capacity. The port itself is expanding as part of the Transcaspian Corridor. The completion of two dry cargo terminals with a capacity of 1.5 million tons/year was completed, and another one for grain with a capacity of 1 million tons / year. It is planned to increase the capacity of the port to 18 million tons per year by 2020.

The efforts of Turkmenistan's political leadership to develop transport infrastructure are impressive. In 2016, at the 96th Maritime Safety Committee meeting of the International Maritime Organization (IMO) in London, the Turkmen delegation presented the Transnational Transit and Transport Corridors initiative.<sup>7</sup> Along with the active political activity, large-scale infrastructure projects are also being developed related to the construction of railways, motorways, bridges, the Turkish port in Turkmenbashi and the reconstruction of airports.<sup>8</sup> The railway line Gazochak - Shahsenem - Dashoguz and Ekerem - Madau are currently under construction. The construction of the railway link between Turkmenistan and Afghanistan's rail networks - Atamyrat-Imamnazar (Turkmenistan) - Akina (Afghanistan) was completed in 2016. On Aug. 15, 2013, Turkmenbashi began construction by the Turkish company GAP İnşaatna, a new \$ 2 billion US port. The project envisages the construction of a ferry, passenger and freight terminals shipyard on a total area of 1 200 000 m<sup>2</sup>.

### **Romania**

For the political decision-makers in Bulgaria, a special interest should be the policy of Romania related to the OBOR. Our northern neighbor founded in 2012 the Silk Road Association to coordinate institutional and private sector contacts with the Eurasian countries that are part of the project and to organize and institutionalize Romania's participation in Transeurasian transport corridors.

Romania is now presenting a project to institutionalize a transport corridor Romania - Georgia - Azerbaijan - Kazakhstan - Turkmenistan - Uzbekistan - China.<sup>9</sup>

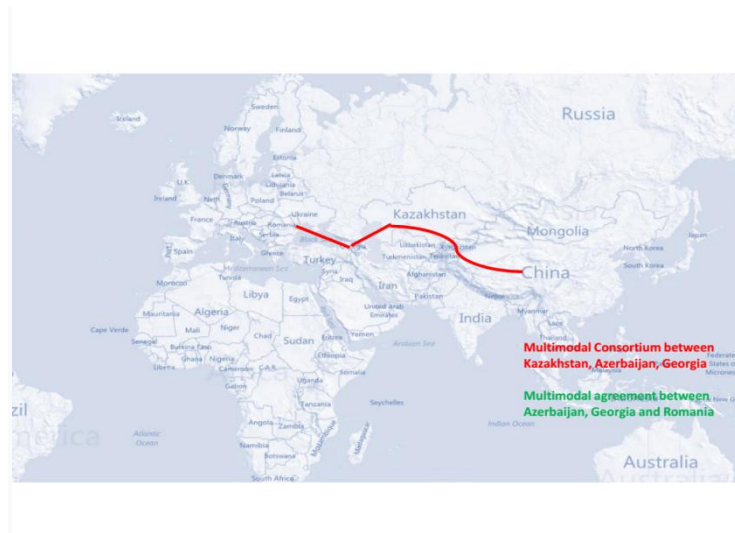
After adopting a new development strategy for the port of Constanta, it has become the largest transport hub for grain cargo (Fig.7). The new Master plan for its development was adopted in 2016 and includes an increase in the port infrastructure in the energy sector under the strategic project AGRI LNG (Azerbaijan - Georgia - Romania interconnector).

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<sup>7</sup><https://akipress.com/news:577262/>

<sup>8</sup><https://uk.tnembassy.gov.tn/en/sustainable-transport/sustainable-transport>

<sup>9</sup>Andree Nistor (vicePresident), Silk Road Association, The Port of Constanta- Major Hub on the Silk Road, 5 Apr 2017, <https://www.google.bg/#q=project+for+strategic+transport+corridor+Romania-Georgia>.



***Fig.7 Port of Constanta in the OBOR.  
Source: Silk Road Association of Romania.***

There are new development plans in the Rhine - Main - Danube direction. They envisage the construction of private LNG terminals in Constanta, Galati, to the ports of Komarno, Slovakia and Meinheim, Germany. China joined the energy market in Romania after successfully concluding negotiations with CEO China Energy Company Limited with KazMunayGas to acquire 51% of former ROMPETROL.

The agreements between the port of Constanta and the ports in Kazakhstan, Turkmenistan, Georgia and China, which have been signed over the past few years, mark undoubtedly a unified consistent political line of interest to increase the flow to the Romanian port. At present, the Association is working on the establishment and institutionalization of a transport corridor on the route Romania - Georgia - Azerbaijan - Kazakhstan - Turkmenistan - Uzbekistan - China. There is a current analysis of the potential of Romanian and Georgian ports to increase the volume of cargoes.

### **Conclusion**

As already noted, Bulgaria's realistic opportunities in the context of the Trans-Eurasian transport corridors should be linked to the possible redirection of some routes from the OBOR route to the Caspian Sea (Azerbaijan - Georgia) - the Black Sea. Obviously, with such a project development, the major bulk of traffic will be directed to Georgia (Anacليا, Poti) - Romania (Constanta). But it will also create real conditions for increasing cargo traffic to the Bulgarian ports of Varna and Bourgas, which make it easier to reach destinations in the Western and Southern Balkans and the Adriatic.

What recommendations can be made to the state elite of Bulgaria in connection with the OBOR project:

Firstly, it is necessary to start some political dialogue and initiate more consultation on the development of the Eurasian transport system.

Secondly, it is important to start construction of intermodal transport hubs. Considering the difficulties and the controversial experience of our country with energy projects, there is a real concern that Bulgaria will be surrounded by this unique transport project again. It is necessary to look for opportunities at a European level to introduce a clearing system, which could be a prerequisite for easier access to markets.

In conclusion, it should be emphasized that the Republic of Bulgaria has many advantages for more active participation in the OBOR project. They are associated not only with its unique geographic location, but also due to the opportunities for connection with European markets as well as a balanced foreign policy contributing to security and stability in the region. It is necessary to increase the state's lobbying activity for these advantages in order to institutionalize the participation of our country in future transport routes.

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# ANALYSIS AND IMPROVEMENT OF ENERGY EFFICIENCY OF SHIP POWER SYSTEM

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**Abstract:** The purpose of this paper is to present a methodology for analysis and optimization of energy efficiency of Ship Power System and to show potential measures for energy savings. Environmental protection, energy efficiency and optimized use of resources are key concerns for scientist all over the world due to global economic growth and increased energy consumption. The greatest potential for conserving resources and lowering energy costs lies in the efficient use of energy.

**Key words:** energy efficiency, optimization, energy savings

## 1. Introduction

The ship as a complex energy system includes Ship Power System and Ship Propulsion System. The greatest amount of energy on the ship is consumed for propulsion. Electrical loads are second in energy consumption. These are the main areas for implementation of energy saving measures. Energy efficiency improvement could be achieved by applying an integrated approach. The ship energy system could be divided mainly into three subsystems - sources of energy; devices for transfer, transmission and distribution of energy; and consumers. (Fig.1.) For evaluation of energy efficiency, it is necessary to undertake a study of distribution and sizes of the energy flows in the system. Optimization of different parts of this system could provide overall efficiency improvement.

The tools that could be applied for evaluation of the effectiveness of the system are "Sankey" diagrams (Fig.2.). These charts visualize the size and distribution of energy flow in the energy system.

The incoming energy flow to the ship is divided into three parts - energy consumed by the main engine, auxiliary engines and auxiliary boiler. The energy (chemical) of the fuel is converted into three types of energies – electrical, mechanical and thermal. Through these charts it is easier to assess consumption, determine the areas with the greatest losses and the



resulting optimization of energy efficiency. Fuel (energy) economy improvements will provide efficiency in maritime transport - reduction of costs and greenhouse gases.

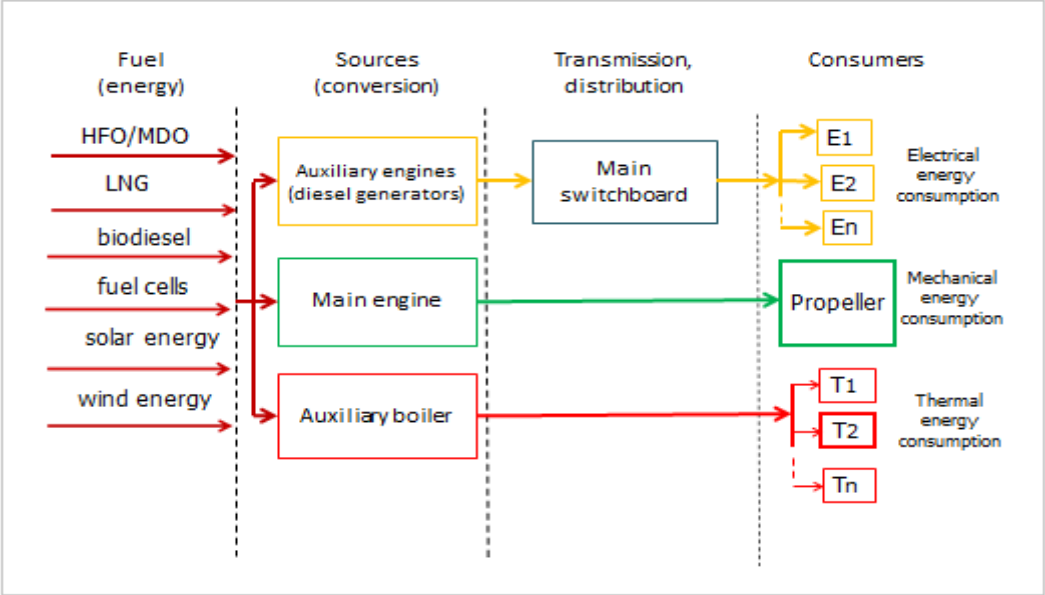


Fig.1. Ship energy system

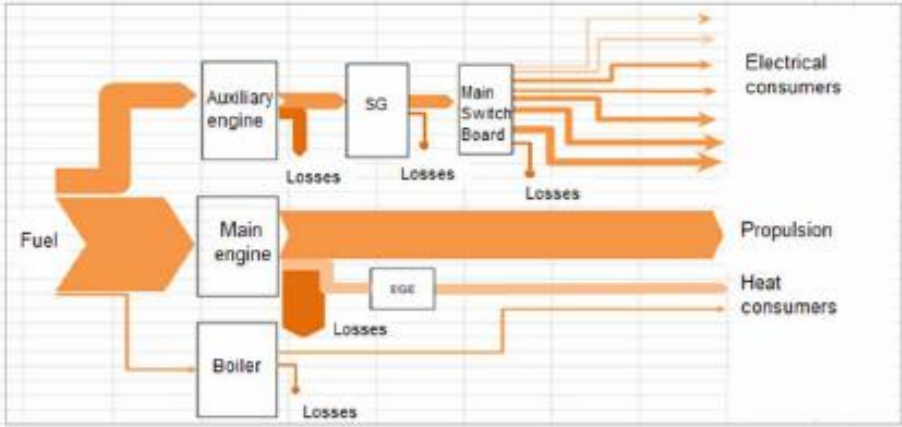


Fig.2. "Sankey" diagram of ship energy flows

**2. Analysis and improvement of Ship Power System energy efficiency**

A great amount of the fuel consumed on the ship is for electricity generation. The proposed methodology for optimization of energy efficiency of Ship Power System includes four main stages: determine baseline data of the system; analysis and assessment; identify and implement the most appropriate measures and practices for improvement and the final stage conclusions for improvement. To achieve energy efficiency optimization, it is necessary to

undertake analysis of the distribution and size of the energy flow in subsystems - from the source through the devices for power transmission to consumers.

## 2.1 Analysis of the energy flow through the auxiliary engines (diesel generators)

For assessment of the effectiveness of auxiliary engines the thermal efficiency is calculated. In the example considered, the ship (Container carrier „Jaguar Max“2,200 TEU) has: Diesel generator (DG) – 4pcs. - YANMAR 6N280L-EN 1470 kW, 720 RPM, Generator type: FEK 55B-10, 1837 kVA, 2358A, 450V AC, 60Hz,  $\cos\varphi = 0.8$ .

We study one of the main modes - **Sailing with working refrigeration equipment.**

In this mode it is necessary to use three diesel generators and the power of auxiliary engines (AE) is:  $P = 4410$  kW. For calculation of daily fuel consumption of AE we use Power consumption in this mode:  $P_{AE} = 3982$  kW

**Daily fuel consumption of AE:** 
$$FOC_{AE/IS} = \frac{P_{AE} \times SFC \times h}{g/t} = \frac{3982 \times 200 \times 24}{1000000} = 19,1 [t/day],$$

where  $SFC_{AE} = 200$  g/kWh - specific fuel consumption of AE

$h = 24$  - transit hours for day;

$g/t = 1000000$  - grams per metric ton;

For evaluation of the thermal efficiency of AE, first is determined the amount of fuel consumed per second  $m_f$  [kg/s] and heat flow  $Q_f = m_f \times C.V.$  emitted in engine during combustion.

The fuel consumption per second: 
$$m_f = \frac{19,1}{24 \times 3600} \times 1000 = 0,221 kg/s$$

$C.V.$  (*calorific value*) is the thermal energy released during combustion of 1kg of fuel [kJ/kg].

$C.V.$  for AE is 42720 kJ/kg (10200 kcal/kg)

The heat flow in engine is: 
$$Q_f = m_f \times C.V. = 0,221 \times 42720 = 9441,12 kW$$

**The resulting thermal efficiency AE is:** 
$$\eta_{BTh} = \frac{P_B}{Q_f} = \frac{3982}{9441,12} = 0,42,$$

where  $P_B = 3982$  kW is the output shaft power in this mode.

**The total energy received from AE** for a year in this mode (292 days) has value[1]:

$$E_{AE} = 9441,12 \times 24 \times 292 = 66163,4 MWh$$

**The useful energy has value:**  $E_{AE/S} = 3982 \times 24 \times 292 = 27905,8 MWh$

**- Energy losses in AE**

The losses can be calculated by total energy  $E_{AE}$  received from AE and useful energy  $E_{AE/S}$ :

$$E_{AE/S/loss} = E_{AE} - E_{AE/S} = 66163,4 - 27905,8 = 38257,6 MWh$$

$$(Q_{loss} = Q - Q_E = 9441,12 - 3982 = 5459,12 kW ;$$

$$E_{loss} = 5459,12 \times 24 \times 292 = 38257,5 MWh)$$

**- Energy efficiency improvement of AE**

Thermal energy losses from exhaust gases and cooling systems represent a significant part of the energy flow through the diesel engine. Part of this energy can be recovered (Waste Heat Recovery System) to save money and reduce emissions, which will increase the efficiency of the system. [3]

The exhaust gas flow from the auxiliary diesel engine can be calculated [2]:

$$\left( \frac{\text{Exhaust Temp. (°F)} + 460}{540} \right) \times \text{Intake Airflow (CFM)} = \text{Exhaust Flow}$$

For the survey vessel, the auxiliary engine is the Diesel 4-Cycle Turbo type and the temperature is 900 °F. Input airflow (CFM) data is provided by the manufacturer and, if missing, it is calculated by multiplying the power (h.p.) by 2.5. The engine tested has a power of 2200 hp. And the incoming airflow has a value: CFM = 4966.5 (at load 90.3%)

The flow of exhaust gases obtained is:

$$\text{Exhaust flow} = \frac{900^\circ F + 460}{540} \times 4966,5 = 12508,22 \text{ kg/h}$$

$C_p = 1,014 \text{ kJ / kg}$  is the specific thermal capacity of the exhaust gases

(<http://www.dieselnet.com>);

The exhaust gas temperature at full load is 400 °C, the output temperature from the turbocharger is 500 °C, and therefore the thermal energy of the exhaust gases is [4]:

$$Q_{us,g} = m_g \cdot c_p \cdot (T_{in} - T_{out}) = \frac{12508,22}{3600} \cdot 1,014 \cdot (500 - 400) = 352,3 kW$$

The amount of additional thermal energy obtained can be increased depending on the operating mode and the number of working DGs.

Energy from the auxiliary engines as waste heat could be used to obtain the necessary amount of steam for consumers when sailing or staying in a port. This will provide a reduction in emissions, the steam (energy) obtained will be at a low cost and the payback period of the investment short.

For energy savings is recommended using one diesel generator (DG) running at nominal mode (load 80% of rated power) when sailing. When consumption is higher (operation of deck machinery, refrigeration containers, pumps and compressors) it is necessary to use several DGs working in parallel.

Fuel consumption varies depending on the load of the diesel – generator. For the studied auxiliary diesel engine 6N280L-EN x 1470kW it is shown in Table 1.

**Table 1.**

Load factor, %	25	50	75	100	110
Fuel oil consumption (FOC), kg/kWh	250,3	221,1	217,1	211	215,9

A comparison can be made and the resulting savings can be calculated by increasing the load on the engine. For the auxiliary diesel engine 6N280L-EN x 1470kW according to data of test trials, at 50% load, the fuel oil consumption is: FOC = 221 kg/kWh, and at load 75%, fuel consumption has value: FOC = 217 kg/kWh. For sailing with duration of 6 months (180 days), 24 hours a day, 983kW power consumption for sailing mode (without refrigeration).

- **at 50% load**, the fuel consumption is:  $FOC = 180 \times 24 \times 221 \times 983 = 938,5t$

- **at 75% load**, the fuel consumption is:  $FOC = 180 \times 24 \times 217 \times 983 = 921,5t$

Fuel saved for sailing mode (without refrigeration) is **17t**. At a cost of \$ 600, the value of the expected savings (for 6 months) is:  $17t \times \$ 600 = \$ 10200$

Fuel savings will provide efficiency improvement and reduction of greenhouse gases:

$$\Delta CO_2 = C_F \times \Delta FOC = 3,206 \times 17t = 54,5 tCO_2 ,$$

where  $\Delta CO_2$  is the amount of carbon emissions saved;  $\Delta FOC$  – fuel saved;  $C_F = 3,206$  (t-CO<sub>2</sub>/t-Fuel) for Diesel/Gas Oil is the conversion factor of emissions CO<sub>2</sub>.

## **2.2 Analysis and energy efficiency improvement of the devices for power transmission and electrical loads**

For evaluation of energy efficiency we study distribution and size of the energy flow through the devices for power transmission to consumers.

If we consider the most typical mode - ***Sailing with operation of refrigeration equipment***

**The energy generated by AE per day is:**  $E_{AE/S} = P \times h = 4410 \times 24 = 105840 kWh$

$P = 4410 \text{ kW}$  - full power of auxiliary engines;

$h = 24$  - transit hours per day;

**The energy generated by AE per year (292 days):**

$$E_{AE, \text{year}/S} = 4410 \times 24 \times 292 = 30905,3 \text{ MWh}$$

In this mode of sailing, the load factor of auxiliary engines is 90.3%; efficiency of AE is  $\eta_{AE} = 96,2\%$ , and the efficiency on the main switchboard is  $\eta = 98\%$ . The amount of energy flow (for 1 year) through the elements of the system is shown in the table below:

**Table 2.**

	<b>Incoming energy flow</b>	<b>Efficiency</b>	<b>Outgoing energy flow</b>	<b>losses</b>
Electric power generated by the AE	30905,3 MWh	96,2%	29730,9 MWh	1174,4 MWh
Main switchboard	29730,9 MWh	98,%	29136,3 MWh	594,6 MWh

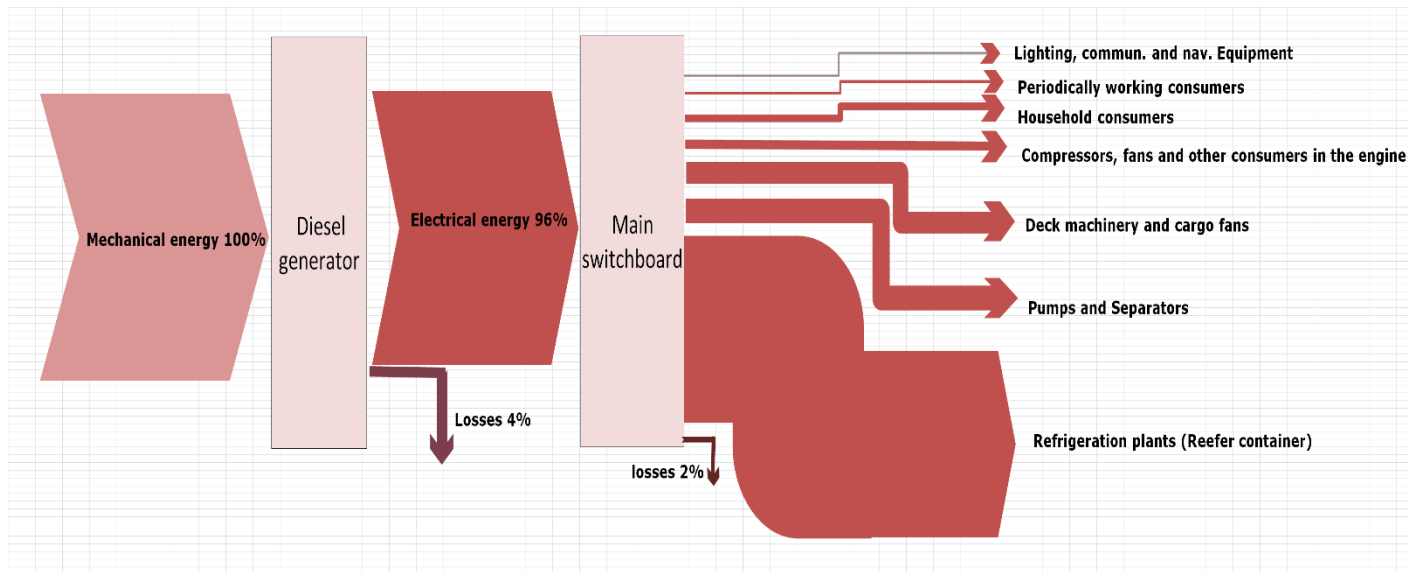
The distribution of energy flow to electrical loads in mode *sailing with operation of refrigeration equipment* is presented in Table 3.

**Table 3.**

	<b>Consumers</b>	<b>Power consumption</b>	<b>Incoming energy flow</b>	<b>Energy %</b>
1.	Pumps and Separators	373,1 kW	2614,7 MWh	9,4%
2.	Compressors, fans and other consumers in the engine room	138,9 kW	973,4 MWh	3,5%
3.	Deck machinery and cargo fans	331,1 kW	2320,35 MWh	8,3%
4.	Refrigeration plants (Reefer container)	2949,3 kW	20668,7 MWh	74%
5.	Household consumers	118 kW	826,94 MWh	3%
6.	Lighting, commun. and nav. equipment	28,8 kW	201,83 MWh	0,7%
7.	Periodically working consumers	43 kW	301,34 MWh	1,1%
	<b>Full power consumption</b>	<b>3982,2 kW</b>	<b>27907,3 MWh</b>	<b>100%</b>

Essential part of the electrical energy is consumed by refrigeration equipment, drive systems of pumps and fans. These consumers are the most common, they provide proper operation of ship systems and mechanisms and good working conditions for the crew.

In order to identify areas of the system that need to be optimized we could use a Sankey diagram of Fig.3. This chart describes the distribution and size of the energy flow from the source of electrical energy through the devices for power transmission and distribution to electrical loads and energy losses.



**Fig.3.** “Sankey” diagram of the energy flows in the Ship Power System

The size of the flows in the chart corresponds to the amount of energy flowing through the subsystems. This diagram also identifies key consumers whose performance needs to be optimized. The most significant impact on the workload of ship power plant have continually working consumers - the mechanisms of the main engine, refrigeration systems, deck machinery, fans and pumps. As this motor driven systems are the largest energy consumer on the ship optimization of the performance of these systems will provide greatest energy savings.

**The main optimization activities include:**

- Proper selection of mechanisms and motors to ensure optimal load of electric drive;
- Implementation of high efficient electric motors and power converters;
- Improved operation;
- Effective management and operation of electric drives - flow control by variable frequency drive.

In the example considered, the ship has 58 number of pumps - cooling, ballast, fire, fuel feed, oil-pumping, etc.; 9 compressors – cargo, conditioner and DG; 66 number of fans - in different locations on the ship. To obtain the most efficient optimization is to adjust the speed of the electric drive. ( $P_2/P_1 = (n_2/n_1)^3$ ).

Flow control by variable frequency drive provides energy savings, lower fuel consumption and reduction of emissions CO<sub>2</sub>.

As an example we may consider the application of the variable frequency drive (VFD) for the seawater cooling pumps (M.Cool.S.W.P.). For comparison of the different methods for control we could apply software calculators (Pump Save, PSAT). They are used to determine the

amount of savings and the investment payback period. Comparison between throttle and frequency control and bypass with frequency control was made.

**The characteristics of the considered system are as follows:**

Density of seawater:	$\rho = 1 \text{ kg / dm}^3$
Nominal volume flow:	$Q_n = 1200 \text{ m}^3 / \text{h}$
Nominal pump head:	$H_n = 20 \text{ m}$
Maximum head:	$H_{\text{max}} = 30 \text{ m}$
Static head:	$H_{\text{st}} = 1 \text{ m}$
Nominal pump efficiency:	$\eta_p = 80\%$
Nominal motor power:	$P_{\text{in}} = 90 \text{ kW}$
Voltage:	400V
Nominal motor efficiency:	$\eta_m = 94\%$
Nominal efficiency of the VFD:	$\eta_{\text{VFD}} = 98\%$
Working time for 1 year:	5400 h
Electricity price (per kWh):	0.144 \$ / kWh
Cost of the investment costs:	25000 \$

Working time of pump at different loads:

60% * Q = 10%
70% * Q = 20%
80% * Q = 50%
100% * Q = 20%

**Savings when replacing a throttle with VFD:**

Required pump power:	81.8 kW
Energy (throttle control):	441 MWh
Energy (VFD):	278 MWh
Energy saved in a year:	163 MWh
Annual energy costs saved:	23 472 \$
Value of the initial investment:	25 000 \$
Payback time:	1.1 Years

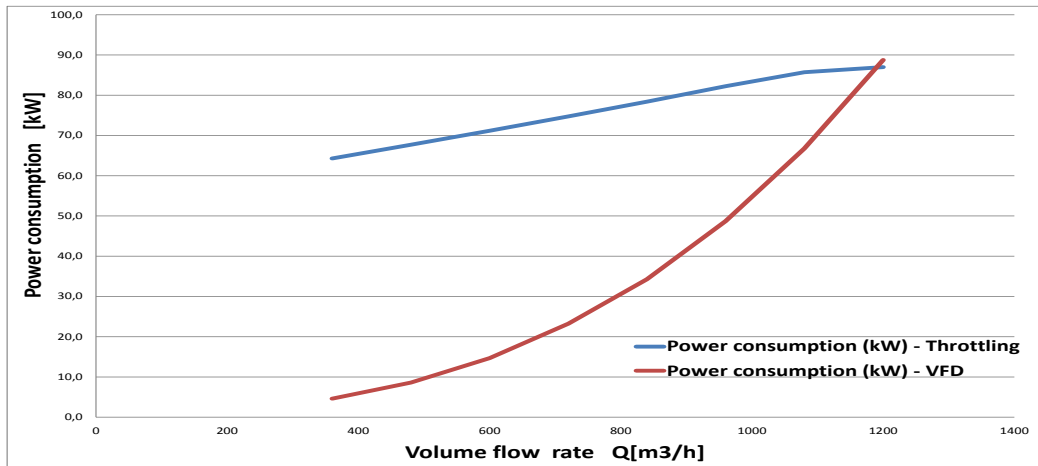


Fig.4. Specified values of the power consumption at throttle and VFD

**Replacement of bypass control with variable frequency drive:**

Required pump power:	83.4 kW
Energy (bypass control):	489 MWh
Energy (VFD):	283 MWh
Energy saved for a year:	206 MWh
Annual energy costs saved:	29 703 \$
Value of the initial investment:	25 000 \$
Payback time:	0.8 Years

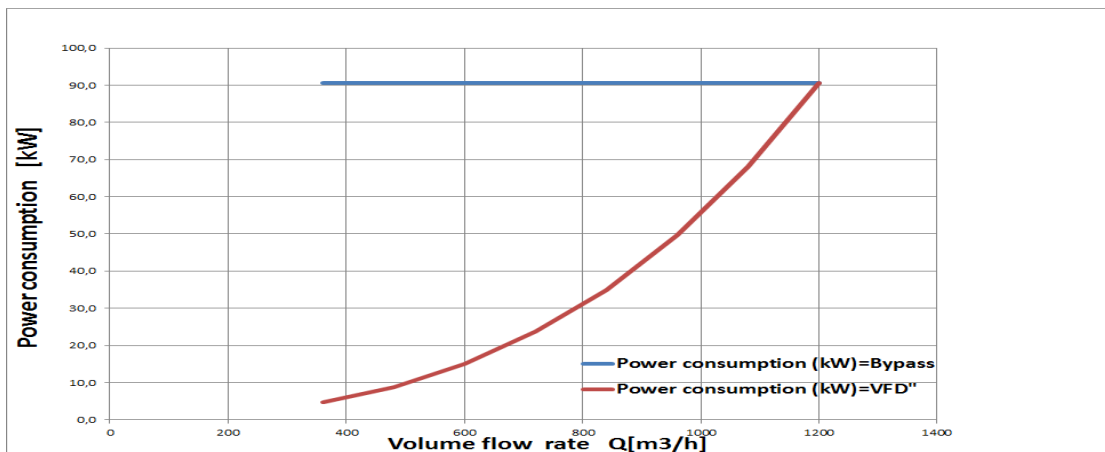
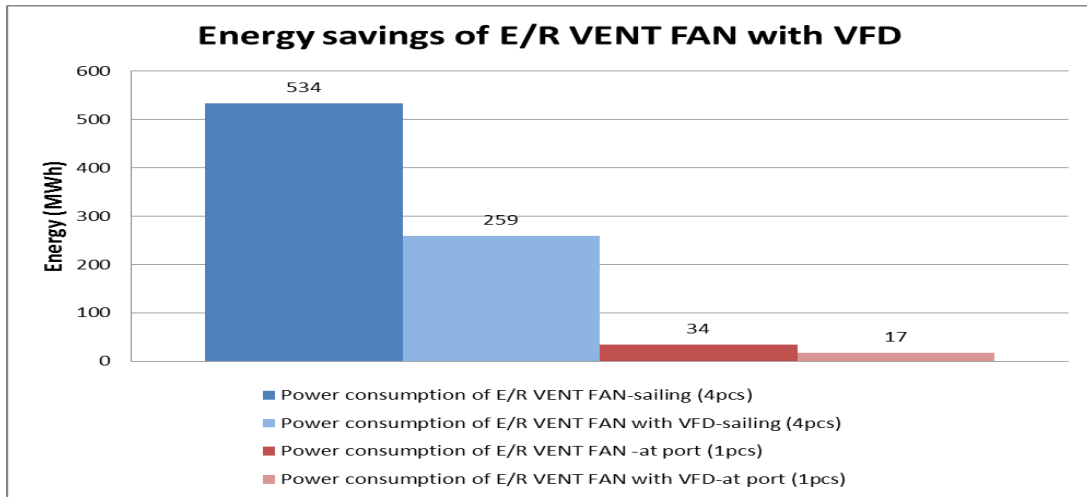


Fig.5. Replacement of bypass control with VFD resulting in greater power savings.

As an example we may consider the application of the VFD for the fans in the engine room.





**Fig.6.** Energy savings when use variable frequency drives for fans in engine room

In this considered **container carrier** (2200 TEU) for the fans in the engine compartment (E/R VENT FAN - 4 pcs work at sailing mode) it is assumed that the motors in 80% of the time operate with 70% of the nominal speed (power 22 kW, efficiency 89%,  $P_k = 98,9$  kW at 5400 hours). When using a variable frequency drives (efficiency = 98%), the energy at part load is:

$$E_1 = 98,9 \times (0,7)^3 \times 5400 \times 1/0,98 \times 0,8 = 150 \text{ MWh}$$

For the rest 20% of the time, the energy at full load is calculated:

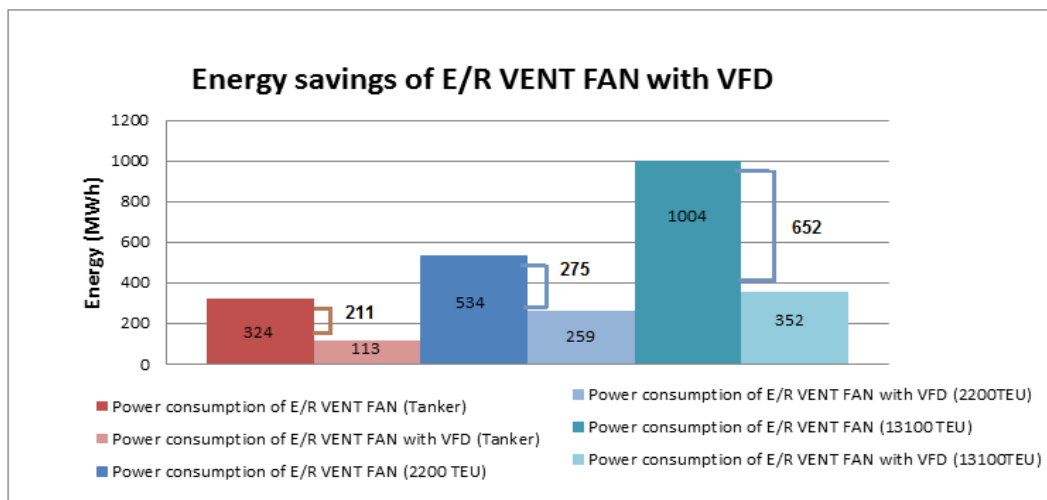
$$E_2 = 98,9 \times (1,0)^3 \times 5400 \times 1/0,98 \times 0,2 = 109 \text{ MWh}$$

Energy consumption when using variable frequency drives is:

$$E_{vfd} = 150 + 109 = 259 \text{ MWh}$$

Power consumption without using a frequency drive is:  $E = 98,9 \times 5400 = 534 \text{ MWh}$

Energy savings:  $E_s = E - E_{vfd} = 275 \text{ MWh}$



**Fig.7.** Savings when using VFD for fans in engine room for a different types and sizes of ships.

For comparison of savings for different ship size and types, were used data for tanker 164,000 DWT and container carrier 13,100 TEU **Tanker** - E / R VENT FAN - 4pcs: power 18.5kW; efficiency 78%; load factor 63%; at 5400 hours.

In the sailing mode - 4 pcs fans and the power consumption is  $P_k = 60$  kW.

The energy consumed at full load is:  $E = 60 \times 5400 = 324$  MWh.

When using a variable frequency drives (efficiency = 98%), the energy at part load (70%) is:

$$E_{vfd} = 60 \times 5400 \times (0.7)^3 \times 1/0.98 = 113 \text{ MWh.}$$

The energy saved is:  $E_s = E - E_{vfd} = 211$  MWh.

**Container carrier (13100 TEU)** - E/R VENT FAN - 3pcs: power 75 kW; efficiency 93%; load factor 77% at 5400 hours. In sailing mode work 3 pcs. Fans and power consumption is  $P_k = 186$  kW.

The energy consumed at full load is:  $E = 186 \times 5400 = 1004$  MWh

When using a variable frequency drives (efficiency = 98%), the energy at part load (70%) is:

$$E_{vfd} = 186 \times 5400 \times (0.7)^3 \times 1/0.98 = 352 \text{ MWh.}$$

The energy saved is:  $E_s = E - E_{vfd} = 652$  MWh.

### 3. Conclusions

Implementation of energy management strategy on the ship could reduce energy consumption and operational costs. By performing energy analysis and evaluation of energy flows on the ship it is easier to choose the most appropriate opportunities for energy savings. The methodology proposed in this paper for energy efficiency improvement consists of overall energy assessment and performance optimization of Ship Power System. Reduction of energy consumption and fuel saving would provide optimization of energy efficiency of ships and environmental protection.

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# AN EDUCATION DESIGN FOR ENERGY-EFFICIENT SHIP HANDLING

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## Abstract

There has been an increasing interest in the energy-efficient operation of vessels. Stakeholders in the maritime industry have identified several methods of improving energy efficiency, and a large number of studies have been conducted. It has been emphasized by many that improving the energy efficiency on board vessels should include factors such as increasing awareness of the problem, knowledge skills and motivation by ensuring the availability of maritime education and training, which has to address both technical and human factor topics. The aim of the paper is to present a proposal for an educational design for energy-efficient ship operation for master mariner students. The objective has been to create a “Practicum” by using full-mission bridge simulator facilities. A full-mission simulator is an image of the world that allows the students to obtain skills through learning-by-doing in a safe environment. The course focus will be on energy efficiency, but sailing a ship is a multi-objective task – when he plans his voyage, the master must take into consideration safety, regulations, commercial interests, and finally also the energy consumption. This often results in conflicting goals and his actions must be balanced, which requires specific competence. The course is based on a combination of simulator sessions and reflection workshops, using the concept of “learning-by-doing” for the awareness training and reflective learning. Due to the safe learning environment, it is possible in a simulator to challenge the balance between safety, time and energy efficiency. Furthermore, during discussion in the reflection sessions, the students are trained in expressing and giving words to their thoughts behind their decisions, enabling them to reflect on action in

groups. The main objective of the course is to give the students the possibility to learn how different choices and actions affect the outcome.

**Keywords:** Maritime education, energy efficiency, simulator, awareness, the reflective practitioner

## 1. Introduction

Over recent decades, there has been an increasing focus on sustainable maritime transport. It has become a part of the political agenda, where regulation is used as the main driver, but due to increasing oil prices, the industry itself has also been driven towards a more energy-efficient operation of ships. The International Maritime Organization (IMO) has introduced guidelines for calculating energy efficiency during both the design [1] and the operation phase [2], and stakeholders in the maritime industry have identified several methods of improving energy efficiency, see for example the DNV GL Energy management study from 2015 [3]. This study is based on input from ship managers, owners and operators answering the key question “To actually increase energy efficiency in ship operation, what really matters?” The report showed that the companies struggle with the implementation of energy performance management and finally concluded “that people make the difference”. This conclusion was based on the fact that forty percent of the companies pointed out that lack of education and experience of crew and office staff is a primary barrier for improving the energy efficiency of ships. The study concludes that improving the energy efficiency onboard vessels must include factors such as awareness, capability and behavior.

The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) [4] sets the standards of competence for seafarers internationally. The latest revision of the STCW convention and code was done in 2010 and entered into force on January 1<sup>st</sup>, 2012 [5]. One of the amendments highlighted in relation to energy-efficient operation is “New requirements for marine environment awareness training and training in leadership and teamwork”. Therefore, it must be expected that future generations of seafarers do not have a lack of education, as pointed out in the DNV – GL Management study. In a survey from 2011 of the Maritime Education and Training (MET) of maritime personnel in the selected Ship Energy Efficiency area [6] [7], the MET institutes interviewed point to simulator training as a way forward, as they use “try-observe-compare” as awareness training. Furthermore, the mind-set “better safe than sorry” is mentioned as a barrier, as among the institutions there was a lack of awareness about how energy efficiency can be achieved without compromising safety.

Onboard training may not be the best choice due to the lack of education of the higher-ranking officers, which was also pointed out in the DNV- GL survey [3].

Based on the findings from a study conducted at SIMAC in 2016, a proposal for an educational design for energy-efficient ship handling for master mariner students is presented in the present paper. The educational design is based on the concept of The Reflective Practitioner, as developed by Donald A. Schön [8]. The professional practitioner, in this case the competent captain, is expected to sail his ship - in short - as fast, as safely and as cheaply as possible in any conditions and under any circumstances. It is not possible to teach him how to do it. There is no way to describe every situation he may encounter, and so he will have to acquire the skills to judge the specific elements of any situation and apply his experience and knowledge in handling it.

The objective has been to create a “Practicum” by using the full-mission simulator facilities. The simulator provides the student with an opportunity to test the effects of his actions and observe the impact of his maneuvers on, for example, the energy consumption in the specific situation. A full-mission simulator is an image of the world that allows the students to obtain skills through learning-by-doing in a safe environment. The course combines simulator sessions with instructions and knowledge sharing, which will provide the students with the opportunity to acquire skills in praxis and reflect-on-action.

## **2. Requirements for Energy Efficiency Training**

The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW) [4] sets the standard for the mandatory minimum requirements for certification of officers in charge of a navigational watch on ships of 500 gross tonnage or more. In the latest revision of the convention, which entered into force in 2012 [5], the amendment included requirements of *knowledge and ability to apply effective resource management* and *obtaining and maintaining situation awareness*. This amendment has been highlighted as one of the more significant changes. In addition, other smaller adjustments have been made that may affect the energy-efficient training. In Chapter II of the convention, the minimum requirements for knowledge, understanding and proficiency are described. The requirements the officer has to comply with in regard to pollution prevention can be seen in Table 1. The third column of the table describes methods for demonstrating competence - added in the latest amendment is the acceptance of approved training as a method for demonstrating competence. It can be seen that approved training in an academy and not only onboard a ship is now possible, making room for a more controlled learning environment. The

quality of onboard training will depend on the competence and motivation of the crew and may not be the best solution. This is also mentioned by DNV GL in their energy management study [3], see Section 1.

Competence	Knowledge, understanding and proficiency	Methods for demonstrating competence	Criteria for evaluating competence
Ensure compliance with pollution prevention requirements	Prevention of pollution of the marine environment and anti-pollution procedures. Knowledge of the precautions to be taken to prevent pollution of the marine environment. Anti-pollution procedures and all associated equipment <i>Importance of proactive measures to protect the marine environment</i>	Examination and assessment of evidence obtained from one or more of the following: .1 approved in-service experience .2 approved training ship experience .3 <i>approved training</i>	Procedures for monitoring shipboard operations and ensuring compliance with MARPOL requirements are fully observed <i>Actions to ensure that a positive environmental reputation is maintained</i>

Table 1 Minimum requirements for knowledge, understanding and proficiency. STCW [5].

Text in italics are amendments in the latest version of the convention.

### 3. Theory

The educational design is inspired by Donald Schön's concept of The Reflective Practitioner [8]. In his books, Donald Schön discusses how knowledge and professionalism is perceived as either technical rational, specialized, firmly bounded, scientific and standardized or on the other hand as an artistic competence to make sense of complexity. Schön's objective is to find a way to educate for professional artistry. He takes the stance that the professional practitioner deals with unique cases which cannot be handled by simply applying one of the rules from the book, and that the competence shown by professional practitioners in unique and maybe conflicted situations is the artistry or the knowing-in-action, which is the hallmark of the practitioner.

Professional knowledge is formed of three different elements and is placed in a hierarchy by Edgar Schein [9], whom Schön refers to as he makes a distinction between basic science, applied science and technical skills and states that professional knowledge cannot be acquired solely through theoretical teaching [8]. Professional knowledge can be viewed in different ways. It may be the knowledge of facts, rules and procedures to solve routine problems, or it may be a way of thinking which gives the right answer to a specific case, and finally it may be the kind of reflection-in-action in which practitioners sometimes make sense of uncertain, unique or conflicting situations of practice [10]. Theories, rules and procedures may be taught in classrooms, but the practitioners' competence can only be obtained through practicing the performance of them. According to Schön, practitioners have to solve problems in the

indeterminate zones of practice, where they face "... uncertainty, uniqueness and value conflict which escape the canons of technical rationality" [10]. To do this calls for a high degree of competence, or even artistry. In his work, Schön is inspired by John Dewey [11], who saw "learning-by-doing" as the primary way to acquire skills, as the practitioner cannot be taught, but has to "see for himself". Reflection-in-action is a key term in Schön's theory and refers to the idea that practitioners "... reflect on practice while they are in the midst of it" [8]. When solving a complex problem, practitioners draw on theory as well as experience. It could seem that they are seeking a solution through trial and error, "But the trails are not randomly related to one another; reflection on each trail and its result sets the stage for the next trail" [10].

To create room for reflection and to complement the theoretical and technical rational teaching, Schön suggests a practicum as a setting for the students to learn in practice. A practicum opens the opportunity for the students to try out knowledge and techniques learned in the classroom. "They learn by undertaking projects that simulate and simplify practice; or they take on real-world projects under close supervision. The practicum is a virtual world, relatively free of the pressures, distractions and risks of the real one, to which nevertheless, it refers" [10]. As the student now learns by doing, the teacher's role changes from teaching to coaching. "Most practicums involve groups of students who are often as important to one another as the coach. Sometimes they play the coach's role. And it is through the medium of the group that a student can immerse himself in the works of the practicum, "... learning new habits of thought and action" [10]. After the workshops, the students get the opportunity to discuss their understanding of the task and outcome and to share experiences of the different means and methods employed to obtain the results wanted.

The individual student reflects-in-action while solving problems, applying previous experience and the theoretical knowledge acquired in the classroom, or maybe working with other students on a specific task, trying out techniques or standards to handle complex situations. Subsequently, the students meet with the coach in a reciprocal reflection-on-action.

The Reflective Practicum is developed to take reflection to a higher level. In the reflective practicum, the coach offers a reciprocal reflective dialog and encourages the student to reflect-on-action. Students must be ready to engage in a discussion, to openly share doubts and to give and receive critique, as "A reflective practicum must include values and norms conducive to reciprocal, public reflection on understandings and feelings usually kept private and tacit" [10]. Reflection-on-action has taken reflection "a step up". Schön exemplifies this by using a ladder metaphor and describes the rungs of the ladder: the first step being reflection-in-action, which is done while performing the task, and following this, the second step, reflection-on-action, is a

description of what is done and why, i.e. the thoughts behind the chosen action and the evaluation of the results. This reflection is reciprocal and the coach's questions, advice, or criticism may be part of it. This may also be described as a first and second order reflection. One step further up the ladder leads to reflection on the process, and the last step on the ladder is a reflection on the dialog itself; reflection on the reflections [10]. In the reflective practicum, learning is acquired moving up and down the ladder as reflection follows action and new action is undertaken following reflection, and so forth.

The work of a reflective practicum takes time, as it takes time to shift back and forth between reflection-on-action and reflection-in-action, sometimes even several months, but a practicum may be incorporated in the educational curriculum of a professional school.

#### **4. Design of the Course**

The crew onboard the ship plays a very important part with regard to energy-efficient ship handling; it is they who make the daily operational decisions, such as route, speed and engine settings - all parameters that influence the energy consumption. For improving the knowledge and understanding the problem, the present course has been developed following the theory of The Reflective Practicum, and so it is meant to be a part of the basic training to become a master mariner.

The aim of the course is to increase the awareness, knowledge, skills and motivation by the education and training of coming officers for energy-efficient ship handling. The focus will be on energy efficiency, but this is only one parameter among many others, such as the environmental conditions, the traffic intensity and the expected weather conditions, which the master mariner, being a professional practitioner, must take into consideration when he plans and conducts his voyage. The master has to consider multiple objects such as safety, regulations, commercial interests, and finally also the energy consumption. These often result in conflicting goals and his actions must be balanced, which requires specific competence.

The course is based on a combination of simulator sessions and reflection workshops, using the concept of “learning-by-doing” for the awareness training and reflective learning. Due to the safe learning environment, in a simulator it is possible to challenge the balance between safety, time and energy efficiency. Furthermore, during discussion in the reflection sessions, the students are trained to express and give words to their thoughts behind their decisions (reflection-in-action), enabling them to reflect-on-action in groups. The main objective of the course is to give the students the possibility to learn how different choices and actions affect the outcome.



The learning program is divided into six phases. Each phase is described by learning objectives, and a description of how these objectives are achieved during the specific session. The students are part of a training group of about eight students; the students are in command, officer on watch (OOW), one at a time, but meet during the workshops. Each phase ends with a small session, where the student (the officer on watch) together with the coach reflect on the performed voyage, thus following Schön's ladder metaphor, moving up and down. It is expected that the students have basic knowledge about energy efficiency management before attending the course. Basic theory, and navigational and ship handling knowledge, are a prerequisite and are acquired through the curriculum for master mariners.

#### **Phase 1: Simulator - Familiarization**

Initially the students must familiarize themselves with the route, the vessel and its maneuverability. The goal here is to make the simulator training realistic.

#### **Phase 2: Simulator – Baseline**

In order to establish a basis for reflection and discussion, the route is sailed three times. A short introduction to the use of a fuel monitor installed on the bridge is given to the students, they are encouraged to use it as a tool and the “learning-by-doing” concept (try-observe-compare) is introduced. The performance and awareness may be influenced by previously acquired experiences, like for example onboard training during their apprenticeship.

#### **Phase 3: Workshop – Knowledge sharing**

The students are presented with information about the voyage and the energy consumption for the first three voyages performed during phase 2, in the form of diagrams and data. The purpose of the session is knowledge sharing – the students will be encouraged to compare, reflect and discuss with each other their way of conducting the voyage. The intention is to make room for reflection-on-action in a group to improve the learning through reciprocal reflections, see Section 3.

#### **Phase 4: Simulator**

After the workshop performed in phase 3, the voyage will be conducted again. Data on the voyage and on energy consumption are collected and used at the end of the session in the reflection on the session with the coach, when the benefit from exchange of experience and the knowledge sharing between the students are considered and discussed.

#### **Phase 5: Simulator - Complex navigation**

The voyage is conducted again with increased complexity - the visibility is reduced and the traffic intensity is increased. During this phase, the student must take into account new and additional environmental elements, forcing him to make decisions considering conflicting

requirements. This will make room for reflection (reflection-in-action) on how changes in condition will affect his actions/decisions, and how the balance between safety and energy efficiency may have changed.

### **Phase 6: Knowledge sharing**

The students are presented with data about all performed voyages. They are encouraged to reflect and discuss the course progress with each other. During this session, the students are trained to express and give words to their thoughts behind the decisions taken. They not only make reflection-on-action in a group, but also reflection on the reflections.

## **5. Discussion**

Increase of awareness is one of the focal points when it comes to energy efficiency, but to be aware requires the competence to identify what to be aware of. Lack of experience and education has been identified as a primary barrier for improving the energy efficiency of ships [3]. Before the 2010 amendments to the STCW convention [5], training in energy efficiency was an objective for onboard training, but as the older, experienced officers onboard had not received education on the subject, they too were trained onboard [7]. The level of skills of the experienced onboard crew may well be low with regard to energy efficiency, and the learning and training of the cadets in the subject would therefore be arbitrary. The described educational design is performed ashore in a simulator. This provides the opportunity to control the process, combining the knowledge obtained during apprenticeship (onboard training) with theoretical knowledge/basic science. The students will be trained for mastering multi-objective conditions - safety, regulations, commercial interests, energy efficiency – forcing them to make decisions based on conflicting conditions. There is no right and wrong; the balance between the multiple objectives are individual, and so the course focuses on the reflection-on-action. If the students are to reflect on their action in a group, they must be trained to express and give words to their thoughts behind their decisions - they need a vocabulary to describe their actions, which together with competence are the most important skills for them to achieve. The vocabulary gives them the possibility to discuss and argue their choice of action, and thereby assessment of the skills acquired becomes possible. Many experienced officers lack this vocabulary, which keeps them from being able to share their knowledge with both colleges and cadets onboard. The reflection-on-action in groups is a centerpiece to the educational design, but it has to be acknowledged that it is a vulnerable situation. The student has to open up to the other participants in the group, not only to give word to their actions, but also to learn from each other's actions. This requires trust between the participants, and if this is not obtained, the

reflection session might be without value. This is why a smaller, more intimate group of only eight participants is suggested.

In order for the students to enter the practicum and to challenge a multi-objective condition, the students need some experience – they must be able to understand the consequences of their actions – and therefore the course has to be placed in the final part of the education.

The DNV-GL survey touches on the subject of the education of the land-based office staff. This course will give the participants – who will become officers on board - the skill and competence for making energy efficiency an objective in the comprehension of the situation. But the land-based staff have a large influence on the operation of the vessel, with requirements from the owner and charterer adding to the complexity of the situation and possibly representing additional conflicting goals. The land-based staff might not understand the complex situation the crew experience on board. The company's culture has to support the change, and both land-based staff and experienced crew need to acquire the awareness and capability to prioritize and support energy-efficient operation- This is why in-service training has to be addressed at a later stage.

## **6. Conclusions**

The described education design ensures training of awareness, capability and behavior. Through the training of reflection-on-action, the student achieves the competence to knowledge share and it enables him to reflect-in-action. By analyzing and reflecting on consumption data, the students become aware of how their choice of action influences the outcome, how their giving priority to one requirement over another affects the others. This visualization is possible in a controlled and safe learning room, as offered in the design, where it is possible to test different solutions without compromising the safety of the vessel and to compare results. The achieved vocabulary makes the future officer able to share knowledge obtained by experience to future students during their apprenticeship, which will add to the capacity building both in companies and in the education system with regard to energy-efficient operation of vessels.

## **7. Acknowledgements**

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# EEDI REDUCTION BY INVESTIGATING METHODS OF REDUCING SHIP RESISTANCE

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**Abstract:** The article systematizes methods of reducing ship resistance, including: optimizing the hull form in order to have smaller form resistance and wave resistance; turning the turbulent flow into laminar flow at the boundary layer and using air cavity via injection of air under or around the hull, to reduce the ship frictional resistance. The paper also indicates the obtained reduction of resistance, difficulties, drawback as well as their effect on other features of ship by applying the above methods in practical. Based on that, designers can choose the most appropriate solution, to have EEDI index satisfaction as well as to improve the ship's safety and economic efficiency, depending on the specific condition.

**Keywords:** EEDI, resistance, hull form, air cavity, boundary layer.

## 1. Introduction

Recently, many efforts have put on environment protection, especially about global warming and reduction of CO<sub>2</sub> emission. The majority of the international society has recognized the necessity of limiting our use of natural resources in order to prevent environmental hazards. Besides, there are considerable development in marine transportation and activities: from offshore installation supply to the exploitation of marine resources. According to Third IMO GHG Study 2014, during the period 2007–2012, maritime transport emits around 1000 million tons of CO<sub>2</sub> annually and is responsible for about 2.5% of global greenhouse gas emissions. Shipping emissions are predicted to increase between 50% and 250% by 2050 – depending on future economic and energy developments. This is not compatible with the internationally agreed goal of keeping the increase of global temperature

by below 2°C compared to pre-industrial levels. This requires worldwide emissions to be reduced at least by a half by 2050. Thus, in 2010, International Maritime Organization introduced Energy Efficiency Design Index (EEDI) as a technical measure to limit pollution of the environment to newest ships. The EEDI is an index that indicates the energy efficiency of a ship in terms of CO<sub>2</sub> (generated)/ton mile (cargo carried). Therefore, smaller EEDI means smaller CO<sub>2</sub> exhausting to the environment. According to the regulation of MARPOL 2011 (Chapter 4 Annex VI Res. MEPC\_203\_62) it requires new ships to be 10% more efficient since beginning in 2015, 20% more efficient by 2020 and 30% more efficient from 2025. With that reason, many efforts have been made to reduce EEDI. From the EEDI equations, according to Bazari & Longva and IMO MEPC 63 (Zabibazari, Tore longva, 2011), there are 15 methods of EEDI reduction. One of those methods is reducing ship resistance, and it is main topic of this paper.

It is known that, for displacement ship, the ship resistance in calm water consists of following main components: wave, form and frictional resistance.

$$R_T = R_F + R_W + R_{VP} \quad (1)$$

Where:  $R_T$  – the total resistance,  $R_F$  - the frictional resistance;  $R_W$  – the wave resistance;  $R_{VP}$  – the viscous form resistance.

Thus, it is necessary to study the dependence of its components on the main characteristics of ship as well as the fluid properties in order to propose the method of reducing these components to reduce the ship resistance.

## 2. Methods of reducing ship frictional resistance

According to ITTC standards, the frictional resistance is determined as:

$$R_F = 1/2 \cdot \rho \cdot C_F \cdot V^2 \cdot S \quad (2)$$

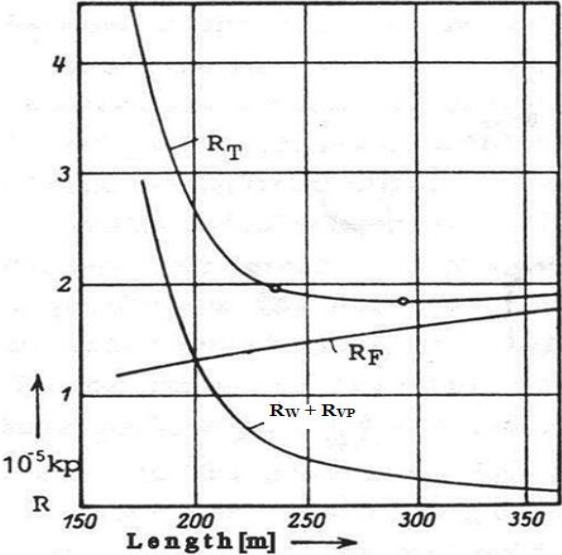
As can be seen in formula (2), the water density ( $\rho$ ) is constant, therefore, the frictional resistance only reduces in the case of decrease the wetted surface of the ship and/or the frictional resistance coefficient ( $C_F$ ).

*Refer to wetted surface.* In practical, there are two ways of reducing the wetted surface area of a ship:

The first way is choosing: the reasonable main dimensions of the ship while remain the same displacement. However, reducing wetted surface area by using this way may increase the remaining resistance components. As can be seen in Figure 1, reducing the ship length (the parameter has greatest influence on wetted surface area) makes the wetted surface area significantly decrease. However, the two remaining resistance components (wave resistance

and form resistance) increases simultaneously. Therefore, the deduction of wetted surface area obtained by applying this method made ineffective in reducing the ship resistance.

- *The second way*: Create an air layer embraced the ship wetted surface. This method is not only to considerably reduce the amount of the wetted surface area but also having no effect on the other resistance components. Therefore, the authors will present this method.



**Fig.1.** Effect of length on the resistance of a ship with constant displacement  $\Delta = 30,000 \text{ t}$  and speed  $V = 29 \text{ kn}$  (Apostolos Papanikolaou 2014, p.82)

Refer to frictional resistance coefficient ( $C_F$ ). This coefficient depends on Reynolds. In case of laminar flow (when Reynolds is less than the critical value  $Re < Re_{cr} = 2,5 \cdot 10^5$ ), frictional resistance coefficient can be defined by formula (3). In case of turbulent flow (when Reynolds is higher than the critical value) frictional resistance coefficient can be defined by formula (4) (Jinkin V.B. 2010, p.102)

$$C_F = 1,328 / \sqrt{Re} \tag{3}$$

$$C_F = \frac{0,075}{(\log_{10}(Re) - 2)^2} \tag{4}$$

As can be seen in formula (3) and (4), in case of laminar flow, frictional resistance coefficient is much smaller than in case of turbulent flow. Actually, the usual value of Reynolds number of displacement ship is  $Re = 10^8 \div 10^9$  which is much higher than the critical value. Thus, to decrease the ship frictional resistance coefficient (synonymous with reducing ship frictional resistance) turning the turbulent flow into laminar flow at the boundary layer should be made.

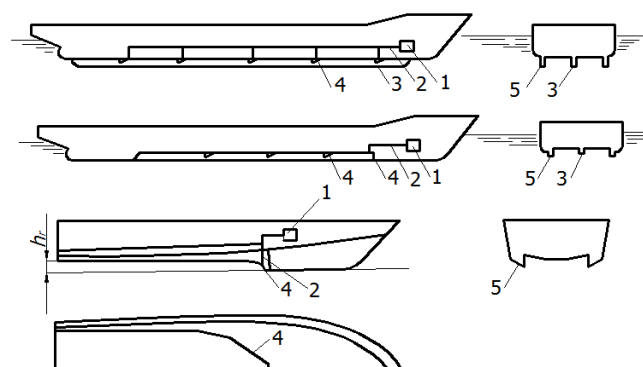
**2.1. Using air bubble lubrication for decreasing friction resistance**

The idea of “air bubble lubrication” – creating the separated thin membrane of air between ship wetted surface and the surrounding liquid in order to reduce the wetted surface area and thereby reducing ship frictional resistance was proposed in the 19th century by the famous scientists Froude and Laval.

The systematic study of the above idea has been made by many authors in different countries around the world, such as Butuzov A.A., Gorbachev Y. N., in Russia (A. A. Butuzov 1990), Fukada, K., Yasuhiro M., in Japan (Fukada, K. 2010), in MARIN’s research projects (Maritime Research Institute of the Netherlands ), PELS (Project Energy-saving air-Lubricated Ships) and SMOOTH (Sustainable Methods for Optimal design and Operation of ships with air lubrical Hulls) (EU project) (E.J. Foeth 2008) Numerous of tests in scale of model and full scale have been made to evaluate the effect of air lubrication by bubble injection on resistance and propulsion, seakeeping and maneuverability. In the time of Soviet, 10 ships using air cavity had been put in operated, which has displacement of 15 tons, speed of 70 km/h. The complete design of domestic passenger ship with capacity 70 and 100 seats and 300 tons displacement, using air cavity had been made.

Experiments carried out on model and full scale ship confirmed the effectiveness of using air cavity in ship’s bottom as follows (Fukada K. 2010), (Kato H. 2003), (E.J. Foeth . 2008), (Jinkin V.B. 2010), (Butuzov A.A. 1990):

- Consider to the low speed cargo ship, the necessity power reduction of the main engine at the calculating speed ranged from 10 to 20 %;



**Figure 2. Scheme of devices creating air cavity in ship’s bottom (A. A. Butuzov 1990)**

*a* – air cavity system in displacement ships, *b* – unique air cavity in displacement ship, *c* – air cavities in high speed craft. 1 – air compressor, 2 – air supply line, 3 – longitudinal keel, 4 – redan, 5 – side girder

- Consider to the high-speed ship, the reduction in necessity power at calculating speed ranged from 15 to 30 %, or if the engine power remained constant, the ship speed will increase from 10 to 30%;



- The consuming energy of air fan in all cases did not exceed 3% of the main engine power;
- The application of the creating air bubbles device does not deteriorate the other performance of the ship (stability, maneuverability, sea keeping) and does not hinder the use of other innovative solutions, the method of increasing the efficiency of propulsion system.
- The use of air cavity also reduces the cost of cleaning and painting the wet surface of ship hull during operation.

However, besides the advantage that the air cavity system exist drawback such as:

- The empirical study indicates that the realization of this idea in reality just successful in the flat bottom of the ship. And recently, this solution is to be applied only on river ships. The current shipping vessels have not used this method. This can be explained by the fact that, firstly, the wet surface part at the flat bottom of the ship is much smaller than that of the river, and secondly it affects the ship's rolling (Jinkin V.B. 2010, p 303).
- Using air cavity under the ship bottom may reduce the efficiency of the propulsion system and according to some studies, the overall reduction in propulsive efficiency due to creating an air cavity is about 2-3 %.
- The effectiveness on reducing ship frictional resistance by applied air cavity depends on speed of ship, environment condition (wave height) and the operation of air compressor. The test results on the model of 300.000 DWT tanker indicates that (A. A. Butuzov 1990):
  - + Efficiency of ship using air cavity system will be declined by reducing the ship speed;
  - + When the ship is running in full load regime on wave level 5, the effect of waves on the efficiency of ship is very small. When increasing the wave level, the unique air cavity was destroyed and effectiveness of the device is dramatically declined: if the ship were running on wave level 6, the benefit in resistance is 7-8 %, while on wave level 7, the ship resistance is not reduced but increased by 10-11 %;
  - + The resistance of ship using air cavity system will increase by about 20% compared to ship not using air cavity when the air compressor does not operate.
- In case of using air cavity system on existing ships, it creates protruded part under the based plane, reducing the cargo capacity of ship when operating in shallow waters.

## **2.2. Turning the turbulent flow into laminar flow at the boundary layer**

The application of laminar at the boundary layer to decline the ship frictional resistance can be made by the boundary layer suction or creating a pliable coating (Coating softened) on the ship surface (Jinkin V.B. 2010).

*In case of using pliable coating:* The creation of pliable coating on the ship surface in some circumstances can be reduce the frictional resistance 1,5÷ 2,0 times until  $Re = 2 \cdot 10^7$  (Jinkin V.B. 2010). Nevertheless, due to the complexity of creating the above coating and the unstable of its elastic parameters ... which is not currently use in practical.

The boundary layer suction can be executed along the surface of ship hull or focused on the specialized gaps arranged along the ship hull. In principle, the suction of boundary layer may ensure that the laminar flow occurs in the boundary layer at any value of Reynold number. Therefore, in this case, the significant efficiency can be obtained after deducting the power consumption of liquid suction. Theoretical assessment indicates that when the ship's Reynold number  $Re = 10^8 \div 10^9$  the optimal the arrangement of suction points of the boundary layer suction can reduce the ship frictional resistance 6-7 times (Jinkin V.B. 2010, p 303). Recently, however, this idea has been realized in practical because it encounters a structural irreparable obstacle (the complexity of creating an effective boundary layer suction system) and technology (there are very strict requirements for surface conditions that require very smooth).

The changing of physical properties of liquid at the boundary layer (the layer between ship hull and liquid) can be obtained by other mean which is – inserting the high polymer layer. The addition of small amount of polymer in the water can reduce the ship hull frictional resistance by 2-3 times. The concentration of polymer is very small ( $10^{-4} - 10^{-6}$ ), which explain that it is impossible to obtain the efficiency by changing the density and viscosity of liquid. The remained problem is that the polymer alters the water physical properties and turning it into non –Newtonian liquid. However, the effect of added polymer is only effective in the turbulent flow of the drainage shape objects.

To realize this method, the only way is to put the polymer in the boundary layer between ship hull and liquid through the gaps or through the surface bore or also by applying on the ship hull paint coatings. In all cases, although, the reduction of resistance is quite large from 15 to 50%,. Researching the effect of this additive on the environment has not been fully studied due to its the high cost, this can explain the reason of no appliance of this method in practical recently (Jinkin V.B. 2010, p.304).

### **3. The methods to reduce wave and form resistance**

#### **3.1. The methods to reduce form resistance**

The viscous form resistance coefficient of the ship is the function of Reynolds number and hull form as in formula (Jinkin V.B. 2010), (Moland, A. F.,2011)

$$C_{VP} = C_F k \quad (5)$$

Where:  $C_F$  – frictional resistance coefficient,  $k$  – form factor correction, depending on the hull form ( $C_B$ ,  $L/B$ ,  $B/T$ , ...).

The formula (5) shows that there are two ways to reduce viscous form resistance

- Reduce frictional resistance coefficient
- Hull form optimization to reduce form factor correction  $k$ . This method is discussed

below together with the methods to reduce wave resistance of the ship

### **3.2. The methods to reduce wave resistance**

The wave resistance of the ship is a function of

- Hull form, especially bow and stern shapes
- The relative position between hull and water surface

So, for a specific speed of the ship, there are two ways to reduce wave resistance

- Hull form optimization;
- Fully immerse the ship under the water surface (Jinkin V.B. 2010).

In case of hull form optimization method, both the wave resistance and viscous form resistance can be reduced. To optimize hull form, the main interest is trying to reduce wave-making resistance, and it becomes main objective of hull form optimization. Ideally, when the bow and stern wave systems cancel each other, the wave-making resistance is minimum. Thus, bow and stern are two interested areas for hull form optimization. Among them, bulbous bow might be the part that has been optimized mostly with many results presented by many authors. Optimized bulbous bow can reduce bow pressure wave and consequently, reduce wave -making resistance. Recently, with the development of computational resources together with the development of Computer-aided-design (CAD) and Computational Fluid Dynamic (CFD), designers have a powerful tool to improve the hull form efficiency, or in other words, to reduce hull resistance.

According to some recent studied, the reduction of wave resistance after hull form optimization step mainly depends on the starting hull form. If the initial hull is designed by some high experienced designers, the amount of reduction is not much. Some study show that the wave resistance can decrease by 4.32% (Weilin Luo 2016), or 13.2 % (Jin-Won Yu, 2017, or 9% (Mathew Renaud 2013) or 12% (Jong-Heon Park 2015).

Besides, hull form optimization using CFD approach also shows some limitation, particularly computational time, software's cost and high skills man power. The increase of constraints also takes more time for preparation, computation and analysis. The uncertainty of

the result can be a problem, for example, the resistance reduction does not meet the expectation or requirement of the customers. Typically, there are thousands variations of hull form during optimization process. It requires large amount of investment on computational resources such as a very big cluster. The increase of constraints, for example: the stability, ship motion requirements makes the problem more complex and requiring more time for preparation, computation and analysis. All of the drawback above show that the hull form optimization is rather costly.

For the method of fully immersing the hull form under water surface, the wave resistance can be reduced significantly because in this case the effect of free surface is almost neglected. Besides, when the submarine moves under water, there is very less wave-making resistance, motion effect and the increase of resistance in case of rough weather. Some authors showed that with same displacement and engine power, the speed of tanker moving under water with the depth of about 1/3 ship's length, is higher about 20-30% than moving on water surface (Jinkin V.B. 2010). In 1989, Malakhit company in Russia built an underwater tanker to carry oil product in North Pole. The basic dimension of that ship is length (L) = 215 m; breadth (B) = 40 m; depth (D) = 40 m, capacity 60.000 m<sup>3</sup>, velocity 16 knots, working depth at 100 m. However, many underwater cargo ship designs have not been produced due to bad influence to living condition of crew and building cost

#### **4. Conclusion**

Based on the study of the methods to reduce ship resistance, the paper has presented some result as follows:

- Summary systematically the methods to reduce frictional resistance, viscous form resistance and wave resistance.
- The paper shows the amount of resistance reduction obtained and the drawback of each methods.
- Within the resistance reduction methods, the hull form optimization, selecting optimized the ship dimension with objective of minimum resistance is the most popular one at the moment. It is possible that it might not be used for near future because all new-built hull form has been optimized and the method reaches its limitation.
- The resistance reduction by using air bubble lubrication and by turning the turbulent flow into laminar flow at the boundary layer is a potential method in the future, due to the development of material technology, leading to the decrease of material price.

## 5. Acknowledgments

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# REGULARITIES OF CHANGES IN SPECIFIC CARBON AND NITROGEN OXIDE EMISSIONS OF MARINE AND TRANSPORT DIESEL ENGINES

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**Abstract.** The analysis of operating conditions of vessels of a fishing fleet is carried out. Features of the processes of injection and mixture formation in diesel engines with a volumetric method of mixture formation are noted, for the estimation of which original authorial indices and the combustion process equation that explicitly takes into account the influence of operational and constructive factors are used. On its basis, equations for the calculation of carbon and nitrogen oxides in exhaust gases have been developed.

**Keywords:** marine diesels, original parameters of injection and mixing processes, original combustion equation, formulas for calculating the nitrogen oxides and solid carbon particles in the exhaust gases

## Introduction

Vessels of fishing industry fleet operate in different regions of the World Ocean. The external working conditions differ in the barometric pressure, temperature and humidity of the air due to the presence of different intensity and directions of wind and currents. The factors influence ships technical condition.

Experimental research of operating factors is often accompanied by great material costs and is not always possible. Therefore, it is necessary to apply the computer simulation method which will allows to study the influence of each of the acting factors and develop recommendations for limiting emissions of harmful substances with the exhaust gases which is especially important at the present time. In addition, with the products of incomplete

combustion, their chemical energy is lost. The cylinders of the diesel don't receive it completely. Thereby, the operational costs and probability of fires in the exhaust system increase. The purpose of the paper is to describe the method for calculating the content of solid carbon particles in the exhaust gases.

### **Theoretical study**

The predominant method of mixture formation in engines used in fishing fleet vessels is jet (volumetric) one, in which the volume of the combustion chamber is divided into a series of macro-volumes proportional to the number of nozzles of the atomizer. A fuel jet flows from each nozzle opening containing [1] a set of drops with diameters from  $10^{-6}$  to  $10^{-3}$  m. The smallest drops are located on the surface of the fuel jets and the larger ones are closer to the axis and in the frontal part

Investigations of the process of atomization of fuel by injectors of diesel engines [1] have shown that the air content in the jet of fuel for the normal course of the combustion process is not enough. The maximum value of the air-fuel ratio is on the axis of the jet (18 - 25) % of the theoretically necessary. On the parts of the jet located closer to the nozzle openings of the nozzle the amount of air is even smaller. At the same time, on the surface of the fuel jet the excess air coefficient is about 0.9 [2]. As a result, there is a significant temperature inhomogeneity in the jet of fuel. As shown by experiments conducted at the Central Research Diesel Institute [3] and other research organizations the fuel ignites on the surface of the jets near the nozzle apertures and covers the entire surface in 0.5-1 ms.

Thus, the main combustion process in the fuel supply period occurs on the surface of the fuel jets which are the boundary of the heat and mass exchange of the air charge with the fuel. Obviously, the greater the surface area of the fuel jets attributed to one mass unit of fuel the higher the speed and completeness of combustion. Therefore, the ratio of the total surface area of fuel jets  $F$  to the value of the cyclic fuel supply is proposed as one of the indicators characterizing the quality of the sputtering and mixture formation processes [4].

$$K_{p\Sigma} = F_{\phi\Sigma} / g_{\text{ц}} , \quad (1)$$

where  $F_{\phi\Sigma}$  – total surface area of fuel jets at the end of the fuel supply process;  
 $g_{\text{ц}}$  – cyclic fuel supply



In high-speed diesel engines the duration of the fuel supply process is comparable to the period of ignition delay. In low- and medium-speed marine diesel engines, the ignition delay period is much shorter than the fuel delivery time.

To calculate the surface of fuel jets it is necessary to have dependencies that take into account the influence of fuel pressure, the diameter and number of nozzle openings, the average parameters of the state of air charge during the combustion period and the characteristics of the fuel.

So far a large number of experimental studies have been carried out to identify the effect of individual factors on the fuel atomization process. The experiments were carried out both on models and when fuel was injected directly into ICE cylinders. In the first case, the units are made in the form of cylindrical "bombs" simulating a certain type of combustion chamber of an internal combustion engine. As a working medium, cold air or a hot inert gas was used [3]. The advantage of this method of investigation is that it is possible to eliminate the influence of the turbulence of the air charge in the cylinder and the combustion process. The process of combustion in marine ICEs begins long before the end of the injection of fuel and does not provide an opportunity to fully determine the parameters characterizing the quality of spraying of fuel. The advantage of research in ICE is that it is possible to estimate the length of the fuel jet and the distribution of fuel in it under the conditions of the combustion process in a specific type of ICE. While studies on models are conducted at constant charge pressures, usually lower than in real ICE.

It is established that the quality of spraying of fuel depends on the parameters of the fuel supply process, the geometric characteristics and technical condition of the elements of the HP fuel system, the pressure and temperature of the air charge; Density, viscosity and surface tension coefficient of injected fuel; Turbulence charge; Initial disturbances arising in the fuel as a result of the action of direct and reverse pressure waves in the HP fuel system high pressure line and during the flow period through the atomizer; Presence of dissolved air in the fuel, etc

At present, there are various methods for modeling the parameters of fuel jets. So, in the method of Professor A.S. Lyshevsky [1] based on the processing of experimental data of Russian and foreign authors, dependencies were obtained for the calculation of the length of the fuel jet, the angle of its cone, the distribution of fuel droplets along the diameters, and the excess air coefficient in the sections of the jet. The diameter of the droplets and their distribution were found by processing the prints left by the drops on the smoky plate.

Professor R.Z. Kavtaradze [2] developed the method of A.S. Lyshevsky adding to it the effect on the geometric characteristics of the fuel jet vortex motion of the air charge in the cylinder.

In the future, optical, holographic and electrical methods were used.

Holographic methods make it possible to obtain a three-dimensional image of the fuel jet and a more complete estimate of the diameters and distribution of droplets.

In the studies of Professor Yu.B. Sviridov [3] atomizers with hole diameters of 0.35 and 0.56 mm were used. The injection was carried out in a medium at normal temperature in order to avoid evaporation of the fuel. The study of the holograms obtained showed the existence of two regions in the stream: a luminous shell and a dark core.

The presence of a luminous shell and a dark nucleus was confirmed in [5]. The values of the fuel concentration, average relative distance between the drops and the coefficient of excess air along the length and radius of the jet were obtained:

$$d = 0.806 / \sqrt[3]{C_{\text{жс}}} ; \quad (2)$$

$$a = (\rho_r (1 - C_{\text{жс}})) / (\rho_{\text{жс}} C_{\text{жс}} K_{\text{cm}}), \quad (3)$$

where  $d$  is the distance between the droplet centers; Where is the distance between the droplet centers

$C_{\text{жс}}$  - concentration of fuel;

$\rho_r$  and  $\rho_{\text{жс}}$  - density of air and fuel, respectively;

$d$  is the stoichiometric coefficient.

Professors R.A. Gafurov and G.A. Glebov from the Kazan State Technical University continued the experiments described above [6] under the conditions of multiple injection of fuel. The fact is that in the real fuel system of a diesel engine with periodic fuel injection, the walls of the fuel pipe oscillate, as a result of which the jet of fuel breaks, with the release of vapors and dissolved gases [7].

The two-layer structure of the fuel flare is confirmed. A spectrum of droplets in its central part is obtained. It is established that before the fuel cutoff, 2 peaks are detected in the spectrum: 90-100 and 180-200  $\mu\text{m}$ , and after the cutoff a third peak is observed at a level of about 300  $\mu\text{m}$ , which corresponds approximately to the diameter of the nozzle opening (0.32 mm).

The data obtained in this paper allow us to distinguish two phases of the jet disintegration: intracannel decay due to cavitation and aerodynamic crushing when the fuel flare interacts with the air charge inside the cylinder.

In [8] and [9], dependences were obtained that relate the average mass temperature of the air charge in the engine cylinder and the average fuel delivery pressure with the geometric parameters of the fuel jet and the concentration of fuel in it, while a number of coefficients were applied.

Taking into account the conducted experiments and the geometric characteristics of the fuel jet, calculated by the method of Professor A.S. Lyshevsky, a model and method for calculating the combustion process has been developed [4]. According to which the relative amount of burnt fuel is calculated:

$$x_i = 1 - \exp \left[ -B \cdot C \cdot \mathcal{D} \cdot E \cdot K^{0.2} (\tau_i / \tau_Z)^{m+1} \right] \quad (4)$$

where  $\tau_i$  is the length of time from the start of the combustion process to the  $i$ -th moment, s;

$\tau_Z$  - duration of the combustion process, c;

$m = 1.88$  - an indicator determined experimentally for a number of marine diesels.

In its turn:

$$B = \left( \frac{\mu_{cn}}{\mu_{c3}} \right)^{1.42} \cdot \left( \frac{d_{cn}}{d_{c3}} \right)^{1.05} \cdot \left( \frac{P_{fn} - P_{cn}}{P_{f3} - P_{c3}} \right)^{0.71} \cdot \left( \frac{\rho_{Tn}}{\rho_{T3}} \right)^{1.05} \cdot \left( \frac{\sigma_3}{\sigma_n} \right)^{0.37} \left( \frac{\mu_n}{\mu_3} \right)^{0.32} \frac{P_{u3} T_{un} J_{cn} g_{u3}}{P_{un} T_{u3} J_{c3} g_{un}}, \quad (5)$$

$$C = \frac{tg\gamma_n(1/\cos\gamma_n + tg\gamma_n)}{tg\gamma_3(1/\cos\gamma_3 + tg\gamma_3)}, \quad (6)$$

$$\mathcal{D} = \frac{\tau_{un0n} \tau_{3np.3}}{\tau_{un03} \tau_{3np.n}} \left( \frac{\tau_{Zn} - 0.5\tau_{3np.n}}{\tau_{Z3} - 0.5\tau_{3np.3}} \right)^{1.6}; \quad (7)$$

$$E = 6,908 \frac{\alpha_{1n}}{\alpha_{13}} \left( \frac{P_{cn} + P_{\max n}}{P_{c3} + P_{\max 3}} \right)^{0.5} \quad (8)$$

$$K_V = \left( \frac{\mu_{cn}}{\mu_{c3}} \right)^{2.13} \left( \frac{d_{cn}}{d_{c3}} \right)^{1.575} \left( \frac{P_{fn} - P_{un}}{P_{f3} - P_{u3}} \right)^{1.065} \left( \frac{\tau_{3np.n}}{\tau_{3np.3}} \right)^{1.5} \cdot \left( \frac{\rho_{Tn}}{\rho_{T3}} \right)^{1.575} \cdot \left( \frac{\sigma_3}{\sigma_n} \right)^{0.555} \left( \frac{\mu_{1n}}{\mu_{13}} \right)^{0.48} \left( \frac{P_{u3}}{P_{un}} \right) \cdot \left( \frac{T_{un}}{T_{u3}} \right) \cdot \frac{tg^2\gamma_n \cdot V_{e3}}{tg^2\gamma_3 \cdot V_{en}} \quad (9)$$

In equations (4) - (10), a high-speed engine with a cylinder diameter of 0.24 m, a piston stroke of 0.27 m and a rotation speed of 1500 rpm (four stroke turbo charged 24 / 27 Russian Standard) was adopted as an engine with an "e" index.

In the equations (2) - (9) the following notations are adopted:

- $\mu_c$  - the nozzle flow rate;
- $d_c$  - diameter of nozzle openings in injectors of one cylinder of internal combustion engines, mm;
- $P_f$  - average fuel pressure in the injector during injection, kPa;
- $P_{ц}, T_{ц}$  - average pressure and temperature of the working fluid in the combustion engine cylinder during the combustion period, MPa;
- $J_c$  - number of nozzle openings in injectors of one cylinder of internal combustion engine, units;
- $\rho_T$  - density of fuel, kg / m<sup>3</sup>;
- $\sigma$  - coefficient of surface tension of fuel, N / m;
- $\mu$  - dynamic viscosity of fuel, Pa. from;
- $g_{ц}$  - cyclic fuel supply, g;
- $\gamma$  - the angle of the cone of the fuel jet, deg .;
- $\tau_{инд}$  - the period of fuel ignition delay, s;
- $\tau_{впр}$  - duration of fuel injection, s;
- $\alpha_1$  - average air-fuel ratio during combustion;
- $\tau_z$  - duration of the combustion process, s;
- $\tau_i$  - current time, counted from the beginning of ignition of fuel, with;
- $V_e$  - volume of the combustion chamber;

Parameters with the index "n" refer to the diesel engine being designed (researched), and with the index "e" to the engine adopted as the standard. The exponents are obtained from the equations of Professor A.S. Lyshevsky, who processed experimental data on fuel dispersion.

The exponents in expressions (5) - (9) are obtained as a result of processing the dependencies for the sputtering process established by Professor A.S. Lyshevsky on the basis of processing and generalization of the results of experiments conducted in Russia and abroad.

As can be seen from the presented data, the complexes of the parameters "B", "C" and "D" in an explicit relative form characterize the effect of design parameters of fuel equipment, fuel characteristics and parameters of the working fluid in the diesel cylinder on the development of fuel jets, the duration of fuel injection and combustion. The duration of the

combustion process is also calculated taking into account the above factors according to the following expression:

$$\tau_{Zn} = \tau_{Z3} \left( \frac{\mu_{c3}}{\mu_{cn}} \right)^{1,42} \cdot \left( \frac{d_{c3}}{d_{cn}} \right)^{1,05} \cdot \left( \frac{P_{f3} - P_{u3}}{P_{fn} - P_{un}} \right)^{0,71} \cdot \left( \frac{\rho_{T3}}{\rho_{Tn}} \right)^{1,05} \cdot \left( \frac{\sigma_n}{\sigma_3} \right)^{0,37} \cdot \left( \frac{\mu_3}{\mu_n} \right)^{0,32} \cdot \frac{J_{c3}}{J_{cn}} \cdot \frac{g_{un}}{g_{u3}} \cdot \sqrt{\frac{(P_{cc} + P_{max})_3}{(P_{cc} + P_{max})_n}} \cdot \frac{T_{u3}}{T_{un}} \cdot \frac{tg\gamma_3 (1/\cos\gamma_3 + tg\gamma_3)}{tg\gamma_n (1/\cos\gamma_n + tg\gamma_n)} \cdot \frac{\tau_{инд.3}}{\tau_{инд.н}} \cdot \frac{\alpha_{13}}{\alpha_{1n}} \cdot \left( \frac{n_3}{n_n} \right)^{0,2} K_v^{-0,2} \quad (10)$$

The more nozzle openings in the atomizer (nozzles with several nozzles in the cylinder), the higher the injection pressure of the fuel and the smaller the diameter of the nozzle openings (all other conditions being equal and constant cyclic delivery), the greater  $F_{\phi}$  and  $Kp2$ . The deterioration of the details of the cylinder-piston group, the decrease in the barometric pressure, the increase in the temperature of the air entering the cylinders, the deterioration of the precision elements of the fuel equipment, the deterioration of the technical state of the pressurization and gas exchange systems violate the quality of the processes of mixture formation and combustion, that is, the values of the indices B, C, D, E and The combustion process is prolonged. In this case, a relatively larger amount of fuel will be located near the surface layer, the combustion process will proceed faster. At the same time, the relative amount of fuel located in the zones with the minimum coefficients of excess air in combustion will decrease, and its residence time will decrease there.

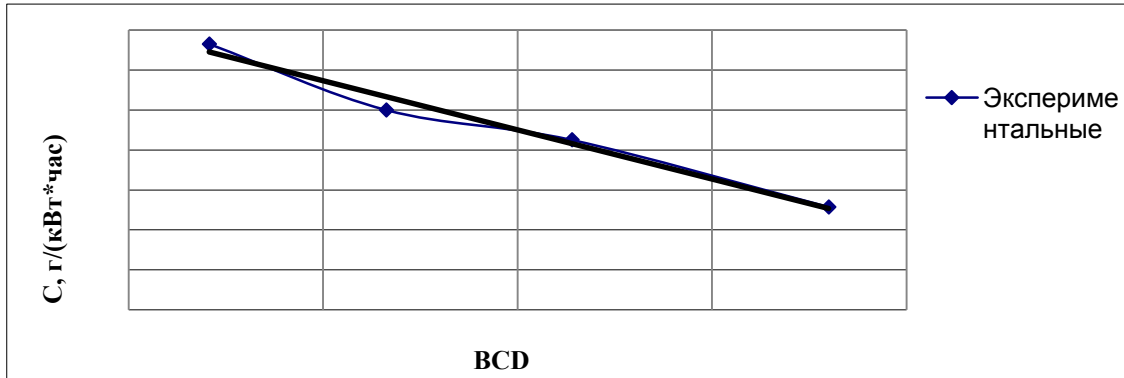
The use of heavy fuels containing a large amount of aromatic and high-molecular hydrocarbons is accompanied by the enlargement of the droplets during atomization and, consequently, an increase in the relative amount of fuel in zones with a lack of oxygen.

Temperatures in the combustion zones reach 2600-2900 K, the farther from the top dead center combustion occurs, the less temperature and more carbon can burn by the time of the opening of the gas distribution valves [2,3]. At such temperatures, intense heating of the supplied fuel occurs, and the lack of air inside the fuel jets causes pyrolysis of the fuel molecules with the elimination of hydrogen and the formation of carbon.

High temperatures in the combustion zone warm up the fuel layers, which are located closer to the axis of the jet, and due to lack of oxygen, soot forms in them. The process of its formation is conventionally divided [10] into three main phases: the formation of an embryo, growth of embryos into soot particles, coagulation of primary soot particles, burnout. The rate

of soot formation is determined by the rate of chemical processes, leading to the appearance of an embryo (ie, the kinetics of the process).

Experiments conducted at the Department of ship power plants on the engine compartment 1NVD 24 are shown in Figure 1.

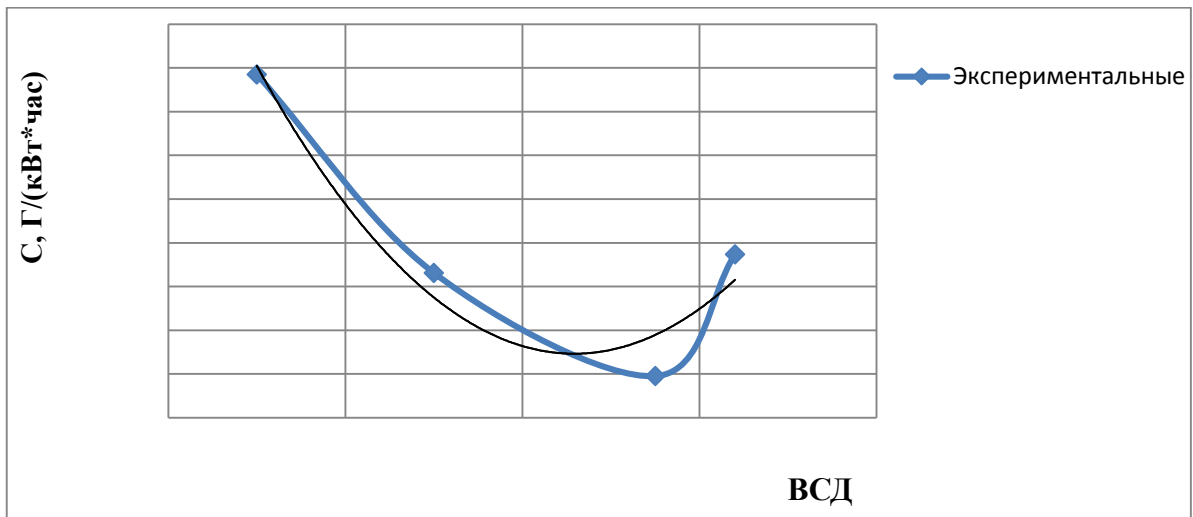


**Figure 1.** Results of experiments on the engine 1NVD 24 [10]

The complex of indicators «BCD» with increasing load on the engine increases, by increasing the differential pressure on the injection, expanding the cone of the fuel jet and increasing the cyclic supply of fuel. As can be seen from Fig. 1, the specific carbon emission decreases inversely proportional to the growth of the product of the IRR.

The following equation is obtained

$$C = -0.123 \cdot BCD + 0,1884 \quad (11)$$



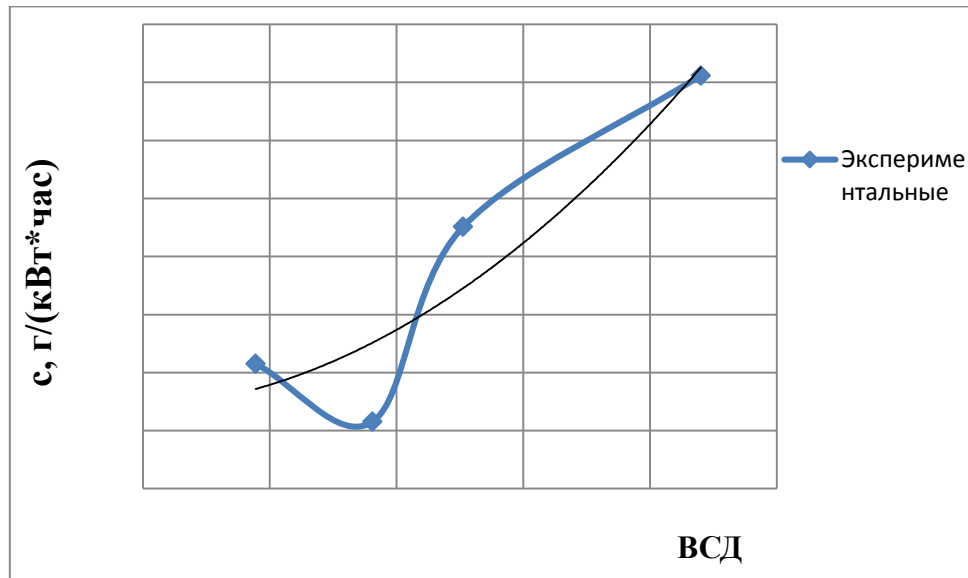
**Figure 2.** Results of experiments on the KAMAZ - 740.10 engine [10,11]

As can be seen from Figures 1 and 2, the mixture formation in the engines proceeds identically. At the same time, in the KAMAZ-740.10 engine, the range of VSD indicators increases with the load increase. At full load (2200 rpm,  $M_e = 380$  Nm), part of the fuel injected

on the walls of the combustion chamber and evaporates from them, which causes a certain increase in specific carbon emissions.

The following equation is obtained

$$C = 10^{-5}(BCД)^2 - 0,0022 \cdot BCД + 0,1535 \quad (12)$$



**Figure 3** Results of experiments on the engine MAN D 2866LXE

A similar picture for emissions can be observed on the engine MAN D 2866LXE (1500 rpm, 179 kW). In this engine, as can be seen from figure 3, film-based mixture formation starts with a load of 50%. In connection with the connection of the film mechanism of the mixture formation, the results are approximated by square polynomials with an error not exceeding 10%. The carbon emission minimums correspond to the time of film-based mixture formation.

The following equation is obtained

$$C = 47,282(BCД)^2 - 4,7344 \cdot BCД + 0,1564 \quad (13)$$

Therefore, based on the developed model, the following dependence was obtained for the calculation of carbon emissions:

$$C_{\Pi} = C_{\text{э}} \left( \frac{J_{\text{сэ}}}{J_{\text{сн}}} \right)^{0,4} \left( \frac{d_{\text{сэ}}}{d_{\text{сн}}} \right)^{0,8} \left( \frac{g_{\text{иэ}}}{g_{\text{ин}}} \right)^{-0,4} \left( \frac{p_{\text{тэ}}}{p_{\text{тн}}} \right)^{0,3} \left( \frac{C_{\text{э}}}{C_{\text{н}}} \right)^{0,08} \left( \frac{\tau_{\text{зэ}}}{\tau_{\text{зн}}} \right)^{-0,12} \left( \frac{n_{\text{э}}}{n_{\text{н}}} \right)^{-0,12} \left( \frac{z_{\text{э}}}{z_{\text{н}}} \right)^{0,12} \left( \frac{\alpha_{\text{э}}}{\alpha_{\text{н}}} \right)^{-0,08} \quad (14)$$

Parameters with the index "e" refer to the engine adopted for the standard, with the index "n" - to the engine being researched (projected).

As parameters in the expression (14), the parameters of the engine 1NVD 24 are applied. In calculating (14) for the KAMAZ-740.10 engine, a carbon emission of 0.033 g / (kWh) was

obtained at the minimum carbon emission mode. The experimental value for this regime is 0.0319 g / (kWh). Thus, the discrepancy between the experimental and calculated data is 9-10%. So, with a load of 50% for the KAMAZ engine (2200 rpm  $M_e = 200$  Nm), the experimental emission values are 0.037 g / (kWh), and the calculated value is 0.041 g / (kWh).

### **Method of application**

When designing the number of parameters included in the equation is specified by the first method. For example, the diameter and number of nozzle holes, the fuel pressure in the nozzle and the other ones are used to achieve expected economy of mechanical and thermal loads. In this case, the calculation of the indicator process is carried out and the content of solid carbon particles in the exhaust gases is calculated simultaneously.

In the second method, when the permissible level of increase in the carbon solids content in the exhaust gas is determined, calculations can be made without modeling the indicator process by making a reduction in the number of nozzle holes due to their contamination or reduction in fuel supply due to wear of the precision elements, reducing the air pressure in the diesel cylinders in end of scavenging process due to the deterioration of the technical state of the supercharge and gas exchange systems or the reduction of barometric pressure or gas transfer system contamination .

### **Conclusion**

Thus, on the basis of theoretical and experimental studies, an equation is proposed for calculating the content of solid carbon particles in exhaust gases of diesel engines. The peculiarity of the equation is the explicit consideration of the influence of a number of structural and operational factors. These include: the diameter and number of nozzle openings, the average fuel pressure, the cyclic fuel supply and its physical properties (fuel density, surface tension coefficient, viscosity), the speed of the crankshaft and the diesel engine speed. The discrepancy between the experimental and calculated values is up to 10%.

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# EXPLORING THE FRONTIERS OF MARITIME ENERGY MANAGEMENT RESEARCH

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**Abstract.** The analysis in hand identifies and examines existing gaps in the contemporary research stream of maritime energy management, via a relevant survey. Based on the input provided by academia, maritime practitioners and industry experts, it also discusses the opportunities that arise for the International Association of Maritime Universities (IAMU) member universities to advance the specific domain of research and promote an energy efficient mode of maritime transport. Energy efficiency has been receiving more and more attention by the wider maritime industry after the Paris Agreement at the 21st Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 21). Research in maritime energy management is still rather new; there are plenty of opportunities for maritime scholars to contribute in the specific domain. The World Maritime University (WMU) has timely foreseen the need of education and research in the field of maritime energy management, long before the adoption of the United Nations Sustainable Development Goals (SDGs); the launch of its new MSc specialisation, under the title “Maritime Energy Management (MEM)” in September 2016 provides a self-explanatory argument. To inaugurate this new specialisation, WMU hosted the International Conference on Maritime Energy Management (MARENER 2017) in Malmo, Sweden, from 24 to 25 January 2017. This forum of intense interaction attracted over 300 participants from more than 80 countries around the world. The conference provided a comprehensive picture of contemporary issues in the maritime energy management research, including parallel sessions according to the pre-determined seven themes: “Regulatory Framework”, “Energy Efficient Ship Design and Operation”, “Energy Management in Ports and Shipyards”, “Alternative Fuels and Marine

Renewable Energy”, “Social and Human Dimensions of Energy Management”, “Economics of Energy Efficiency”, and “Theoretical Aspects of Maritime Energy Management”. Upon the completion of the event, the organising committee of MARENER 2017 conducted an online evaluation survey in order to better understand the latest developments within the domain of maritime energy management research. In total, 55 responses were received from the external conference participants. The survey identified a number of issues that must be addressed in the future. Indicative examples include how to bridge the identified gap between developed and developing countries, and the role of maritime education and training (MET) in maritime energy management. The current analysis categorises emerging areas of research and puts forward the necessary suggestions to promote future research and collaboration among the IAMU member universities.

**Keywords:** Maritime Energy Management · Research and Collaboration · Maritime Education and Training (MET) · MARENER 2017

## **1. Introduction**

The topic of “Energy Efficiency” has long been evolving in the maritime industry, with the aim to improve its environmental footprint and at the same time maintain an economically competitive shipping business. This trend became very clear after the Paris Agreement at the 21st Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 21), that established strong requirements upon the wider maritime industry to play an active role in relation to energy efficiency. In order to respond to the global needs in low carbon emissions by maritime transport endeavours, multidisciplinary research on maritime energy management is necessary; from technical and engineering subjects, to legal, economic, and even social ones. However, research in maritime energy management is still rather new; this is a strong indicator that there are plenty of opportunities, not only for those that very “maritime” oriented but also for many other scholars to contribute in the specific field of study.

The analysis in hand is heavily based on a relevant study conducted by the World Maritime University (WMU) in order to gather ideas and thoughts about future research in maritime energy management from academics and practitioners around the world. The main aim is to provide potential directions and identify the right scopes within the maritime energy management research stream for the benefit of the International Association of Maritime Universities (IAMU) member universities. There are numerous benefits under the above-

mentioned framework; pursuing similar agendas could further encourage collaboration in teaching and research activities among the member universities.

## **2. Current discussions on energy efficiency in shipping**

Sustainable Development Goals (SDGs)<sup>1</sup> include Goal 7: “Ensure Access to Affordable, Reliable, Sustainable and Modern Energy for All”, which has raised the concern of how the maritime transport industry can contribute to the energy efficiency issue. All transport sectors are criticised by slow adaptation to diversified energy choice. Indeed, all modes of transport have been heavily depended on oil as their (primary) energy source. In Europe, the oil dependency of transport sectors accounts for 93.6% in 2014 (Eurostat, 2016a). This fact in turn has raised a number of concerns, including energy, environmental and security ones. Mobility of people and goods are expected to increase globally in the future; therefore, growth needs to be as efficient as possible (OECD/IEA, 2016). In fact, over 90% of world trade (UNCTAD, 2016) and about half of European Union’s (EU) trade in goods are carried by sea as it is well known to be the most cost-effective transportation (Eurostat, 2016b). In this respect, the maritime sector can make a significant contribution to energy efficiency, making an impact at the global level.

According to the Third IMO GHG Study (IMO, 2014), the maritime industry annually emits around a thousand million tonnes of CO<sub>2</sub> and is responsible for 2.5% of global greenhouse gas emissions. For the period 2007-2012, on average, the maritime transport sector accounted for 3.1% of annual global CO<sub>2</sub>, which were equivalent to 2.8% of annual greenhouse gases (GHGs). For a future prediction, ships’ CO<sub>2</sub> emissions are expected to increase between 50% and 250% by 2050; however, if operational measures and implementing existing technologies are appropriately applied, there is a potential of reducing CO<sub>2</sub> emissions by up to 75% (IMO, 2009). This responsibility of the maritime industry was timely realised, as shown by the adoption of the Annex VI of the International Convention for the Prevention of Pollution from Ships (MARPOL). Through the specific legal toolbox, it is now an obligation to implement the Energy Efficiency Design Index (EEDI) for certain types of new ships, as well

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<sup>1</sup> On the 25th of September 2015, under the auspices of the United Nations (UN), countries adopted a set of goals to end poverty, protect the planet, and ensure prosperity for all as part of a new sustainable development agenda. The specific initiative is also more widely known under the following title: “Transforming our world: the 2030 Agenda for Sustainable Development”. There are 17 Sustainable Development Goals (SDGs); of particular interest are Goal 7, which aims to ensure access to affordable, reliable, sustainable and modern energy for all and Goal 12, which focuses on sustainable consumption and production patterns. Each goal has specific targets to be achieved over the next 15 years, with the complete details being available at: <http://www.un.org/sustainabledevelopment/sustainable-development-goals/>, accessed January 2017.

as the Ship Energy Efficiency Management Plan (SEEMP) for all ships.

While the IMO's efforts are seen as a rather complex operating framework for international shipping due to various other national and regional legislations, EU adopted a legal framework (Regulation EU 2015/757) for the monitoring, reporting and verification (MRV) of CO<sub>2</sub> emissions from maritime transport. Through this MRV Regulation, EU wants to obtain a better understanding of fuel consumption and CO<sub>2</sub> emissions from shipping activities within Europe. Under the MRV framework, three steps are suggested: [1] Monitoring, reporting and verification of carbon emissions from ships; [2] GHG reduction targets for the maritime transport sector; and [3] Further measures, such as Market-Based Measures (MBM).

These initiatives to support SDG 7 have been in fact driven by so-called developed countries and there are scarce research and literature efforts in relation to the developing countries' perspectives on energy efficient shipping. This view is articulated by the UN's SDG 7.a, stating that 'by 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy and energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology (UCLG, 2016).' The global challenge in this context would be how the global maritime industry can contribute to successful actions for SDG 7 without leaving developing countries behind (Ölçer et al., 2017).

### **3. The role of maritime universities in the maritime energy management domain**

The rise of energy efficient shipping increases the opportunities for maritime universities to support the industry needs and participate in policy-making at both national and international levels. For example, the Finnish government advocates policy coherence for sustainable development: The concept of "Towards carbon-free, clean and renewable energy cost efficiently" is taken into consideration of their national plans and strategies (Finnish Government, 2016). The EU project, Sea Traffic Management (STM) presented a case from their study that 4% of fuel saving can be achieved by ship's route optimisation between Sweden and Denmark and this accounts for 2,000 million Euros per year (Siwe, 2017). These examples testify that both policy-makers and industry members are looking for the "right" opportunities to advance an energy efficient maritime transport and are ready for investing into such efforts. However, the involvement of maritime universities in the maritime energy management domain could be more encouraged. As maritime experts, there should follow a more

crucial/leading role; maritime universities can be instrumental in the collaboration with all the relevant stakeholders.

Maritime Energy Management is a rather new area for education and research. One of the very promising initiatives from maritime universities within that domain can be associated with WMU. As part of WMU's contribution to the UN SDGs, a new MSc specialisation called "Maritime Energy Management (MEM)" was launched in September 2016. To inaugurate this new specialisation, WMU hosted the International Conference on Maritime Energy Management (MARENER 2017) in Malmo, Sweden, from 24 to 25 January 2017, attracting over 300 participants from more than 80 countries around the world. The conference provided a comprehensive picture of contemporary maritime energy management issues, including parallel sessions according to the pre-determined seven themes: "Regulatory Framework", "Energy Efficient Ship Design and Operation", "Energy Management in Ports and Shipyards", "Alternative Fuels and Marine Renewable Energy", "Social and Human Dimensions of Energy Management", "Economics of Energy Efficiency", and "Theoretical Aspects of Maritime Energy Management". Creating such opportunities for education and research in maritime energy management is extremely important.

On the other hand, the dissemination of knowledge and information to guide future research directions of this new scholarship is equally valuable; the topic of Liquefied Natural Gas (LNG) provides a strong indicative example (Dalaklis et al., 2017). Therefore, this paper intends to share the analysis of future research needs in the maritime energy management field among the IAMU member universities in order to build research capacity for the global maritime community.

#### **4. Methods**

The need of research in the maritime energy management field was investigated by (honest) opinions shared by the MARENER 2017 participants, who have in-depth knowledge about the real existing challenges and what exact type of opportunities must be exploited in order to ensure the sustainable future of the maritime sector. Such an ontological approach was further strengthened by triangulation which provides a "family of answers" (Pawson and Tilley, 1997), containing several contingent contexts of realities.

Online survey research was applied by immediately following up the conference participants, regarding to their insights, inspirations, and expectations. Other available methods, such as telephone interviews and hard-copy surveys, were not identified as suitable in terms of time and cost issues within the university's conference activities. The link to the

online evaluation survey was sent by follow-up emails with the participants, including a thank-you message and other useful links, such as the presentations files.

In summary, the online evaluation survey about MARENER 2017 was conducted from 30 January until the 14 February 2017. In total, fifty-five non-WMU participants responded, and the overall response rate was 46%. The conference participants were both academics and maritime professionals who had a particular interest in the given subject. Eysenbach and Wyatt (2002) suggest that a qualitative internet survey requires to deliberately looking into specific groups or individuals in order to obtain a profound understanding of their views. Though both quantitative and qualitative data were obtained, the current analysis mainly discusses qualitative data from open-ended survey responses, which are relevant to its scope. The data were coded to summarise and capture the essence of what informants expressed in terms of future research needs in the maritime energy management field. To understand patterns and regularity about the data by coding (Saldaña, 2016) helps the researchers to identify the key issues from the individual experiences of MARENER 2017.

## **5. Data analysis**

The survey respondents were all externals, and many of them (35 out of 55 respondents) identified themselves as coming from education sectors: Almost the half (49.1%, n=27) of the total respondents were university academic staff, whereas 14.5% (n=8) university students. The industry representation was 12.7% (n=7) from maritime-related companies; 7.3% (n=4) from governments; and 3.6% (n=2) from ports. The respondents who were employed in energy sectors were 18.2% (n=10) and environmental sectors 12.7% (n=7). A few respondents were naval architects (n=3), seafarers (n=2), or engineers other than seafarers (n=2). Finally, in terms of gender, male participants were 67.3% (n=37) and female 32.7% (n=18).

### **5.1. Benchmarking maritime energy management research**

The survey respondents discussed their insights about MARENER 2017 and it appeared that the conference had offered several important ways to examine potential maritime energy management research topics. For example, the major contribution of MARENER 2017 was to present multidisciplinary approaches to maritime energy management. Approximately a quarter of the respondents (23.6%, n=13) addressed a wide range of different views and areas of interest in the field of research. It was confirmed by many respondents that the methodologies to achieve/promote energy efficiency in shipping are broad and so as the multidisciplinary aspects of maritime energy management. Another important highlighted

issue was that the existing knowledge about maritime energy management had significantly expanded during the conference (20.0%, n=11). MARENER 2017 benchmarked to what exactly level both industry and academia know about maritime energy management (knowledge-level identification). It is indicative that up-to-date research results, examples and information on energy efficiency, different perspectives by country and EU, and various measures to improve energy efficiency were raised by the respondents. The survey also revealed the current challenges within maritime energy management, which are not all common to every country but rather different countries face different problems. This concern was raised by 9.1% (n=5) of the respondents and was deemed as important by both policy makers and practitioners.

## **5.2. Bridging the gap in maritime energy management research**

Though MARENER 2017 covered a wide range of aspects in maritime energy management research, the survey enabled the identification of some gaps in which the conference could not fully address. The answers from the respondents were generally spread over different areas, however 12.7% (n=7) of them expressed that the maritime energy research in relation to the human element should be strengthened, including the issues of education and training, social and economic impact on sustainable energy, gender, and awareness. The importance of human element in maritime energy management is already addressed by Kitada and Ölçer (2015). Other similar examples include Dalaklis (2016); Ölçer et al. (2017). Another identified gap is related to industry views on maritime energy management (10.9%, n=6). The responders were mainly interested in how business and commercial aspects can influence maritime energy management, such as split incentive cases, applications of energy systems, integrated logistic services, and the ways of coping with practical issues. Furthermore, the areas of ship design (9.1%, n=5), ship operation (7.3%, n=4), renewable energy (7.3%, n=4), regulation (7.3%, n=4), port (7.3%, n=4), and fuel (7.3%, n=4) have been pin-pointed as areas of further interest. For example, ship design research can include ship retrofitting for energy efficiency by manufacturers; ship operation research can address wind propulsion, voyage optimisation, and weather routing; renewable energy research can develop more on ocean energy; policy and regulation research can focus on ship's energy auditing, regulatory framework, ratification and implementation of IMO conventions, and biodiversity protection; port research can explore smart port, infrastructure, standards, and management; and fuel research can look into fuel cells, alternative fuels, and LNG. Other opinions also suggested the areas of climate change and offshore industry in relation to maritime energy management.



### **5.3. Future directions of maritime energy management research**

The survey explored the respondents' views about the future directions of maritime energy management research. The most common answer (20.0%, n=11) was to build specialised expertise within the field. For example, a more narrow focus on a specific area of maritime energy management is on demand. This trend was clearly expected, because some of the on-going research efforts on maritime energy are still in the development phase or immature. People are interested in further development of new ideas and their applications into practice. It can be also stated that most of the available data about energy are not necessarily specific to the maritime sector. Generally speaking, it is not easy to find relevant research and reports about maritime energy management, especially at a national level. This suggests that more and more experts in maritime energy management are “demanded” by the industry, and thus, the future directions of maritime energy management research could be to narrow down the existing knowledge and to understand the issues of maritime energy management in depth.

Another topic to be included in the future research agenda should be practical applications of theories (16.4%, n=9): For example, the actual examples of implementing regulations; practical approaches from maritime companies; applicability of maritime energy technologies in developing countries; ship owners' perspective in decision-making about applying new technologies; commercial experiences and their relation to academic research; viewpoints from energy efficiency equipment manufacturers; and more technical, efficient and economically feasible methods.

In addition, research relating to SDGs was also identified as a need (7.3%, n=4). For instance, how to bridge the gap between developed and developing countries to meet the SDGs is an important research objective. Though specialised knowledge on maritime energy management is necessary, it is also important to look the agenda of energy beyond the maritime sector. Energy in SDG Goal 7 has a linkage to other SDGs, such as Goal 13 (Climate Change) and 14 (Ocean). An intersectional approach addressing several SDGs would be one of the future directions in maritime energy management research. Other answers were also interesting and they included the topic of human element (5.5%, n=3), port (5.5%, n=3), technology (5.5%, n=3), and others (e.g., Monitoring, Reporting, and Verification (MRV); ship operation; and governments).

## **6. Conclusion and remarks**

The analysis of the MARENER 2017 evaluation online survey identified the current status of

maritime energy management research (benchmarking), as well as the gaps to fill in for the future. From the conference and the survey study, it is evident that there is a need for more practical examples and real-life applications to facilitate the already available theoretical understanding. In this regard, WMU has already taken an action to address such needs and established a module called [EGY 107] “Applied Energy Research” within the MEM specialisation. This module offers a unique experience of practical applications of theories in practice for the MEM specialisation students in their early research career. Though the majority of literature and reports relating to energy efficiency in the maritime sector has been published in so-called developed countries, it is equally important to understand how the other countries, especially developing countries, deal with similar problems of maritime energy management by proper scientific methods.

As a final note, the study also confirmed that a multidisciplinary approach is a necessary direction of future research in maritime energy management; the later requires a very wide range of experts across the interrelated transport and engineering industries. Human element and industry views were found to be particularly important in terms of effective implementation of regulations and policies. Needless to say, the role of maritime universities is crucial to create research-based knowledge in the field; the IAMU network must lead the way and lead research and innovation within the maritime energy management domain.

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# THE INTERFACE BETWEEN THE MARITIME EDUCATION, TRAINING AND THE TECHNOLOGICAL INNOVATIONS IN THE NEW SHIP DESIGN

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**Abstract** Maritime education, training (MET) and research must support the marine students to understand the Technological Innovations in the New Ship Design and Dynamic Stability in the Operational Areas. The ship's master and other officers need to predict in advance the motions of the ship. Ship motion prediction will increase the safety level of navigation in different operational areas such as inland water and different open sea areas.

The studies of human mind shows that the cognitive attitude of ship master/human fall short to cope with multi-variable problems and it always tends to simplify complicated problems in order to find a solution such as predicting the ship motions in different conditions. This fact can be traced when the master handles a ship in variable bad weather.

New Ship designs changed dramatically and in generally trend to have more deck cargo, which leads to higher centre of gravity (*C.G.*) and to higher stability demands. This problem is very obvious in containers vessel as well in *RO-RO*, *RoPax*-Ferries and Cruise liners. The other trend is for higher speeds and better fuel economy, which has led to completely different hull forms. They may face dangerous phenomena, e.g. large angle of rolling, parametric resonance. Ship stability may also be reduced dramatically when there is water on deck or the deck is in the water, on the wave crest and when broaching-to. Consequently, the cargo on board will be subjected to external and internal forces, which may cause shifting cargo, cargo damage, loss cargo and ship's damage or loss.

Therefore, the recent theoretical knowledge and empirical applications in ship hydrodynamics are essential to be applied into the practical world and maritime studies in order to increase safety in ship operations. This research will focus on both areas of the interface between the Maritime Education, Training and the Technological Innovations in the New Ship Design and Dynamic Stability in the Operational Areas.

**Key words:** MET, New Ship Design, Dynamic Stability, Operational areas.

## **1 Introduction**

The main purpose of this research is to provide the necessary knowledge to ship officers, masters, and persons responsible in the nautical field to achieve a safe voyage with regard to ship stability and its motion. Therefore, there are potential needs to develop the training and education in terms of MET and its assessments .

Ship designs changed dramatically to optimize calm water resistance to increase the speed and to achieve better fuel economy which leads to completely different hull forms. The other trend is to have more deck cargo, which leads to higher stability demands. This problem is very obvious in the modern ships. The behaviour of the modern ships e.g. large container ships may face dangerous phenomena and high probability of synchronisation and parametric resonance.

The hull geometry is to be addressed the hydrodynamics interaction of the hull, propeller and rudder. Special attention should be given to the control of ship motion.

The nautical learners in the maritime institutes study the IMO regulation and the intact stability requirements that cover a specific acceptable level of safety. The current regulations are based only on empirical criteria related to the calm water lever arm curve.

The innovation in the new ships design requires new syllabus for the nautical learners related to the design stability, regulatory stability and operational stability. When applying the science of ship hydrodynamics, it is a must to take into considerations the problems of (dynamic) intact stability.

Therefore, the theoretical knowledge in ship hydrodynamics is essential to apply into the practical world of shipping in order to improve safe ship operation. This study will focus on the potential needs of the interface between the maritime education, training and the technological innovations in the new ship design. Therefore, this paper will offers a case study of how to apply the science of ship hydrodynamics into the real world of shipping for safer operation.

## **2 Definition of the problem**

The new ship designs such as transom aft, barge-type-aft bodies are commonly built and bow flare is often increased to allow for more cargo capacity. The result is a higher centre of gravity than before and the characteristics of the righting lever curves will have changes. Usually they have higher heeling angles. Changes in designs, speeds and size tend to be more

in the future. Consequently, shipmaster and crew on board have difficulties to judge the consequences of these developments and it becomes difficult for them to correctly identify dangerous combinations of wave angle, encounter wave period and ship speed in rough or severe seas. Therefore, they may face dangerous phenomena which may cause shifting cargo and ship's damage or loss.

The majority of the maritime community believes that reducing the speeds in rough conditions is a safer action for sailing but this is not a correct action in many cases especially with some modern vessels. Recently, some of the large container ships suffered from parametric excitation, loosing and /or damaging a lot of cargo and being in the danger of capsize and the appropriate guidance on how to avoid these situations is in general not foreseen.

The master knows that in severe weather conditions, a very efficient way to reduce the risk imposed on the ship, crew and cargo is to avoid sailing in such conditions. Therefore, the master needs reasons to justify his decisions and that reasons cannot be well clarified without demonstrating the ship dynamic stability in all stages of the voyage

The IMO intact stability criteria (resolution A.749 (18), 1995) wrote some years ago based on the static lever arm curve for still water condition and this cannot represent real world.

Even the polar diagram in (MSC/circ. 707 (IMO), 1995 and MSC.1/Circ.1228, 2007) provide a general unified boundary of safe and unsafe combination of the operational parameters for all types of conventional ships. Resolution (MSC.267(85), 2008) as adoption of the international code on intact stability put the responsibilities of ship safety on the administration. The organization mentioned that the performance and the criteria for the identified phenomena related to sailing waves and dynamic stability need to be developed.

In general, the assessments in the maritime institutes for the marine subjects are separated or isolated test for each subject. In this context, it can be defined as "One Link Assessment". That mean, the assessments are subject by subject as clarified in this context separated or isolated. Therefore, these mode of assessments will not address the real practical world of the sea voyage. They will cover the complete sea voyage as separated links of topics, e.g. ship stability, stowage cargo, sailing navigation and .....*etc.* In this perspective the roll of the MET became imperative to train the learners and to put the right assessment that corresponding the real practical sea voyage life.

### 3 Ship's motions and general guidance

To solve the problem that defined in item 2 in this paper, it needs a clarification to tackle the interface among ship's motions and the different marine subjects.

Manoeuvring is addressing ship behaviour in the horizontal plane (surge, sway, yaw motions), this will affect mainly the ship handling, the surface navigation, the collision avoidance and in general the safe of the watch keeping. Stability and sea keeping are addressing ship behaviour in the longitudinal and transverse plane (mainly heave, pitch and roll motions). Mainly, Ship construction, design stability, regulatory stability, operational stability and ships form will be significant subjects in type of motion.

There are some phenomena raise the risk of ship heavily motion or capsizing such as pure loss of stability, especially in wave crest, roll resonance, parametric rolling, cargo shift and broaching to. In other words, the major causes for big amplitude of ship motion or increase the risk of capsize are the phenomena of broaching, loss of transverse stability and low cycle resonance e.g. synchronisation and parametric rolling.

The following is item 4 in this paper is a case study of a real ship in real sea voyage. The study will show the different marine curriculums integrated together to be in one chain implementation to achieve a safe sea voyage. A modern ship with initial hull form and a modification for the same ship to optimise sea keeping safety.

### 4 Case study " *M/V. Cementina*" and two ships' forms

This study will focus on ship roll motion, synchronous rolling and parametric rolling.

#### 4.1 *M/V: Cementina*

The author assumed three scenarios for the *M/V: Cementina* with its condition of loading and the sailing operation area in beam seas and quartering seas. The ship is a bulk carrier (after a marine survey renewed to carry cement cargo). The recently ship particulars are Lengths over all (*LOA*) 64.10 m, Length between perpendicular(*L*)=58.10 m, Molded breadth (*B*)=10.83 m, Molded depth to upper deck (*D*)=4.57 m, Draft on summer freeboard (*T*)=4.39 m, Dead weight to summer freeboard (*DWT*)=1229.40 T and *CB* at summer free board=0.7. The main ratio will be defined as  $B.T=10.82*4.39=47.5$ ,  $B/T=10.82/4.39=2.46$  and  $L/D=58.1/4.57=12.71$ . The main dimensions decide many of the ship characteristics, e.g. stability, hold capacity, power requirements and economic efficiency (Schneekluth & Bertram, 1998). The sea area of operation is North Atlantic and Baltic Sea. For the first scenario, the equations that govern the roll motion in beam seas as follows:

$$a \ddot{X}_4 + b \dot{X}_4 + c X_4 = d \quad (1)$$

Where:  $a$ ,  $b$  &  $c$  are proportionality factors,  $\ddot{X}_4$  is roll acceleration,  $\dot{X}_4$  is roll Velocity,  $X_4$  is roll angle and  $d$  is external roll excitation. The proportionality factors “ $a$ ” depends on influence of surrounding water, inertia, displacement, ship’ beam, roll coefficient and radius of gyration. Radius of gyration depends on cargo stowage and mass distribution in the ship. In other words, it is the inertia mass moment of the rolling ship including the hydrodynamic mass moment effect of the surrounding water. The parameter “ $b$ ” in the roll motion equation describes the damping. It is more common to introduce a dimensionless parameter “ $D$ ” as follows:

$$b/a = 2 \delta \quad (2)$$

$$D = \delta / \omega_o \quad (3)$$

Where:  $\delta$  is a coefficient in the exponent of the exponential decay of the roll motion in time and  $\omega_o$  is the natural circular roll frequency. The proportionality factor “ $c$ ” as a restoring coefficient can be expressed as follows:

$$C = g \cdot \Delta \cdot GM \quad (4)$$

$$\Delta = displacement = \rho \nabla \quad (5)$$

Where:  $\Delta$  is the displacement,  $\rho$  is the water density and  $\nabla$  is the under water volume. The relation between “ $c$ ” and “ $a$ ” as a ratio  $c/a$  is equal to the natural circular roll frequency squared:

$$\omega_o^2 = c/a \quad (6)$$

$$\text{Ship natural circular frequency} = \omega_o = 2 \pi / T_o \quad (7)$$

The prediction of the natural circular frequency can be found out as follows:

$$\omega_o = \sqrt{\frac{g \cdot \Delta \cdot GM}{\Delta \cdot i' T^2}} \quad (8)$$

Where:  $\Delta$  is the displacement and “ $i' T$ ” is the radius of gyration.

$$GM = \lim_{n \rightarrow \infty} \left( \frac{fr \cdot B}{T_o} \right)^2 \quad \therefore \quad T_o = \frac{fr \cdot B}{\sqrt{GM}} \quad (9)$$

The rolling coefficient “ $fr$ ” depend on the loading condition and the cargo plan. “ $B$ ” is the ship’s beam. In addition to apply the above equations to calculate the maximum linear roll for the *M/V. Cementina* in the beam seas, the author assumed the scenarios for the regular wave of maximum occurrence in the North Atlantic, other for one particular extreme but rare wave and the third in roll resonance, (ship damping  $D = 0.10$ ). The maximum occurrence in the North Atlantic was a wave height ( $H_w$ ) of 1.5 meter and wave time period ( $T_w$ ) of 6 to 7 sec.



The one particular extreme but rare wave was a wave height ( $H_W$ ) of *9.5 meter* and wave time period ( $T_W$ ) of *6 to 7 sec*. The following set of equations used to find out the maximum roll angle (Kastner, 2001) and (kobyliniski & Kastner, 2003):

$$\text{Wave length } (T_W) = \frac{g}{2\pi} \cdot T_W^2 \quad (10)$$

$$\mathcal{G}_{max.} = \text{maximum wave slope} = \pi \cdot H_W / L_W \quad (11)$$

$$\eta = \omega_w / \omega_o = \text{tuning factor} \quad (12)$$

$$V_3 (\text{amplification factor}) = \frac{1}{\sqrt{(1-\eta)^2 + 4D^2\eta^2}} \quad (13)$$

$$\Phi_{max.} = \mathcal{G}_{max.} \cdot V_3 \quad (14)$$

The result of the maximum roll angle ( $\Phi_{max.}$ ) in the maximum occurrence in the North Atlantic was *4.5 degrees*. For the one particular extreme but rare wave was *29 degrees*. In case of resonance when  $T_O = T_W$  which about *8.9 seconds* with the maximum amplification factor was *69.5 degrees*.

The second scenario is a resonance in the stern quartering sea. The excitation frequency is expressed by the encounter spectrum of the pitch  $P$ , which is about double the response roll frequency of spectrum  $R$  (or the inverse pitch period about one half the roll periods). When the encounter wave period equal double ship natural rolling period, the ship will pitch two times against one time roll. In this case the  $GM$  will decrease and the parametric rolling will increase. Mathieu resonance occurs when the wave periods of encounter  $T_E$  is nearly one half of the natural roll period  $T_O$  or when they both are nearly equal. Condition for Mathieu resonance in following sea and quartering sea to be avoided:

$$T_E = \frac{1}{2} T_O \quad (15)$$

$$T_E = T_O \quad (16)$$

The author assumed other three scenarios for the  $M/V$ : *Cementina* with its condition of loading and the operation area of sailing in North Atlantic in *30 and 60 degrees* stern quartering seas.

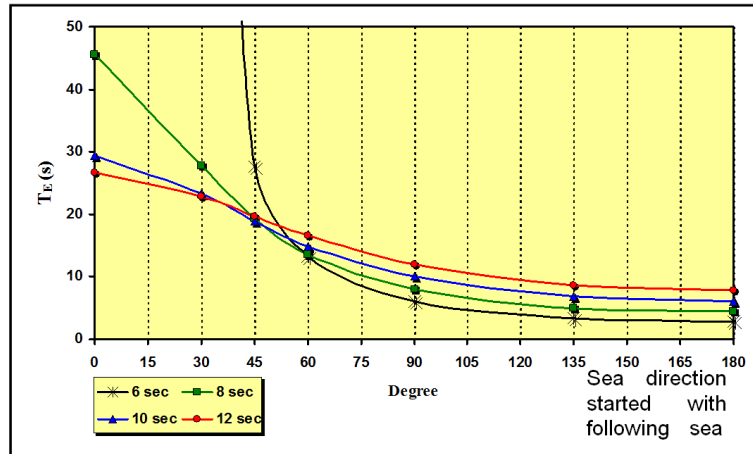
In the first and second scenarios, the ship achieves all the requirement of the stability conditions (proximal  $GM = 0.16$  meter) and assumed to sail in speed *20 knots*. In the first scenario, the wave time was *12 seconds* and stern quartering sea was *30 degrees* as shows in figure 1. In the second scenario, the wave time was *6 seconds* and stern quartering sea was *60 degrees*. Equation 17 is to find out the encounter period (Kastner, 2001) and (kobyliniski & Kastner, 2003). See figure 1.

$$T_E = \frac{T_W^2}{T_W - (2\pi/g) \cdot V \cdot \cos.\chi} \quad (17)$$

Where: ( $V$ ) is the ship's speed and ( $\chi$ ) is the sea encounter angle.

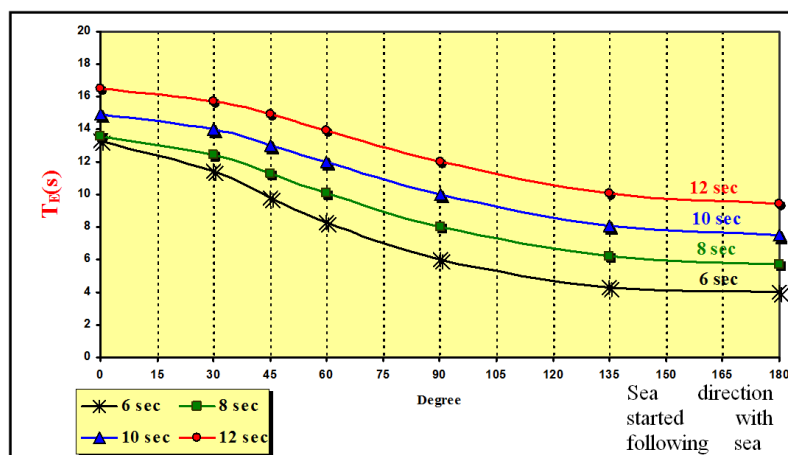
The result of the first scenario compared with the dangerous resonance zone, Synchronous rolling motion will start to occur when  $T_E$  nearly equal  $T_O = 22.9 \text{ sec}$ . Parametric rolling, which will occur when  $T_E = \frac{1}{2} T_O$ . That mean  $T_E = 11.45 \text{ sec}$ .

Figure 1 shows in general, the risk of resonance period for *M/V Cementina* with ship's speed *20 knots*, and waves time between 6 and 12 sec., will be approximately between sea encounter angle 30 and 60 degrees.



**Figure 1:** The probability of encounter periods when the ship running in *20 knots*.

The result of the second scenario compared with the dangerous resonance zone, Synchronous rolling motion will start to occur when  $T_E$  nearly equal  $T_O = 13.3 \text{ sec}$ . Parametric rolling, which will occur when  $T_E = \frac{1}{2} T_O$ . That mean  $T_E = 6.65 \text{ sec}$ . When ship's speed reduced to be 10 knots, the results improved as shows in figure 2.



**Figure 2:** The probability of encounter periods when the ship running in *10 knots*.

In the third scenario was at  $T_W = 6$  to 7 seconds and 30 degrees stern quartering sea. The ship achieves all the requirements of the stability conditions and assume to sail in speed 10

knots to achieve less probability of roll resonance but the results were much different from the first and second scenarios because  $GM$  in this scenario was  $0.55$  meter.

The result of the third scenario compared with the dangerous resonance zone, Roll resonance will occur when ship's speed is  $10$  knots. The ship master can change the ship speed to  $20$  knots to get rid of roll resonance.

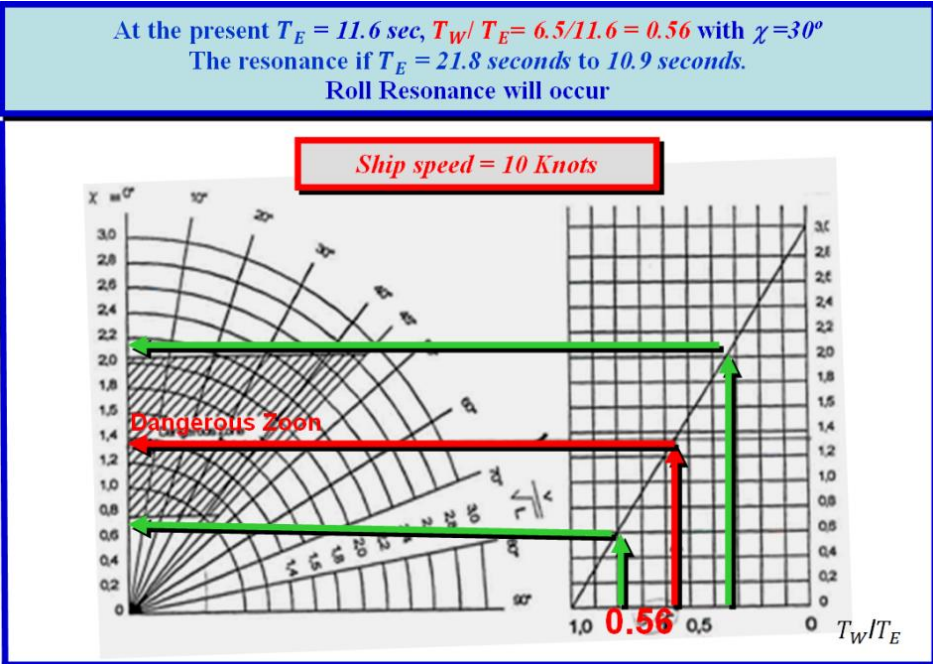
**4.2 Using polar diagram to indicate dangerous zone**

The polar diagram indicating dangerous zone of encountering to high wave is similar to the above results but in very general boundary. Each ship has its own dynamic behavior as a motion and the polar diagram in Figure 3 will not represent the accurate and the real situation of the individual ship.

Therefore, the next step is to plot  $V(knots) / T(s)$  versus  $\chi$ . See  $T_E$  curve in figure 3 to clarify an approximate boundary situation. When the speed is reduced to be  $= 10$  knots with  $T_W = 6$  seconds and  $\chi = 30$  degree, the result is  $T_E = 11.4$  seconds and if  $T_W = 6.5$  seconds, the result is  $T_E = 11.6$  seconds. According to the value of  $T_O = 21.8$  seconds, the resonance will occur when  $T_E = 21.8$  seconds to  $10.9$  seconds. Apply the polar diagram with the present  $T_E = 11.6$  seconds. See figure 3.

When the encounter wave period is nearly equal to double (i.e. about  $1.5$  to  $2.8$  time's approximately) of the observed wave period, the ship is considered to be situated in the dangerous zone as shown in figure 3.

The ship stills in the dangerous zone when  $T_W/T_E = 6.5/11.6 = 0.56$  with  $\chi = 30$  degree. Reduce the speed more or increase the speed to come out of the dangerous zone.



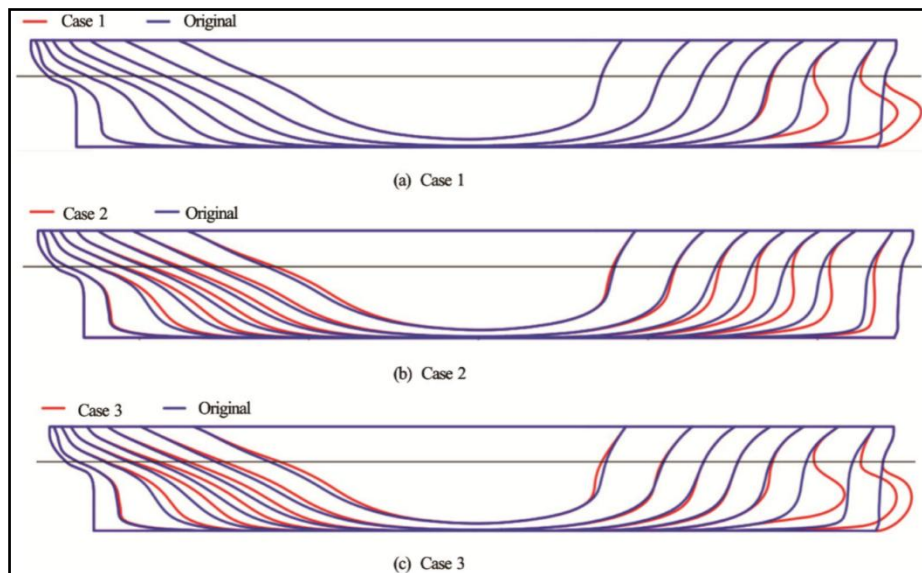
**Figure 3:** Operation diagram for the master as proposed by IMO, MCS/Circ.707.

According to this study in case of roll resonance, as the speed increase as encounter angle will increase and vice versa.

### 4.3 Dynamic characterizes of new ships are rapidly changing

An advanced research in George Mason University in USA to optimize the best average speed performance. Three optimal designs are selected from three sets of optimal solutions. In addition, the comparisons of body plan and sheer plan between the original hull and three optimal hulls are shown in Figure 4.

In order to check the performance of the different hulls, the wave drag coefficients, total drag coefficients, wave drag and total drag are evaluated for the original forms. The optimal hull from Case 3 has the best overall performance (C. Yang and F. Huang, 2016). As wave travels down along the hull, the stability (as indicated by GM) varies as the wave crests travel along the hull especially with modern container ships.



**Figure 4:** Comparison of sheer plans between the original hull and the optimal hulls

## 5 Results

In this context, a comprehensive analysis of the requirements and techniques to produce the geometry of ship models for modern ship. It has specified some important aspects that influence the ship motion. The comparison results of the different models were completely different. The behavior of the modified model in case 3 would have in general better performance in the dynamic stability and will decrease dramatically the risk of ship capsizing due to resonance or parametric rolling in bad weather, especially in the quartering and following seas due to decrease the transverse and longitudinal waves moment that case the risk of high excitation and capsizing.

To check the safety level of a specific ship, the analyses behaviour of the ship must be in waves and in the environment of the operation area. It should be noted that the current IMO operation guidance is not a valid criteria to guarantee the absolute safety.

A polar diagram listed in the IMO regulation does not take into account the actual stability and the dynamic characteristics of an individual ship, but provides a general unified boundary of safe and unsafe combination of the operational parameters for all types of conventional ships.

The three scenarios of *M/V Cementina* in item 4.1 demonstrate Condition for Mathieu resonance in quartering sea to be avoided and how is the *10 knots* ship's speed is very effective to ride out the resonance in the second scenario and it is not effective in the same condition in the third scenario when the *GM* was different.

## **6 Conclusion**

This paper shows that the cognitive attitude of ship master/human fall short to coop with multi-variable problems such as handling a ship in a rough weather and it is essential to improve the MET syllabus of the nautical learners. The improvement will address the sea conditions, metrological condition, ships' design, cargo stowage, stability as a chain of evaluation for planning the real world of sea voyage in advance. This real chain of evaluation will defined as "Chain Assessment" in the MET institutes and special training such as work shop would be before this type of Assessments. The "Chain Assessment" shall capture multi disciplines link by link in unique integrated chain to tackle the real life of the practical sea.

IMO regulations and requirements have to define the required minimum safety standard and should allow for a comprehensive evaluation of a ship's dynamic performance in waves. There is a large demand for more reliable and up to date guidance than the current general guidelines e.g. the IMO MSC/Circ. 707 and MSC.1/Circ.1228.

In different sea states and weather conditions, ship masters and officers in the watch need to prepare for the voyage plan in advance the speeds/courses restrictions that have high probability of resonance to avoid the dangerous situations such as surf-riding, broaching to and high excitation in the synchronous condition and parametric rolling.

To plane for the optimal mode of navigation as safer voyage and clean ocean after this modern innovation and new ships design, the roll of MET assessment for the learners must address "Chain Assessment" instead of "One Link Assessment".

A system must be established to support the ship master decision making, by computer-based system. The system shall be able to predict and optimize the best mode of operation

(manoeuvre and sea keeping). At least a comprehensive guidance about the prediction of ship performance navigating in different weather condition must be available on the bridge.

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## ANALYSIS OF THE LOGISTICS TRANSPORT CORRIDORS I BLACK SEA REGION BASED ON THE SHORT SEA SHIPPING CONCEPT

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**Abstract:** Regardless of fluctuations in world trade caused by economic cycles and the development of political processes remains a general trend of sustained growth of trade flows. This leads to an increase in both the demand for logistics services and the requirements for them. In this sense, decisive is the planning and construction of transport systems as a basis for the development of competitive logistics.

An important aspect is the promotion of multimodal transport, which in search of optimal transport solutions will reduce the use of relatively expensive and environmentally unfriendly road transportation. This will be at the expense of the efficient combination of different modes in which the concept of short sea shipping occupies a central place. Although this concept is widely applied in many places in the Black Sea, it still has significant potential. It was prompted by stagnation in economic relations as a result of political and economic crises in the region since the late twentieth and early twenty-first century. To evaluate the potential of the concept in the development of transport is done research on Intermodal logistics network in the logistics corridor Central Asia - Central Europe. To optimize intermodal transport links a comparative analysis of the various transport alternatives on the route Tehran – Budapest is done. On this basis it is made optimization assessment on three main criteria - cost, delivery time and environmental protection and basic recommendations on strategic planning development of the Bulgarian transport infrastructure is given.

**Key words:** Short sea shipping, multimodal transportation, intermodal transportation, transport route optimization.

## **Introduction**

The growing globalization of industry and commerce, which is increasingly characterized by a global territorial distribution of supply chains, is increasingly demanding for transport as a part of the logistics systems. In this sense, the different means of transport and the macro-framework, and in particular the transport and communication infrastructure, are constantly evolving to meet the increasing demands. Only with significant qualitative and quantitative changes in these structures is it possible to build and control internationally-oriented efficient supply chains.

The principal focus of this study is on the key features of the Black Sea region and its links with Central Europe and Central Asia, which due to their historical links can be considered as a relatively homogeneous commercial space. This is in particular due to the development of the ancient Silk Road in the period of the XXX century BC - XV century AC, the belonging of parts of the region to various state formations and economic unions from the second half of the 20th century. In spite of the sharp geopolitical opposition during the period since 2008 between the US-dominated liberal-democratic world and the emerging economies, the expansion of historically established ties, accompanied by the change of traditional understanding of state borders in the context of The European Union (EU) and the Eurasian Economic Community (EAEC).

Multimodal transport plays a major role in the international logistics, and any improvement in this direction provides significant opportunities for achieving sustainable competitiveness. Therefore, the focal aspects of the design of the transport corridors related to the logistics processes in the Black Sea region and the possible transport options between Central Asia and Central Europe, as well the issues related to the intermodal capacities and the reduction of transport-related emissions, have been studied.

A key factor for the development of the transport sector in Bulgaria, and logistics in particular, is the favourable geographic position of the country, providing an exceptional opportunity to become a connecting transport link between the countries of Western and Central Europe, the Middle East, Western and Central Asia, as well as in the North-South direction.

The aim of this study is to define the concept of Short Sea Shipping (SSS) in the Black Sea and to characterize the conditions for its implementation as an alternative to rail and road transportation and an effective mean of diversifying transport in the circumstances of the dynamically



changing environment in the region. (1) To achieve this goal, similar concepts have been explored in other parts of the world, environmental conditions and by comparative analysis is determined its implementation. The study also presents conclusions on the development of environmentally, economically, socially and politically balanced sustainable transport concepts.

This study does not provide a detailed analysis of transport services, although it would be interesting to assess their potential from a logistical, economic and environmental point of view. The results can serve operators to obtain a better assessment of the environment and price aspects.

## **1. Prospects for the development of the concept of regular short sea shipping in the Black Sea**

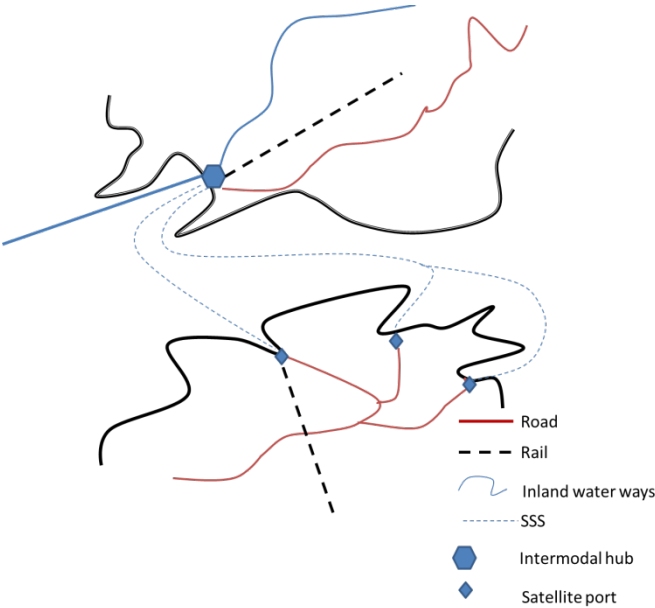
### **1.1.1. Primary features of the SSS concept**

Traditionally, the concept of the SSS is the result of the concepts of logistics chains and intermodality. Its main advantages are the low price, the potentially lower emissions, the available infrastructure and the significant capacity of the ships. Although maritime transport is seen as an ecological alternative to the road transport and the considerable advantages offered by the SSS concept, there are significant challenges. These are, above all, related to the high costs of fuels and harbour taxes; high risks associated with its application; new regulations and environmental charges. For example, application of the requirements to control emissions of sulphur oxides (Sulphur Emission Control Areas (SECAs) in the North and Baltic Sea provides for strict limits on the sulphur content of marine fuels, which automatically means a higher price for bunkering. As a consequence can be expected an increase in the cost of shipping. Stringent environmental regulations are essential to achieve a significant reduction in atmospheric emissions from ships, but they also need to take into account the desire to encourage modal shift from road to the sea.

The SSS concept makes special requirements for rapid and effective transshipment between sea and road or rail transport, which may be technically difficult to achieve in smaller ports. Another problem is the different infrastructure capacity in different ports, which leads to a risk of delays or increased transport time. Problems with load speed and capacity differences also have an impact on the integration of the entire transport system.

The SSS concept includes the transport of cargo between ports and intermodal port hubs with a fixed timetable. (2) Accuracy and frequency are essential factors as they allow the transport at sea of time sensitive goods which are currently transported by other means of transport. The growing importance of maritime transport in future transport systems means increasing requirements

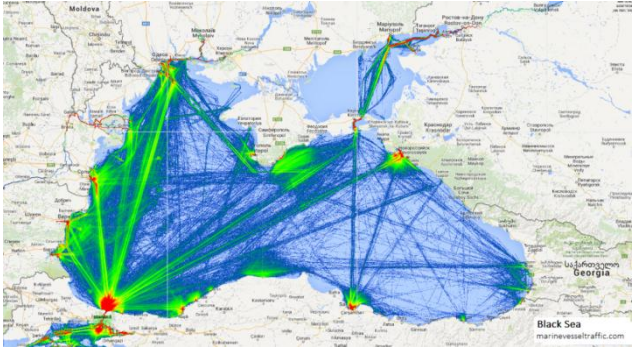
for efficiency, sustainability, and economic stability. Implementation of this concept may in the future lead to problems related to the capacity of rail and/or road infrastructure and to open up additional markets. (2)



**Fig. 1.1** SSS Conceptual scheme

**1.1.2. Transport hubs in the Black Sea region**

From the point of view of integration in the transport system, the built infrastructure and the existing traffic (Figure 1.2), we can conclude that the ports of Istanbul, Bourgas, Varna, Constanta, Odessa, Novorossiysk (Caucasus), Poti, Batumi, and Samsun can be considered as regional Transport hubs in the SSS concept. (Figure 1.2)



**Fig. 1.2** Density map of maritime traffic in the Black Sea, 2013 (3) (4)

### 1.1.3. The SSS concept in the context of Black Sea Maritime Logistics

From a historical point of view, the Balkans and the Black Sea play an important role as the link between Central and Western Europe and the Middle East. As a bridge between Europe, Africa, and Asia, they have become an important geostrategic region for carrying out some transport projects.

Through the territory of Bulgaria, two major transport corridors along the East-West axis pass, serving the trade between Europe and Asia. These are the "North Corridor" linking China, Mongolia, North and South Korea and Japan along the Trans-Siberian Highway to the European countries, and South Corridor from China, Pakistan, India, and Indochina through Iran to the Middle East, Turkey, North Africa and Europe. These corridors intersect the territory of Bulgaria with its branches through the Caspian region and the Caucasus, joining the route of the ancient Silk Road (TRACECA corridor) connecting China in Central Asia with the Balkans and Europe in the past. (5)

In this sense, the SSS concept in the Black Sea (also in the Caspian Sea) serves to integrate the already described transport systems. (Figure 1.3)



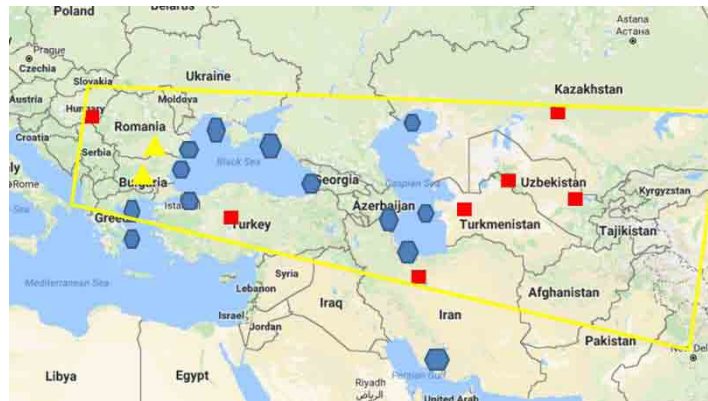
**Fig. 1.3** The SSS concept in the Black Sea in the integration of transport systems

Unlike other areas where the development of the concept depends on the overseas lines, in the Black Sea, it is a function of the development of the transport corridors between Western Europe and Asia as a link between European and Asian transport systems. In this sense, it offers opportunities for new business models at both operational and commercial levels.

## 2. Development of the short sea shipping concept (SSS) in the context of the development and optimization of logistic transport corridors

The development of the concept of short sea shipping is in direct dependence not only on the development of transport corridors but also on the development of logistics infrastructure.

To operate a system with a certain return, the scale of investments is critical. This applies particularly to local and regional logistics facilities. Often such terminals have low traffic volume and therefore do not operate with the required efficiency. This has the effect of reducing their potential for intermodal opportunities and ultimately limiting access to road and rail transport. To some extent, these problems are solved by introducing highly efficient multimodal innovative systems (6) for horizontal cargo handling (7) (8). Extremely promising are the so-called rail highways (9).

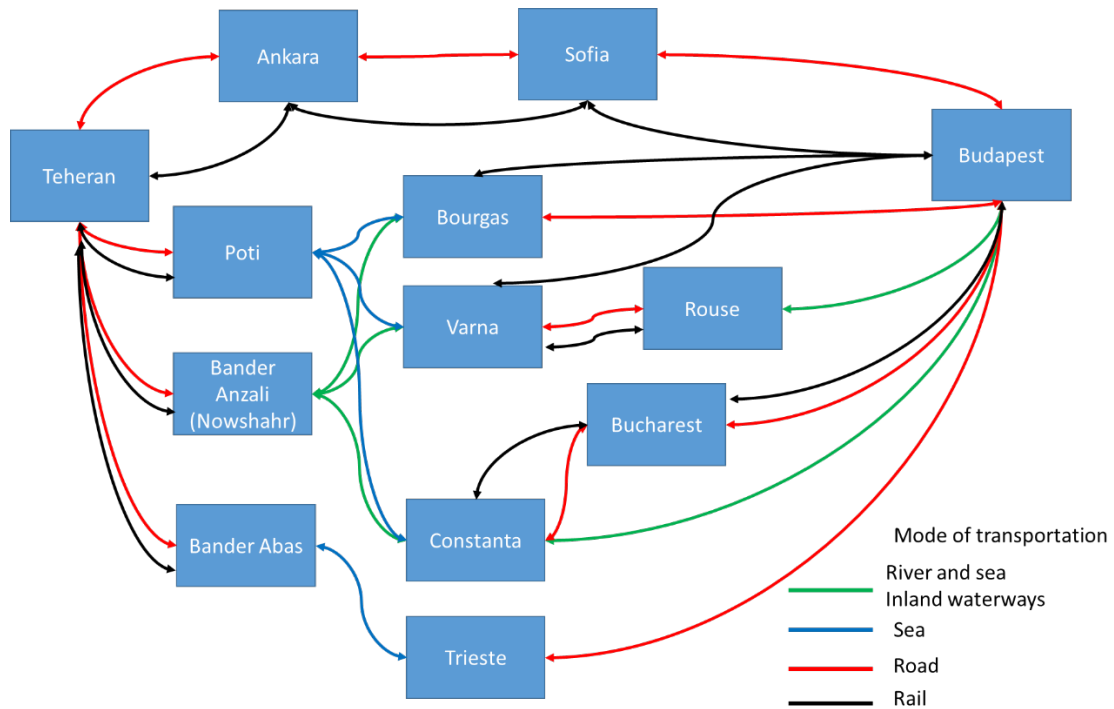


**Fig. 2.1** Logistics facilities in the context of the SSS concept in the Black Sea

Thus we can define the corresponding logistics corridor (Figure 2.1). It is also crucial to target investments in the most efficient chains, taking into account their complex economic and environmental sustainability.

### 2.1.1. Optimizing intermodal transport links

To determine optimal intermodal transport links, we will look at their options between two specific endpoints. Tehran is used as a core unit in Central Asia and Budapest - in Central Europe, where high-performance multimodal transport links have been developed across Europe.



**Fig. 2.2** Logistics transport network Tehran - Budapest

**Tab. 2.1** Transport chains Tehran - Budapest

	<b>Intermodal transport chain</b>
2.1.	Tehran- (lorry) -Poti- (Ferry) -Varna- (Railway) -Ruse- (Ferry) -Budapest
2.1.a	Tehran- (Railway) -Poti- (Ferryboat) -Varna- (Railway) -Ruse- (Ferryboat) -Budapest
2.2.	Tehran- (truck) -Poti- (Ferry) -Varna- (truck) -Budapest
2.2.a	Tehran- (Railway) -Poti- (Ferryboat) -Varna- (Railway) -Budapest
2.3.	Tehran- (truck) -Poti- (Ferryboat) -Burgas- (truck) -Budapest
2.3.a	Tehran- (Railway) -Poti- (Ferryboat) -Burgas- (truck) -Budapest
2.4.	Tehran- (truck) -Poti- (Ferryboat) -Constanta- (truck) -Budapest
2.4.a	Tehran- (Railway) -Poly- (Ferryboat) -Constanta- (Railway) -Budapest
2.5.	Tehran- (truck) -Poti- (Ferryboat) -Constanta- (Ferryboat) -Budapest
2.5.a	Tehran- (Railway) -Poti- (Ferryboat) -Constanta- (Ferryboat) -Budapest
2.6.	Tehran- (truck) -Bander Anzali- (Ferryboat Sea-River) -Constanta- (Ferryboat) -Budapest
2.7.	Tehran- (truck) -Bander Anzali- (Ferryboat sea-river) -Varna- (truck) -Budapest
2.7.a	Tehran- (Railway) -Bander Anzali- (Ferryboat sea-river) -Varna- (Railway) -Budapest
2.8.	Tehran- (truck) -Bander Anzali- (Ferryboat sea-river) -Burgas- (truck) -Budapest
2.8.a	Tehran- (Railroad) -Bander Anzali- (Ferryboat Sea-river) -Burgas- (truck) -Budapest
2.9.	Tehran- (truck) -Bander Abbas- (Ferryboat) -Trieste

	<b>Intermodal transport chain</b>
2.9.a	Tehran- (Railroad) –Bander Abbas- (Ferry) -Trieste
2.10.	Tehran- (Rail / Truck) -Ankara- (Rail / Truck) -Sofia- (Rail / Truck) -Budapest

**Tab. 2.2** Results of the study of the transport chains Tehran - Budapest

	distance					Duration (hours)	cost (\$)	CO2 (kg/t·km)
	track km	rail km	Ferry (river-sea) km	Ferry nm	sum			
2.1.	1464	260	1127	611	3982	186	3330	146,21
2.1.a		1724	1127	611	3982	186	2627	109,61
2.2.	2544			611	3676	83	4105	185,73
2.2.a		2544		611	3676	83	2883	122,13
2.3.	2625			627	3786	86	4233	191,53
2.3.a	1161	1464		627	3786	86	1812	154,93
2.4.	2541			582	3619	83	4084	184,57
2.4.a		2541		582	3619	83	2864	121,04
2.5.	2541			582	3619	83	4084	184,57
2.5.a		2541		582	3619	83	2864	121,04
2.6.			4541		4541	423	4541	81,74
2.7.	1080		3234		4314	302	3161	128,40
2.7.a		1080	3234		4314	302	2697	101,40
2.8.	1161		3289		4450	310	3305	134,67
2.8.a		1161	3289		4450	310	2806	105,64
2.9.	1276			4196	9047	364	4220	222,82
2.9.a		1276		4196	9047	364	3607	190,92
2.10.	3770				3770	54	5580	245,05

The estimates applied in Table 2.2 show that the fastest is the automobile transport link. An optimal price has the chain 2.1.a Tehran- (Rail) -Poti- (Ferry) -Varna- (Railroad) -Ruse- (Ferry-boat) -Budapest, and the least harmful in emission terms is the link using the river-sea concept and the connection Caspian Sea across the Volga River, the Don, the Black Sea and the Danube River (10). The Different cargo has a different "appetite" for these criteria, and at the company level there are no mechanisms to impose the implication the most environmentally friendly options. This requires cooperation actions at regional and interregional level to establish regulatory mechanisms in this direction.

The results of Table 2.2. are processed and shown in Table 2.3 to obtain complex minimums and maximums. Thus, optimal intermodal transport chains according to the criteria value, time and amount of harmful emissions are 2.4.a Tehran- (Railway) -Poti- (Ferryboat) -Constanta- (Railroad) -Budapest and 2.5.a Tehran- (Railroad) -Poti- (Ferryboat) -Constanta- (Ferryboat) -Budapest. The 2.2.a Tehran- (Railroad) -Poti- (Ferryboat) -Varna- (Railroad) -Budapest and 2.3.a Tehran- (Rail) -Port- (Ferryboat) -Burgas- (Truck) -Budapest are just a bit behind. It follows that the ports of Varna and Bourgas must set their strategic priorities to improve their competitiveness in these areas.

**Tab. 2.3** Bringing the results of the study of the Tehran-Budapest transport chains to choosing the optimal option

Ranking	CO <sub>2</sub>	Cost (\$)	Duration (hours)	
6,503	1,789	1,268	3,446	2.1
5,787	1,341	1,000	3,446	2.1a
5,372	2,272	1,563	1,537	2.2
4,129	1,494	1,098	1,537	2.2a
5,552	2,343	1,612	1,597	2.3
4,183	1,185	0,069	1,597	2.3a
5,341	2,258	1,555	1,528	2.4
4,099	1,481	1,090	1,528	2.4a
5,341	2,258	1,555	1,528	2.5
4,099	1,481	1,090	1,528	2.5a
10,554	1,000	1,729	7,825	2.6
8,361	1,571	1,203	5,586	2.7
7,854	1,241	1,027	5,586	2.7a
8,664	1,648	1,258	5,741	2.8
8,101	1,292	1,068	5,741	2.8a
11,067	2,726	1,606	6,735	2.9
10,444	2,336	1,373	6,735	2.9a
6,122	2,998	2,124	1,000	2.10

At a national level, a source of competitive advantage may be the continuous improvement of administrative services and the reduction of bureaucratic procedures. To some extent, this can be solved by deepening multimodality in freight, where mergers and acquisitions will not only

result in economies of scale but also in the use of complex optimization models at a company level. Last but not least, there is the investment potential of the large international logistics companies. Thus, the dynamic development approach enables investment in highly efficient innovative methods and tools for handling and transporting cargo.

### **Conclusions**

Planning of intermodal transport chains cannot be achieved as a result of unambiguous optimization criteria, as it is based on a multi-criterion management approach that often compromises or counts some quality criteria.

A central element of the logistics corridor Central Asia - Central Europe is the development of SSS in the Black Sea. It is a highly effective link between Europe's and Asia's transport systems of increasing importance in the context of evolving integration processes. Its role will also increase with increasing environmental requirements to the transport system.

The demand for optimal transport solutions will drive businesses into mergers and acquisitions in the transport sector, which will provide financial opportunities for infrastructure modernization and the implementation of innovative means and methods for handling and transporting freight.

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# **PROTECTION METHODS TO COMBAT THE CORROSION OF STEEL PILINGS - CASE STUDY OF HAI PHONG PORT IN HAI PHONG CITY, VIET NAM**

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**Abstract:** Since steel piling firstly used in 1908 at Black Rock Harbour (USA), nowadays its variety of sizes and shapes has been applied widely and more popular especially in marine constructions such as piers, jetties, wharves, embankments, breakwaters, offshore drilling platforms, etc. Although there are a lot of advantages to use steel piling in constructions, the biggest issues needs to be solved to effectively protect them in the high corrosive environment like sea water.

Hai Phong old port, which is located just outside Hai Phong downtown, was built by steel piling since 1960s. The port has been playing an important role as a main gate of the North of Viet Nam for a long time. As over 50 years of operation, its steel piling wall has been degraded caused by the corrosion.

Presently, there are various kinds of protection methods to combat corrosion of steel piling sheet including three (03) main groups as the encasement of steel in concrete (referred to as "concrete jacket"), the protective coatings and cathodic protection (abbreviated to as "CP") . As the corrosion causes, the suitable solutions will be selected and applied. The paper discusses about the cathodic protection as the most appropriate supplementing protection method for Hai Phong old port.

**Keywords:** Hai Phong port; Steel piling; Marine structure; Corrosion protection; Cathodic protection.

## **1. Introduction**

### **1.1. Information**

Hai Phong old port has the berth length 1,717 m. As the initially designed capacity, the port could receive vessels with the tonnage up to 10,000 DWT. As the rapid socio - economics development of Hai Phong City and the Northern economic region as well, the Hai Phong

present port is extended year by year toward ocean with the deeper water area for cargo shipping. And the old port is planned to convert to passenger terminal.

The port is the one of earliest marine construction used the steel piling sheets. To combat the corrosion, the current applied corrosion protection methods are encasing the steel piles in concrete and the combined protective coatings. The encasing concrete jacket used as the heading beam is both to combat corrosion in the fluctuating water and the berthing place. The concrete jacket is produced by the fresh concrete grade 300. The top of beam is at the height 4.05 m and the bottom at the height +0.40 m.

As over 50 years of operation, the steel piling system of the old port has been degraded caused by the corrosion. At present, the average thickness of steel sheet is approximately 18.50 mm, reduced 2.50 mm as compared with the initial design; the corrosion rate is 0.06 mm per year. In order to ensure the good working condition of the port and its durability, it's so necessary to have the more effective protection methods other than the old to combat the corrosion of the marine structure in the seawater.



**Figure 1.** The plan of Hai Phong old port including 11 berths

**1.2. Situation [1]**

The port has totally 11 berth segments. The survey and evaluation are made for the berths No. 7 and No. 8 with the data of the larsen V steel thickness in the following table:

**Table 1:** Survey data of the larsen V steel thickness of Hai Phong port

No.	Berth	Year (Built-Survey)	Duration of operation	Corrosion rate (mm/year)	Thickness of steel piling sheet corroded (mm)	Thick steel piling left (mm)
1	Number 7	1973 - 2015	42	0.062	2.108	18.892

2	Number 8	1973 - 2015	42	0.062	2.046	18.954
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Over time, the key wall system of Haiphong main port by Larsen V steel piling sheet would be corroded more and more and the corrosion rate has increased. This problem may cause to reduce of bearing capacity and lifetime of the port. Thus, solutions should apply corrosion protection methods soon to protect the old system and other parts of the steel piers under Hai Phong main port.

## **2. Corrosion protection methods**

The current applied corrosion protection methods can be divided into three main groups including the application of various protective coatings, the encasement of steel in concrete and cathodic protection. Actually, the various combinations of 03 mentioned methods could be considered to enhance the effectiveness of corrosion combat. The following paragraphs shall discuss on the advantages, disadvantages and the application scope of each method in order to propose the most suitable one for corrosion protection.

### **2.1. Protective Coatings**

Protective coatings on steel piling are intended to act as a barrier to separate the steel surface from its corrosive environment. The development of suitable coatings for long-term protection of steel in seawater has been quite slow. There are numerous types of coatings now in existence, many of which are used in combination with other types as well as alone. Types of coatings in use today may be divided into a number of categories. The most common categories are metallic and nonmetallic.

*The protective coating method has the following main advantages:*

- Simple, low cost, popular and diversified materials;
- The fabrication process can be made in the factory, so it is convenient to apply the industrialization process and time saving.

*However, this protection method owns outstanding disadvantages to marine constructions as follows:*

- Its application to the steel components submerged in water or soil or tidal areas is so hard especially in maintenance and repair;
- Easily getting damage during the construction process, especially in the high friction between the steel components and the environment such as soil, mud, etc.
- Short maintenance period and strongly influenced by the hot and humid weather condition in Viet Nam;

- Low protection efficiency; not suitable for large-scale steel structures, constructions in the high corrosive environment like marine constructions (Eg. seaports, dykes, dam, etc.).

The corrosion protection method by the protective coatings has the mostly wide application scope in the steel structures but it's unfeasible to be used for the steel marine construction lonely. However, it may be combined with other protection methods to improve the effectiveness of corrosion combat.

## **2.2. Concrete jackets [2]**

The method sometimes used for the steel marine structures from corrosion is to encase or jacket the steel in concrete. In order to ensure the effective protection, the concrete must be good in quality, properly placed and cured, and adequate thickness as well.

Concrete jacketing of steel piling has proven very effective when it extends from the top of the piling to under low water level to be the compatible berthing beam. Though this protection method has been used early, but it only gets much the effective protection to steeling encased directly by concrete. Its effective range in the corrosion protection is quite narrow and almost impossible apply to whole steel structures. Besides, the concrete encasement method can significantly increase the unwanted load to the construction. The ability of preventing collision is its weakness and the flexibility in exploitation, maintenance and replacement is not good as well. Its construction process is also complex, costly, long and requiring the auxiliaries and sub-constructions. And it may affect the exploitation conditions of the flow in the marine constructions.

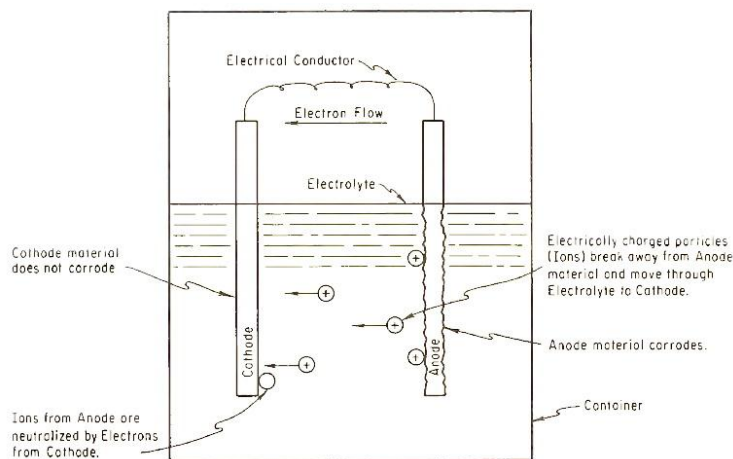
## **2.3. Cathodic protection [4]**

Cathodic protection is another method of mitigating the corrosion of steel piling in seawater. This method is suitable for protecting the immersed zone of the piling. Corrosion of steel is an electrochemical process which takes place in a corrosion cell. Electrodes of corrosion cells are either cathodic or anodic. The electric current leaves the metal surface at the anode and travels through the electrolyte to the cathode by ion transfer. Corrosion of the metal occurs at the anode where the electric current leaves the metal.

The anodic metal corrodes as current flows to the cathode. The principle is illustrated in Figure 2. In the electrolytic system, direct current electricity of sufficient magnitude is supplied by an outside source. The source is usually a rectifier, which converts alternating current electricity to direct current which flows from one or more anodes through the electrolyte to the metal being protected.

Actually, the cathodic protection (CP) is divided to two types including the galvanic anode CP systems and the impressed current CP system. For galvanic anode CP systems, the anode

of the electrochemical cell is a casting of an electrochemically active alloy (normally aluminium, zinc or magnesium based). This anode is also the current source for the CP system and will be consumed. Accordingly, it is often referred to as a sacrificial anode. For the impressed current CP system, an inert (non-consuming) anode is used and the current is supplied by a rectifier.



**Figure 2.** Principle of Galvanic Corrosion Cell [2]

For permanently installed offshore structures, galvanic anodes are usually preferred. The design is simple, the system is mechanically robust and no external current source is needed. In addition, inspection and maintenance during operation can largely be limited to periodic visual inspection of anode consumption and measuring the potential using the reference electrode. However, due to weight and drag forces caused by galvanic anodes, impressed current CP systems are sometimes chosen for permanently installed floating structures.

The cathodic protection is applicable for all types of metals and alloys commonly used for subsea applications. It prevents local corrosion forms as well as uniform corrosion attack, and eliminates the possibility for galvanic corrosion when metallic materials with different electrochemical characteristics are combined. This method is primarily intended for metal surfaces permanently exposed to seawater or marine sediments. Still, it is often fully effective in preventing any severe corrosion.

In order to comprehensively enhance and improve the corrosion protection effectiveness for the marine steel structure, the cathodic protection can be combined with the protective coatings and the concrete jackets to reduce the area requiring protection also.

#### **2.4. Proposed corrosion protection method**

The Hai Phong old port has been exploited for a long time, and the corrosion of steel piling wall has appeared with the rate faster and faster overtime. Besides, the port also applied the corrosion protection methods as the protective coatings and the concrete jackets, so it is currently impossible to reuse these methods. It is necessary to apply the other effective method

to reduce the corrosion rate and ensure the operation conditions. The cathodic protection using sacrificial anode system is recommended and proposed to use for the Hai Phong old port because its simplicity and efficiency. Also, it is most suitable for marine structure.

### **3. The tentative application of the cathodic protection using galvanic anodes for Hai Phong old port**

The application is made for the berths No.7 and No. 8 with the technical specifications [1] as follows:

- The length of each berth: 163.6 m;
- The top altitude: +4.50 m (following the sea chart measure);
- The bottom altitude: -8.70 m.
- The designing altitude of the high water level: +3.5 m;
- The designing altitude of the low water level: +0.6 m.

The structure is the steel piling soft wall by V Larsen steel piles which have the length of 22 m. Their bottom altitude is -20.0 m and the top is +2.0 m. The part of steel pile under sea-water has been coated by two layers of ground-coat paint and anticorrosive paint.

In order to combat the corrosion of the steel piling sheet, the reinforced concrete M300 has been applied from the altitude +4.50 to +0.40 to be compatibly used as the berthing place.

The corrosion protection method applied for the steel piling wall to lengthen lifetime and ensure the operation condition of is the galvanic anode CP system. Before calculating and designing the galvanic anode system, the input data need to be determined including:

- Specifications of steel piling sheet;
- Requirement for the corrosion protection system meaning the lifetime of sacrificial anodes;
- Specification of combining protective coatings;
- Natural conditions;
- Sea-water at the construction place, etc.

The galvanic anode CP system is calculated and designed in the following procedures [3]:

#### **3.1. Surface area calculations needed to be protected**

The surface areas require CP shall be calculated separately for surfaces which influence the CP current demand. For the larsen steel piling sheet, the surface is determined by the following formula:

$$A_c = L * H_c * f \quad (1)$$

*In which:*

$A_c$ : the surface area need to be protected ( $m^2$ );

$L$ : overall length of steel pile (m);

$H_c$ : the height of the piles in the CP range (m)

$$H_c = H_{c, \text{water}} + H_{c, \text{soil}}$$

$H_{c, \text{water}}$  = (Height of pile head - Height of mud bottom);

$H_{c, \text{soil}}$  = (Height of mud bottom - Height of pile bottom);

$f$ : The extension coefficient of steel piles ( $f = 1.9$ ).

### 3.2. Current demand calculation

The current demand  $I_c$  (A) is calculated by the formula:

$$I_c = A_c * i_c * f_c \quad (2)$$

*In which:*

$A_c$ : the surface area need to be protected ( $m^2$ );

$i_c$ : the required current intensity ( $A/m^2$ );

$f_c$ : the coefficient of paint peeling is calculated as follows:

$$f_c = a + b * t \quad (3)$$

$a, b$ : constants depending on the characteristics of the paint and the environment

$t$ : usage time (determined each years)

### 3.3. Anode Mass Calculations

The total net anode mass,  $M$  (kg), required to maintain cathodic protection throughout the design life,  $t_f$  (yrs), is to be calculated from  $I_{cm}$  (A) for each unit of the protection object (including any current drain):

$$M = \frac{I_{cm} * t * 8760}{u * \varepsilon} \quad (4)$$

In (3.4), 8760 refers to hours per year;  $u$  - coefficient of using anode ( $u = 0.9$ );  $\varepsilon$  - Electrochemical capacitance of material ( $\varepsilon = 2500$  Ah/kg in seawater).

### 3.4. Calculation of number of anodes

From the anode type selected and the number of anodes, anode dimensions and anode net mass shall be defined to meet the requirements for:

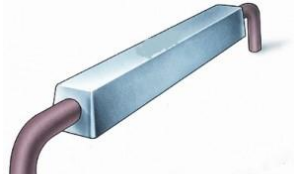
- Initial/final current output,  $I_{ci}/ I_{cf}$  (A);
- Anode current capacity  $C_a$  (Ah)

which relate to the CP current demand,  $I_c$  (A), of the protection object.





a) Cylinder



b) Trapezoid



c) Semi-annular

**Figure 3.** Common types of sacrificial anodes

The types of cylinder and semi-annular shapes are suitable for steel pipe structures. Trapezoid is preferred to use for other steel surface. For the V larsen steel piles of Hai Phong port, the trapezoid type of the galvanic anode CP system (Long Slender Stand-Off type) is selected to use.

### 3.5. Calculation of suitability of sacrificial anode

The current capacity of each anode is calculated by the following formula:

$$I_a = \frac{E_c^o - E_a^o}{R_a} \quad (5)$$

Where as:

$E_c^o$ : the design protective potential;

$E_a^o$ : the design closed circuit potential of the anode material.

The Anode resistance is determined by the selected anode type. For an anode of the Long Slender Stand-Off type, the resistance of the anode is calculated according to the formula (DNV B401 standard):

$$R_a = \frac{\rho}{2 * \pi * L} \left( \ln \frac{4L}{R} - 1 \right) \quad (6)$$

Where as:

$\rho$ : sea water resistivity 0.23 ( $\Omega\text{m}$ );

L: length of anode (m);

R: Radius of anode (m) for round anode;

$R = C/2\pi$  for anodized rounded anodes (C is the anode cross sectional area).

The beginning current ( $I_{ai}$ ) and the end ( $I_{af}$ ) of each anode shall be determined by (5) and (6).

When the sacrificial anode has dissolved to the effective coefficient, the remaining volume of the anode at the last moment is calculated as follows:

$$m_{af} = m_{ai} * (1-u) \quad (7)$$

The length of anode at the last moment ( $L_f$ ):

$$L_f = L_i - 0.1 * u * L_i \quad (8)$$

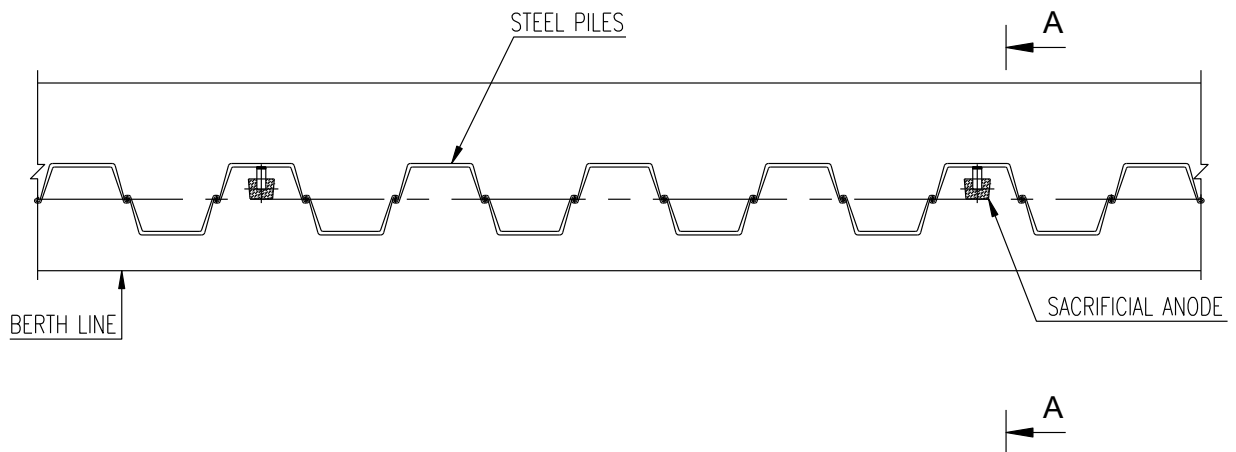
The last radius of the anode:

$$r_{final} = \sqrt{\frac{m_{ai}(1-u)}{\pi * density * L_f} + r_{core}^2} \quad (9)$$

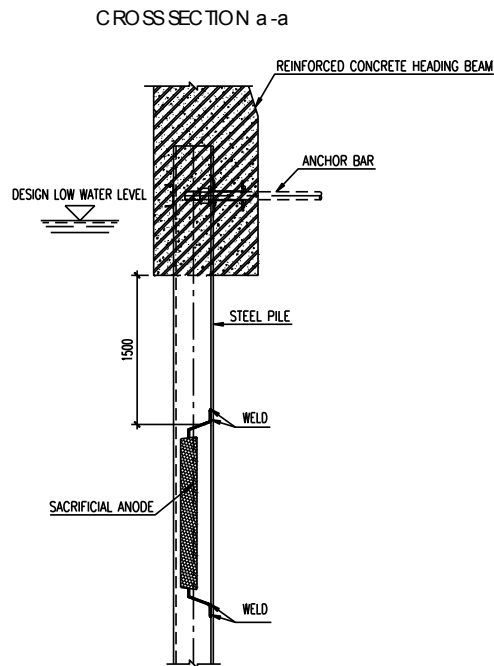
In the case the results of the anode currents at the beginning and the end are greater than the required protective currents on the steel piles:  $I_{ai} > I_{ci}$  and  $I_{af} > I_{cf}$ , this asserts shape, size and volume of the anode meets the requirement for the protective current for the building up to 90% of its design life time.

### 3.6. The installation of sacrificial anode

- The distance of installation is from the lowest water level to the upper point of the anode;
- The anode spacing can fluctuate within  $\pm 1$  m;
- Visual inspection to remove or repair damage during transportation prior to installation;
- Welding anode directly to the steel pile, the weld should be checked to ensure the weld characteristics according to the specified standards.



**Figure 4.** Arrangement of sacrificial anodes in the plan



**Figure 5.** Installation of sacrificial anodes in the cross section

#### 4. Conclusion

As the long-time operation of Hai Phong port, the steel piling system has been corroded with the faster rate over time though it has been protected by the concrete jacket and the protective coatings. As discussed above, the protective coatings are so restricted to the steel components submerged in soil, water and tidal areas. And it's easily damaged in the construction process when the high friction between steel and environment (such as soil, mud) appears. Its application to the marine construction which requires the high protection efficiency can be only the supplement to the overall protection. The concrete jackets may provide the higher local protection, but it is only effective to the directly encased components by concrete and unfeasible to be used for whole construction. Moreover, the major failures can appear when collisions occur. Though these two protection methods are lower cost and simpler, they are unsuitable and difficult to the in-service marine constructions by their limited range protection.

By discussing and analyzing three corrosion protection methods above, the cathodic protection is proposed as the most effective and active corrosion combat for marine structures especially the in-service construction such as Hai Phong port. For case study of Hai Phong port, the galvanic anode CP system using the Long Slender Stand-Off type with the trapezoid cross is recommended by the addressed outstanding advantages including the high protection efficiency, the good corrosion control and the flexibility in maintenance and operation as well. This method is proposed and designed for significantly enhancing and improving its lifetime and durability of the Hai Phong port system.

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# CONDITION MONITORING FOR AUTOMATED FERRIES

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**Abstract** Automated ferries can be considered as an important step along the road to autonomous vessels. With the currently available technologies, ferries can easily be automated to perform predefined journeys. This means that it can be retro-fitted to many existing ferries around the world, creating significant scope for the future roll out of the concept. The shift from having a crew on board to having land-based technicians/operators observing and/or controlling the ferry remotely will no doubt revolutionize the ferry industry. Even though the idea is promising the major challenge is to make the operation reliable and safe.

This paper aims at investigating the important of continuous monitoring of the conditions of key elements to achieve high reliability in future automated ferries. The full paper will identify key elements in an automated ferry such as propulsion system and power generation system and lists the parameters that should be monitored in these systems to assess their condition. Moreover, algorithms that can be used to assess the health of individual subsystems, and development of a reliability centered maintenance program for the ferry will be discussed.

**Keywords:** condition monitoring, autonomous, ferries, vessels, technologies

## Introduction

During the last decade autonomous ships was just an idea and was considered almost impossible. In fact, the actual idea of a ship without crew is not new, though. To some extent, the idea of crewless ships is the phase of a process that has been going on ever since humans put the first boat in the water. As technology has advanced, ship builders have gradually

replaced crew members with mechanical parts(Andrews, 2016). Two years ago talk of intelligent ships was considered a fantasy. Today, the prospect of a remote controlled ship in commercial use by the end of the decade is a reality.

The technology of an autonomous and unmanned ship has been a subject of lively discussion in recent journals, conferences and seminars on development of marine technology.

An autonomous ship is a sea going surface vessel which is capable of operating without any crew on board. Although things are still at the research and development stage, but Rolls-Royce anticipate the first commercial vessel to navigate entirely by itself to carry the cars at a short distance. The Advanced Autonomous Waterborne Applications (AAWA) Initiative is a €6.6 million project funded by Tekes (Finnish Funding Agency for Technology and Innovation) aims to produce the specification and preliminary designs for the next generation of advanced ship solutions. It brings together universities, ship designers, equipment manufacturers, and classification societies to explore the economic, social, legal, regulatory and technological factors, which need to be addressed to make autonomous ships a reality. The project will run until the end of 2017 and will pave the way for solutions designed to validate the project's research.

### **Technologies for Autonomous Vessels**

The development of crewless vehicle in sea has seen with great progress during the last 10 years. This has been enabled by advances in technologies, which enables perception of the surrounding environment, path planning and vehicle control in real time. With a combination of an array of advanced sensor technologies becoming available also beyond earlier military and scientific use and rapidly increasing data processing performance, we have reached a technological level on which full vehicular autonomy is indeed feasible. Research on autonomous cars offers the most extensive source of publicly available information on technologies developed for autonomous vehicles.

The key aspect to successful vehicular autonomy is reliability and safety. Despite all of the recent technological advances, conclusive demonstrations of sufficiently reliable autonomous car navigation in varying real-world conditions have not been presented. The available technologies that can be applied for ship autonomy and the remaining challenges ahead to reach required technological readiness for a proof of concept demonstrator by the year 2017.

Although, these ships where crew work hard, now have been converting into the concept of autonomous vessels means crewless ships. By coming of this advanced concept, technologists do their serious effort to less the work hard of seamen. Moreover ship builders have gradually replaced crew members with mechanical parts, hence autonomous ferry is the stepping stone towards autonomous ships and the aim of this paper is to investigate the importance of condition monitoring to achieve required reliability.

### **1. Autonomous navigation of the vessel**

Collision-free motion techniques can be divided into either global methods, based on path planning using a priori information, or local methods which are based on reactive navigation using sensory information (Campbell, Naeem, & Irwin, 2012; Pietrzykowski & Uriasz, 2009; Statheros, Howells, & McDonald-Maier, 2008; Tam, Bucknall, & Greig, 2009). Planning a collision free path for an autonomous machine through an environment containing static or moving obstacles, in this case a vessel moving in both harbor area and open sea, is a problem that has been extensively studied during the past decades. Different systems require different planning strategies.

Two of the most common path planning approaches are graph based and sampling based approaches. Graph based approaches and their numerous variants have been the most studied algorithms for optimal path planning problems. The main advantage of sampling based approaches, such as probabilistic road map (PRM) and rapidly exploring random tree (RRT) and their variants, is the ability to easily include dynamic and kinematic constraints of the vehicle. For reactive obstacle avoidance, these optimal path planning approaches may not be efficient enough. Therefore, algorithms such as velocity obstacles are commonly used (Campbell et al., 2012; Statheros et al., 2008; Tam et al., 2009).

In AAWA, a solution for the integration of a complete autonomous ship navigation architecture is being developed, which takes advantage of a Rolls-Royce Dynamic Positioning (DP) system developed for future autonomous ships and links it with an Automatic Navigation System (ANS), including Situational Awareness (SA), Collision Avoidance (CA), Route Planning (RP), and Ship State Definition (SSD) modules developed in the AAWA project.

Map information is used in for path planning, obstacle avoidance, and localization of the autonomous ship. On sea and harbour area, it is possible to use nautical and terrain charts to

obtain information about shipping lanes, shoals and coastal terrain. Dynamic obstacles, such as other vessels, are mapped by using the ship's situational awareness system, combined with e.g. AIS data. Many methods have been developed for processing perception data for modelling and representing a 2D or 3D world, to mention for example occupancy grid maps, height grid and Quadtree type of maps (Mooney).

Two of the most common approaches for presenting the world are topological and metric maps. Topological approaches describe the connectivity of spatial locations in the environment, whereas metric maps describe the world through a geometric presentation. Topological maps are best suited for high-level path and mission planning. Metric maps contain geometric information that is necessary to plan and execute trajectories safely while avoiding collisions. The mapping process creates a representation of the surrounding world (Brotten, MacKay, & Collier, 2012).

## **2. Situational Awareness (SA) for autonomous ships**

The main task of sensor fusion is to combine the data from different sensor source in such a way that optimal SA perception is guaranteed under all conditions and in all situations. SA data is then used to map local obstacles to enable reactive collision avoidance.

There are some important sensor technologies for Situational Awareness:

Cameras are a natural choice for SA. They are cheap, small in size and durable, and can provide very high spatial resolution with colour information for object identification. True night-vision is possible with thermal IR imagers and a pair of cameras can be used in a stereoscopic configuration for 3D sensing. Due to the huge range of both commercial and niche applications, camera technology is still constantly improving. The large existing knowledge-base on visual analysis algorithms provides many potential solutions also for marine Situational Awareness. In maritime application the use of radar has a long history. Therefore, several radar system suppliers can be found in the market for obstacle detection and mapping. Radar capability is influenced by the operating frequency band of the radar, so that typically higher frequencies offer better angle and range resolution. There is a wide variety of radars in the market, intended for different purposes, having specific carrier frequencies, bandwidths, transmit durations, waveforms, antennas etc. Typically, marine radars are microwave radars using S or X-bands, which are robust in different weather conditions (Heuel, 2013). However, the resolution of traditional marine radar may not be sufficient for reactive collision avoidance.



### **3. Off-ship communication**

The capability for remote human interaction and control has to be enabled for situations, which the ship autonomy cannot resolve or is not allowed to handle by itself. Relaying the SA information gathered by the ship's sensors to a remote operator may require the transfer of significant amounts of data. Due to practical limitations on e.g. satellite communications at open sea, the same amount of bandwidth may not be available at all times. Methods for reducing the amount of sensor data only to what is absolutely needed for the human operator to perceive the environment of the ship needs to be considered. Also issues such as data security (intentional tampering) and link reliability should be addressed and the possibilities of using multiple alternative communication networks (satellite, VHF, 4G) depending on availability and performance needs should be examined.

Possible effects of weather or multi-user congestion on communication performance should be considered carefully when implementing the control and intelligence of the whole autonomy system through the Virtual Captain. Difficult situations may arise if poor weather simultaneously causes reduction of SA system capability, requiring more shore control intervention or decision making, and a reduction in datalink capability required to transfer sensor data from the ship. Correct behaviors and precautions for such situations should be defined.

#### **Why we need condition monitoring**

The purpose of condition monitoring is to give better understanding of problems such as alarm and shut downs and to provide procedures of trouble shooting and problem investigation.

#### **What is Conditioned Monitoring of autonomous Vessels?**

Cyber influx provides enormous opportunities for maximizing the performance and efficiency of a product. Due to this it becomes easier to assess appropriateness level of large vessels. Conditioned monitoring of a vessel involves careful observation and maintenance of vessel's equipment's like testing of acoustic emission, vibration monitoring and oil and temperature analysis. Conditioned monitoring is vital for predictive maintenance so that necessary steps could be taken to prevent from major failure by early detection of possible threats.

This report will take a closer look at the available technologies that can be applied for ship autonomy and the remaining challenges ahead to reach required technological readiness for a proof-of-concept demonstrator by the year 2017.

### **Methods Used For Conditioned Monitoring Of Crewless Vessels**

There are two main methods used for condition monitoring, and these are trend monitoring and condition checking. Trend monitoring is the continuous or regular measurement and interpretation of data, collected during machine operation, to indicate variations in the condition of the machine or its components, in the interests of safe and economical operation. This involves the selection of some suitable and measurable indication of machine or component deterioration, and the study of the trend in this measurement with running time to indicate when deterioration is exceeding a critical rate. The principle involved which shows the way in which such trend monitoring can give a lead time before the deterioration reaches a level at which the machine would have to be shut down. This lead time is one of the main advantages of using trend monitoring rather than simple alarms or automatic shutdown devices (Neale & Woodley, 1975).

Condition inspection is where a check estimation is taken with the machine running, utilizing some suitable indicator and this is then utilized as a measure of the machine condition around that period. To make it effective measurements must be precise and quantifiable, and there must be known limiting figures which must not be exceeded for more than a specific number of further allowable running hours. To get these limiting figures, it requires a big amount of recorded past data for the specific type of machine, therefore this strategy is less flexible than the trend monitoring, especially if it is required to give lead time as well as machine information. It can be especially valuable, be that as it may, in a circumstance where there are numerous similar machineries working together as in this case comparative checking can be possible between the machine which is observed, and other similar machineries which are new or in great condition (Neale & Woodley, 1975).

### **Advantages of Conditioned Monitoring in autonomous Vessels**

1) Condition monitoring allows engineers to anticipate a potential failure and take action. Let's say a certain piece of equipment usually vibrates at a given frequency. If that frequency starts to vary, or changes substantially, it could mean something inside the machine is starting to fail or needs to be replaced.

- 2) Ships are dangerous workplaces, so there is good reason to remove human crews as much as possible.
- 3) Ships are also good candidates for automation because they are slow moving (especially compared to aircraft) so longer voyages are tiring and exhausting for humans.
- 4) Condition monitoring helps cost saving, time, and resources. While there is cost involved with monitoring, it is usually minimal compared to the downtime associated with doing maintenance too often or making unexpected repairs.

### What people have done so far in condition monitoring?

The autonomous ship including the computer equipment that controls the operation of the ship are designed and constructed by a human being. The software, i.e. the behavior of the system in different operational situations, is also designed by a human being. It is obvious that the human element is involved in every single act of the autonomous ship, even though it is unmanned. In case of an unmanned ship, the total size of software package is massive and the structure of this package is amazingly complex. It is divided into subsystems and minor entities inside a huge amount of several devices communicating with each other. Potentially there can be one or more software bugs caused by a human error in every single piece of the large system. The process of developing and testing the control software for the autonomous ship is therefore extremely critical. What kind of errors could the software engineers make? The development of a real-time software system is a complicated iterative process consisting of different phases, such as requirement definition and analysis, planning of data structures and operation algorithms, planning of data transmission, designing the structure of the software, defining the scheduling and priorities of the tasks, designing the self-diagnostics and the algorithms for exceptional situations, coding the modules, testing on the module level, integration, testing on the system level etc.

It is beyond the scope of this paper to discuss the methods of creating good software for critical systems. There are hundreds of books and papers written on this topic and many international standards published to support the development of safety-critical systems. Human potentially can make huge errors, even a simple error can lead to a total failure of software such as typing errors during the coding phase. A bit more irritating errors result from poor interface design and unpractical operating algorithms but the good thing about this kind of software errors is that they are obvious and can be easily corrected. Mature software does not contain this kind of error. Since the software not suffer from aging effect that is the

amount of error will not increase with age, so we can use these software for many decades. The most difficult and dangerous software errors are those that are connected with abnormal situations and algorithms in exceptional circumstances. Many maritime accidents have resulted from a poorly designed algorithm leading to an unexpected and dangerous operation under exceptional circumstances. Nobody knew before hand how the system would behave in such situation. Some accidents of this type are analysed in Ahvenjarvi (Ahvenjarvi, 2002). The problem of this kind of software design errors is that they are very difficult to reveal beforehand. It may happen that the exceptional situation was not anticipated by the group of experts who wrote the requirement definition for the software.

### **Future trends and Challenges**

How can an autonomous vessel be made at least as safe as existing ships, what new risks will it face and how can they be mitigated

### **Concluding remarks**

Introduction of the autonomous ship does not mean that there is no more a human element involved in the navigation process. However this paper depend on the report of condition monitoring. The information extricated from it will demonstrate the technical and economic importance of condition monitoring. This paper will develop an interest of Ship builder and operators to change conventional monitoring system to condition monitoring system.

The outcome Phase II will be the technical, legal and safety specifications for a full model and it will be demonstrate before the end of this year. The revolution has begun and an autonomous commercial ships will be use by the end of the decade.

### **Acknowledgement**

I would like to thank my research coordinators Shantha Jayasinghe and Mohan Anantharaman for their contribution for this research. The completion of this research is a direct result of their efforts and devotion of their precious time precious time. I would also like to pay thanks to my University of Tasmania for my professional development as a marine researcher.

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# BUILDING MARITIME DATA HUB BY USING THE ARDUINO IoT PLATFORM

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**Abstract:** The study of marine resources, the status of water bodies and others is directly related to the measurement of a large number of parameters and further processed individually or as dependent on each other. Failing due to objective reasons / lack of power, lack of sufficient computing resources, excessive appreciation in the presence of expertise in place, the need to obtain data from several points split in space and sometimes in time / to perform data processing in the place of collection is implemented different platforms that have several types of sensors. This requires the use of a single system for data collection and consolidation and unified message for transmission to the expert control system.

With the integration of data from different types of sensors must be considered interfaces and standards used in equipment platform to collect data and in accordance with world standards in the production of electronic equipment for the marine industry is seen dominance of standard NMEA 0183 -HS and NMEA 2000 communication of these sensors and the system for collecting information.

In some cases used sensors are not realized by providing output NMEA standard, which requires a transformative device that interface to NMEA. This approach allows for the implementation of each sensor network used in shipping than one side. On the other allows for the realization of a system for collecting and processing data, which have unification of input interfaces to reduce the cost and scalability.

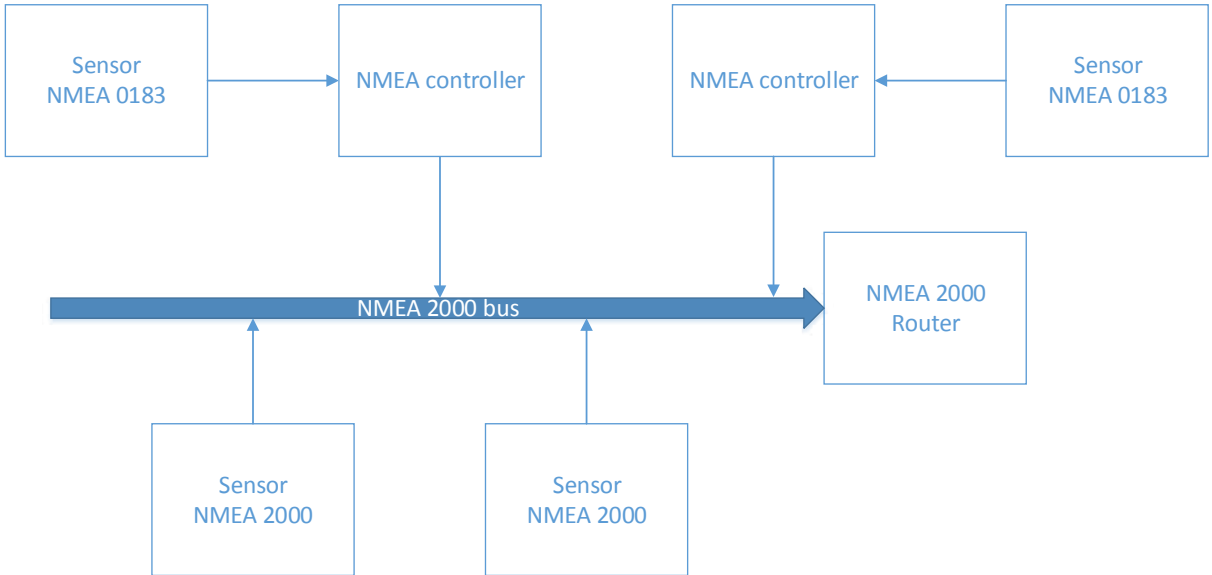
For transformation of the interface need a device with the ability to customize the algorithm of conversion depending on the input data, such as configuration must allow dynamic change in the course of work. Most suitable for this purpose is a module based on a microprocessor that supports current market sensor interface and sufficient processing power to perform the conversion without added lag.

The proposed solution gives flexibility when working with different types of sensors, as well as the ability to process only the software package for compatibility with the different NMEA standards. Expansion of the set of sensors combined with the ability to use the created hub for all available and incoming protocols, as well as the ability to operate independently, as a system for collecting, processing, storing and transmitting received data shows the adequacy of the use of modern Arduino platforms.

**Keywords:** NMEA, sensor data processing, unify data message, IoT, Arduino

**Introduction**

The study of marine resources, the status of water bodies and others is directly related to the measurement of a large number of parameters and further processed individually or as dependent on each other. Failing due to objective reasons / lack of power, lack of sufficient computing resources, excessive appreciation in the presence of expertise in place, the need to obtain data from several points split in space and sometimes in time / to perform data processing in the place of collection is implemented different platforms that have several types of sensors. This requires the use of a single system for data collection and consolidation and unified message for transmission to the expert control system (Tsvetkov, 2013).

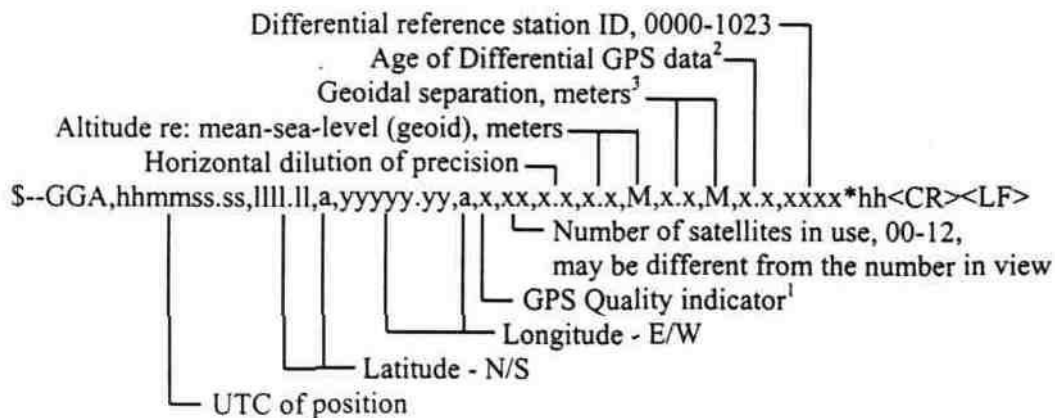


**Figure 1** NMEA 2000 sensor network

With the integration of data from different types of sensors must be considered interfaces and standards used in equipment platform to collect data and in accordance with world standards in the production of electronic equipment for the marine industry is seen dominance of

standard NMEA 0183 -HS and NMEA 2000 communication of these sensors and the system for collecting information (NMEA, 2008) (Association, 2008).

The NMEA 2000 standard implements a network of sensors communicating over a common bus and router to the control system or NMEA 0183 by using transient converters and re-switching to the joint network (Figure 1) (NMEA, 2008) (Association, 2008)).



**Figure 2** NMEA GGA message

The NMEA standard also provides for a special mode of transmission of information in a formalized message for each type of data from different sensors. For example, over 10 different messages are available for the GPS receiver, which starting with the NMEA standard "\$" and using ASCII characters, such as the Global Positioning System Fix Data (GGA) (Figure 2) (Luft, et al., 2002) (NMEA, 2008) (Tsvetkov, 2013) (Tsvetkov, M., Nikolov, Zh., 2013).

The unification of the output data allows for the implementation of a network of sensors from different manufacturers (Dimitrov, 2015) and adding additional sensors at the only requirement to satisfy the hardware parameters and standards for the transmission of messages.

### Methods and results

In some cases, the used sensors are not implemented with a NMEA standard output that requires a device that converts the specified interface to the NMEA. Through this approach, it is possible to introduce each sensor in a network used in shipping on the one hand. On the other hand, it is possible to implement a system for data collection and processing, in which there is uniformity of the input interfaces in order to reduce the cost and scalability.



For transformation of the interface need a device with the ability to customize the algorithm of conversion depending on the input data, such as configuration must allow dynamic change in the workflow. The most suitable for this purpose is a microprocessor-based module supporting current market interfaces and sufficient computational power to perform the conversion without adding lag.

When converting data from the most commonly used sensors such as temperature, pressure, direction, voltage, speed, rate, position, salinity, etc. A conversion rate of between hundreds of milliseconds to a few seconds is required, depending on the rate of process change, the speed of data conversion from the sensor, and the need for up-to-date data to the control system. At operating speeds above 8 MHz (and generally over 50 MHz) in modern microcontroller systems and performing instructions within one generator stroke, the maximum data transmission time in the communications network is within one millisecond and is mainly determined of the sensor conversion rate. The latter allows for the use of a microcontroller system for data transmission from several sensors, which would reduce the financial and the logistic costs (like a consumption, repairability and installation space).

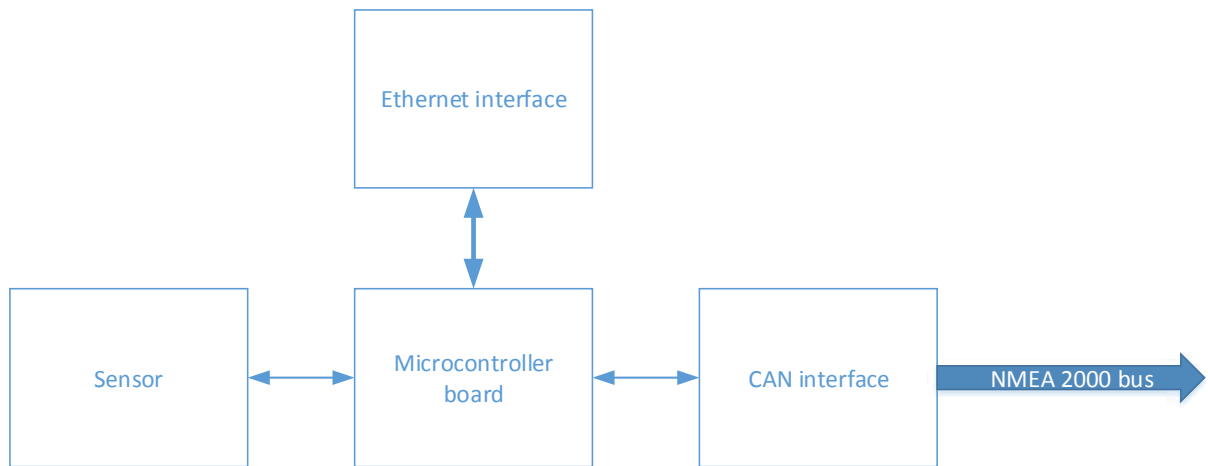
The implementation of the approach is based on the following initial requirements:

- low cost by using widely applicable microcontroller systems;
- a short time to add a new sensor;
- possibility of reconfiguring the system in the process of changing the sensor type;
- low consumption and small size;
- To have ability to scale the capabilities developed by increasing the computing and interface resources.

The system is based on a block diagram shown on Figure 3 and consisting of a sensor communicating with a given protocol (digital or analogue) with a microcontroller. It receives and processes the information by converting the input value into the corresponding NMEA standard and transmits the received message via the CAN interface NMEA network. The Ethernet interface is used to configure the reader settings from the sensor and the transmitted message to the network.

This set of requirements is fully covered by one of the leading platforms for the development of the Internet of Things - Arduino.

The platform provides a set of the most commonly used sensor interfaces - I2C, SPI, USART, USB and analog-to-digital converter, which helps to achieve low cost. The absence of an interface is compensated by the availability of a wide variety of interface boards that provide 100% coverage of currently available communication protocols with external sensors.



**Figure 3** NMEA microcontroller interface

Using the unified programming language with a wide range of library functions available and the large set of systems running under it provide the required capabilities for a short time to develop and scalable resources. The time to switch from an eight-bit, 16 MHz microcontroller to a state-of-the-art Cortex architecture, a 32-bit 160 MHz microcontroller with much larger computing resources, will take several minutes and can be done locally. Additionally, the unified standard used when making the boards may not require replacement of the whole block but only an element of it.

## Sensor configuration

Configure the sensor connected to the platform ID 375-5568-251

NMEA configuration

**Select NMEA message**

SMTW

**NMEA 2000 speed**

Sensor information

**Name:**

**Type of sensor**

Temperature

**Data type**

digital

analog

Sensor interface (only for digital)

UART

I2C

SPI

SPI

OVI

TWI

Write configuration
Clear

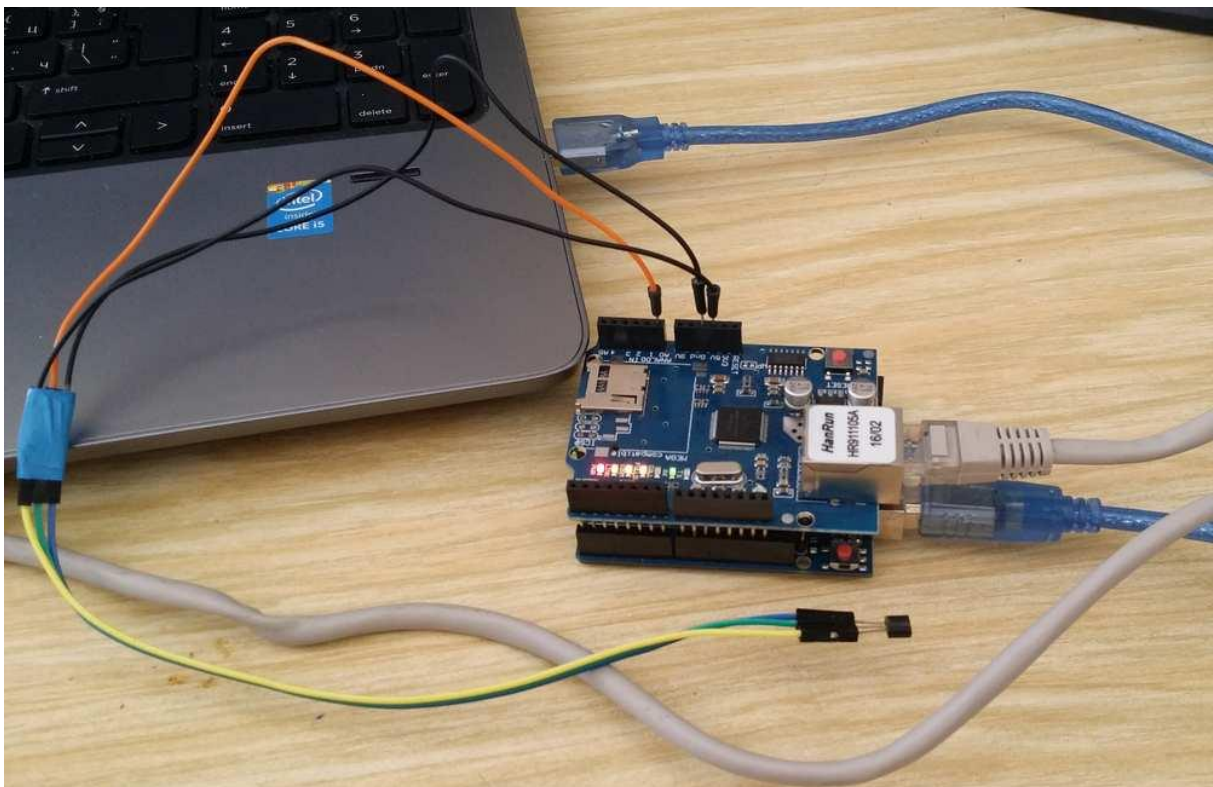
**Figure 4** Ethernet configuration page

The possibility of reconfiguration during operation is provided by an additional Ethernet interface that provides communication via a website (Figure 4). All the necessary settings are

intuitively done on the site and recorded in the microcontroller system, which changes its settings. Reconfiguration takes place in several steps:

- Selection of interface type for sensor operation;
- Interface characteristics;
- Characteristics of the NMEA message.

To verify the approach, an experimental setup has been developed using an analogue temperature sensor, the Arduino Uno platform with additional expansion boards for Ethernet interface and CAN interface (Figure 5).



**Figure 5** An experimental set-up with IoT platform

The Arduino language was used to develop the software package by real-time transformation of the data obtained from the analog sensor in the NMEA format representing the air temperature and transmitting them to the NMEA 2000 network using a message \$--MTA (Figure 6). Configuration of the converter is done through a web interface that providing adjustment of the following parameters:

- characteristics of the network interface;
- time of data transmission from the sensor;
- synchronization source;
- time and format for recording the sensor data;

- characteristics of the sensor data displayed in table and graphical form;
- features for tuning the data transmission via an Ethernet interface to an collect and processing system;
- adding additional sensors (optional);
- logic of the sensor data transmission - transmission at a certain interval or at change;
- set a time interval for transmission in each channel – NMEA200 and Ethernet.

```
$--MTA, x.x, C *hh <CR><LR>
| Temperature, degrees C
```

**Figure 6** NMEA Temperature message

In the so-constructed node provided for the conversion of data from analog sensors, transmitted to the NMEA 2000 network, data retention for a certain period, and the transmission of data in an alternate network built on Ethernet, which facilitates the integration of that approach in a new generation of OneNet NMEA networks.

## Conclusion

The construction of an intermediate system to convert data from any sensor to the NMEA 2000 standard allows the addition of a large number of inaccessible sensors. The application of widely used microcontroller systems with a large community enables the cost reduction of the device and the use of the available library functions for sensors, which in turn speeds up the process of integration of new sensors.

Next steps to develop communication protocols for data exchange in ship information systems is to switch to a network protocol that provides greater capabilities, from both data rate and communication security, longer distances and broader applications in practice. Such a protocol can be Ethernet using wired and wireless communication.

The proposed solution gives flexibility when working with different types of sensors, as well as the ability to process only the software package for compatibility with the different NMEA standards. Expansion of the set of sensors combined with the ability to use the created hub for all available and incoming protocols, as well as the ability to operate independently, as a system for collecting, processing, storing and transmitting received data shows the adequacy of the use of modern Arduino platforms.

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## PRINCIPLES OF CREATING INVARIANT STANDARDS FOR THE FUNCTIONAL DIAGNOSIS OF MARINE DIESELS

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**Abstract text.** The principles of constructing invariant standards for the functional diagnosis of marine diesel engines are formulated. An example of the construction of invariant standards for the diagnosis of work processes in the cylinders of a particular engine is given; The results of practical diagnostics of working processes in engine cylinders are given.

**Keywords:** invariant standard, principles of construction, diagnostic results

Practical difficulties in the functional diagnosis of the main marine diesels are caused by the instability of the propeller characteristics. Under the influence of variable perturbations on the side of the propeller, the possible variations in the engine's energy and economic parameters significantly exceed the deviations caused by changes in the technical state of the systems ensuring the quality of combustion of the fuel in the cylinders. [1,2] For these reasons, direct use of heat engineering parameters to assess the quality of the combustion process in Cylinders of main marine diesel engines does not allow to detect possible violations of the combustion process at an early stage of their development.

The efficiency of functional diagnosing of working processes in the cylinders of the main marine diesels under operational conditions can be significantly improved by using special standards that have the property of invariance with respect to the characteristics of the propeller. The construction of such standards is made in accordance with the following principles [3,4,5].

1. The set of properties incorporated into the design of the engine in the design process and determining its ability to produce mechanical energy with a given quality will be characterized by a field permissible for long-term operation of the regimes. By this field we

mean the part of the coordinate plane  $P_e - n$  (effective power - the speed of rotation) bounded to the left and right by the verticals  $n_{\min} = const$  and  $n_H = const$ ; Top - the upper limiting characteristic; Below the coordinate axis. The field limited in this way includes the whole set of regimes determining the conditions for the combustion of fuel in the cylinders. The position of the boundaries of the described field is determined only by the properties of the engine and does not depend on the features of the consumer of mechanical energy, i.e. It has the property of invariance with respect to the characteristics of the consumer and therefore is subsequently taken as the standard.

2. It is known that the standards are intended to determine the specific properties of objects or processes. Therefore, in order to assess the quality of combustion of the fuel in cylinders, it is necessary to form quantitative structures, having the property of invariance, on the basis of input into the working cylinders and output from the working cylinders of the parameters, with respect to possible perturbations on the part of the consumer. The input parameters are assumed to be the same for all cylinders; Weekends are different. This ensures that the features of the flow of working processes in the individual cylinders of the engine are taken into account.

3. Quantitative structures that have the property of invariance with respect to the characteristics of consumers of mechanical energy are of practical value only in those cases when the parameters on which they are based are available for operational control in ship conditions.

The sequence of computational operations for a quantitative description of the formulated principles will be demonstrated using the example of the formation of invariant standards for functional diagnostics of the quality of combustion processes in engine cylinders 6 cylinder four stroke turbocharged 25/34-3.

For this purpose, we use the results of bench tests of the engine on a series of load characteristics in the range of rotation frequencies from  $n_H = 500 \text{ min}^{-1}$  to  $n_{\min} = 350$ , with step  $\Delta n = 50 \text{ min}^{-1}$ .

During the testing, the following informative parameters were measured:

$t_g$  - exhaust gas temperature at the exit from the cylinders,  $^{\circ}\text{C}$ ;

$n$  - crankshaft speed,  $\text{min}^{-1}$ ;

$h$  - position of the load indicator, conventional units.

In the following calculations, we use the dimensionless values of the informative parameters

$$t_g = \frac{t_g}{t_{gh}}; \quad n_0 = \frac{n}{n_h}; \quad h_0 = \frac{h}{h_h}, \quad (1)$$

where  $t_{gh}$ ,  $n_h$  u  $h_h$  – normalizing parameters, the numerical values of which in this case are taken as follows:

$$t_{gh} = 390 \text{ } ^\circ\text{C}; \quad n_h = 500 \text{ } \mu\text{mH}^{-1}; \quad h_h = 4,9.$$

The use of dimensionless informative parameters excludes the question of the dimensions of the input and output parameters of invariant standards. In addition, informative parameters are expressed by numbers of the same order, which increases the stability of the computational process.

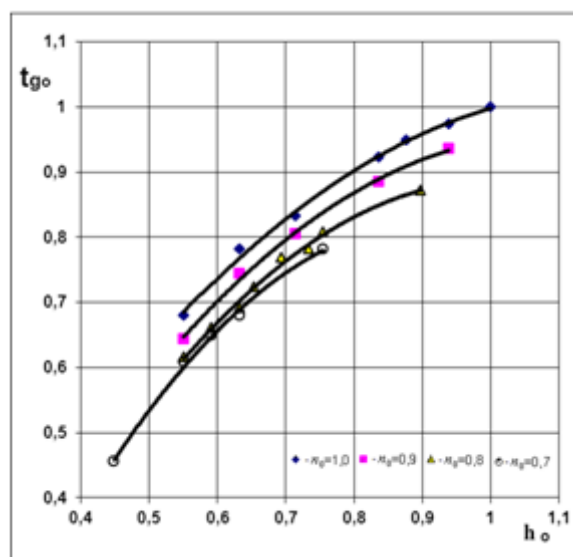


Fig.1. Load characteristics of the first engine cylinder 6 cylinder four stroke turbocharged 25 / 34-3 in the coordinates  $t_{go}=f(h_o)$

In Fig. 1. The load characteristics of the first cylinder of the engine 6 cylinder four stroke turbocharged 25 / 34-3 in the coordinate system  $t_{go} = f(h_o)$

It can be seen that these are monotonous curves, therefore each of them with a high degree of reliability ( $R^2 \geq 0,99$ ) can be approximated by a second-order polynomial of the form

$$t_{go} = x_1(n_o) \cdot h_o^2 + x_2(n_o) \cdot h_o + x_3(n_o), \quad (2)$$

and/but the entire series of load characteristics, the system of the following polynomials:



$$\begin{aligned}
t_{go} &= -0.8732 \cdot h_o^2 + 2.0501 \cdot h_o - 0.1789, & n &= 1.0; \\
t_{go} &= -1.0884 \cdot h_o^2 + 2.3587 \cdot h_o - 0.3218, & n &= 0.9; \\
t_{go} &= -1.316 \cdot h_o^2 + 2.6532 \cdot h_o - 0.449, & n &= 0.8; \\
t_{go} &= -1.6797 \cdot h_o^2 + 3.073 \cdot h_o - 0.6827, & n &= 0.7.
\end{aligned} \tag{3}$$

The system of polynomials (3) allows us to determine the patterns of change in the parameters to be determined  $x_i = f(n_o)$ .

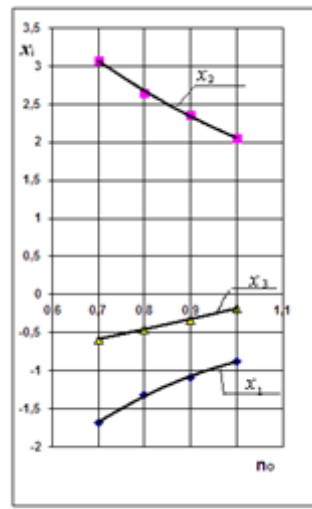


Fig.2. Graphical representation of dependencies  $x_1=f(n_o)$ ,  $x_2=f(n_o)$ ,  $x_3=f(n_o)$

In Fig.2. Graphical representation of the dependencies  $x_1 = f(n_o)$ ,  $x_2 = f(n_o)$ ,  $x_3 = f(n_o)$ . It is seen that these are also monotonous curves, so with a high degree of certainty ( $R^2 \geq 0,99$ ) they are approximated by polynomials of the second order

$$\begin{aligned}
x_1(n_o) &= -3.8625 \cdot n_o^2 + 9.2073 \cdot n_o - 6.2251; \\
x_2(n_o) &= 2.78 \cdot n_o^2 - 8.0892 \cdot n_o + 7.3663; \\
x_3(n_o) &= 0.23 \cdot n_o^2 + 0.9476 \cdot n_o - 1.3576.
\end{aligned} \tag{4}$$

Substitution of (4) into (2) yields the equation of the surface formed by the successive displacement of the segment of the monotone curve  $t_{go}=f(h_o)$  of the first cylinder in the range of rotation speed change  $0.7 \leq n_o \leq 1.0$

$$t_{gop}^I = (-3.8625 \cdot n_o^2 + 9.2073 \cdot n_o - 6.2251) \cdot h_o^2 + (2.78 \cdot n_o^2 - 8.0892 \cdot n_o + 7.3663) \cdot h_o + (0.23 \cdot n_o^2 + 0.9476 \cdot n_o - 1.3576) \cdot h_o. \tag{5}$$

According to the above algorithm, the equations of surfaces obtained by the successive displacement of load characteristics of the remaining engine cylinders are obtained. 6 CHN 25 / 34-3:

$$\begin{aligned}
 t_{gop}^{II} &= (-11.287 \cdot n_o^2 + 23.087 \cdot n_o - 12.32) \cdot h_o^2 + (12.336 \cdot n_o^2 - 25.275 \cdot n_o + 14.441) \cdot h_o + \\
 &+ (-3.2025 \cdot n_o^2 + 6.8727 \cdot n_o - 3.5649); \\
 t_{gop}^{III} &= (-8.8975 \cdot n_o^2 + 17.977 \cdot n_o - 9.7956) \cdot h_o^2 + (10.085 \cdot n_o^2 - 20.396 \cdot n_o + 12.105) \cdot h_o + \\
 &+ (-2.665 \cdot n_o^2 + 5.6359 \cdot n_o - 3.666); \\
 t_{gop}^{IV} &= (-7.91 \cdot n_o^2 + 17.174 \cdot n_o - 9.6694) \cdot h_o^2 + (6.86 \cdot n_o^2 - 16.026 \cdot n_o + 10.408) \cdot h_o + \\
 &+ (-0.7625 \cdot n_o^2 + 2.8269 \cdot n_o - 1.8519); \\
 t_{gop}^V &= (-16.197 \cdot n_o^2 + 35.987 \cdot n_o - 19.943) \cdot h_o^2 + (14.125 \cdot n_o^2 - 35.074 \cdot n_o + 21.775) \cdot h_o + \\
 &+ (-1.5 \cdot n_o^2 + 6.355 \cdot n_o - 4.5003); \\
 t_{gop}^{VI} &= (-16.395 \cdot n_o^2 + 35.273 \cdot n_o - 19.498) \cdot h_o^2 + (12.93 \cdot n_o^2 - 31.331 \cdot n_o + 19.994) \cdot h_o + \\
 &+ (-0.69 \cdot n_o^2 + 4.3364 \cdot n_o - 3.6266).
 \end{aligned}
 \tag{6}$$

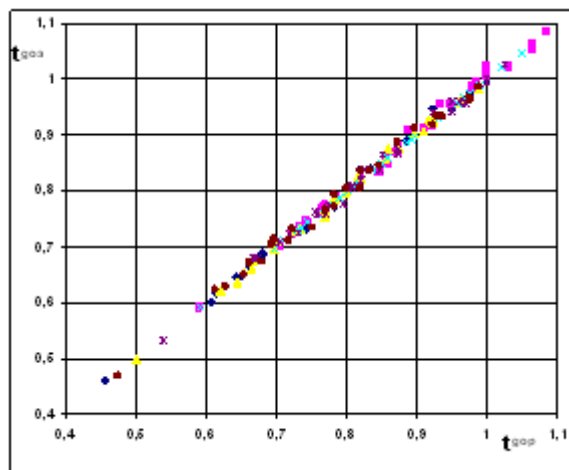


Fig.3. Single invariant standard of the engine 6CH25/34-3

On the basis of (5) and (6), through the representation  $t_{go3} = f(t_{gop})$ , a single invariant standard of the engine 6ЧН25 / 34-3, presented in Fig.3, can be formed.

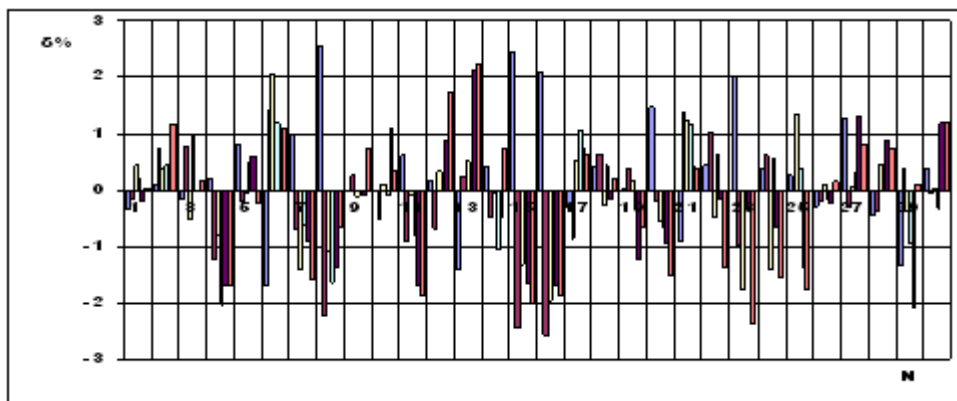


Fig.4. Distribution histogram of calculation errors for the entire set of input data

In Fig. 4. the distribution histogram of calculation errors for the entire set of input data is resulted. It can be seen that equations (5) - (6) reproduce the experimental data with an error not exceeding  $\pm 3\%$ .

Diagnosis of work processes in engine cylinders by means of models (5) - (6) and a single invariant standard is performed according to the following algorithm.

1. In an arbitrary period of operation, the values of the informative parameters  $t_{go}$ ,  $n$  and  $h$  are recorded in 4-5 modes belonging to the region accepted as the standard.
2. By the relations (1), the dimensionless values of the informative parameters  $t_{go}$ ,  $n_o$  and  $h_o$ . are determined.
3. From the equations (5) - (6), the calculated values of the temperature of the exhaust gases along the cylinders  $t_{gop}$  are determined.
4. Dependencies  $t_{go3} = f(t_{gop})$ , corresponding to the actual conditions of fuel combustion in the cylinders, are constructed.
5. Taking into account the real deviations of the constructed dependences from the standard, a conclusion is made about the quality of the functioning of the cylinders.

The results of the practical diagnosis of the engine 6 cylinder four stroke turbocharged 25 / 34-3 according to the described algorithm are shown in Fig. 5 and 6.

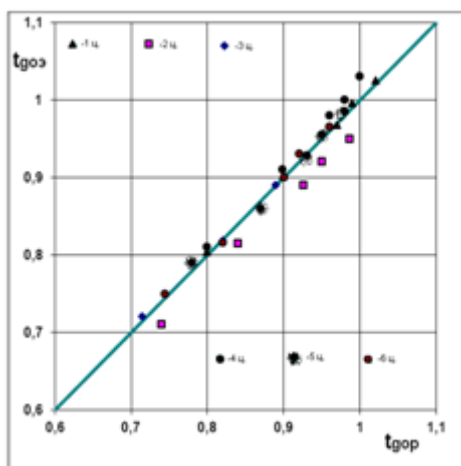


Fig. 5 Results of practical testing of experimental - theoretical models. Malfunctions:  
 1 cylinder - injection pressure of fuel reduced to 7.5 MPa; 2 cylinder - injection pressure of fuel reduced to 5 MPa; 3 cylinder - the gaps in the valve drive are increased to 1 mm;  
 4 cylinders - the gaps in the valve actuator are increased to 1.5 mm

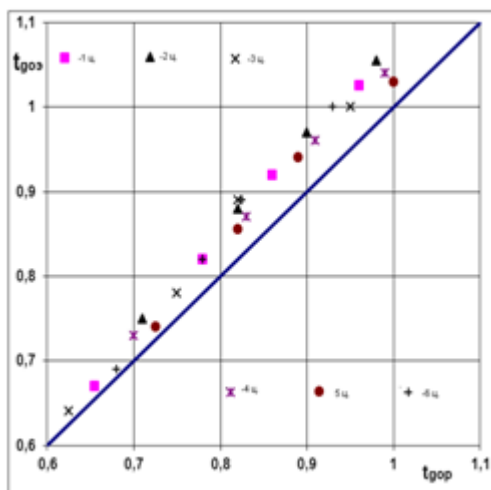


Fig. 6 Results of the practical testing of experimental and theoretical models. The fault is reduced by 50% of the flow cross section of the air filter

The diagnostic results shown in Fig. 5 correspond to the conditions of the engine tests with misaligned injectors of the first and second cylinders and increased clearance in the valve actuator of the third and fourth cylinders.

The fuel injection pressure of the injector of the first cylinder was 5.0 MPa, i.e. Was more than four times less than the nominal. Here, the effect of excessive reduction of the injection pressure on the flow of the working process in the cylinder is manifested in accordance with

the condition  $t_{goe} < t_{gop}$ , i.e. The actually measured values of the temperatures of the exhaust gases on all the investigated regimes are less than the calculated ones. Apparently in this case, the combined influence of the factors determining the fineness of fuel spraying and the range of fuel flares is manifested in such a way that part of the injected fuel enters the walls of the combustion chamber and does not participate in the combustion process. With prolonged exposure, it is this manifestation of the malfunction of the fuel equipment set that can lead to the most severe consequences. Not burnt fuel flushes the lubricant from the cylinder walls and cokes at the bottom of the piston, i.e. In the cylinder, the system conditions for the heating of the piston are created. Ultimately, the impact of these factors can lead to wedging of the piston. For the reasons stated, in cases where the measured values of the temperature of the exhaust gases on a cylinder are less than the calculated ones, the malfunction in the complete set of fuel equipment of this cylinder should be immediately rectified.

The fuel injection pressure of the second cylinder injector was 7.5 MPa. It can be seen that all the modes of this cylinder with a spread that does not exceed the error in measuring the temperature of the exhaust gases are stacked on the standard. Obviously, this injection pressure is close to the minimum allowable, at which no noticeable deterioration of the mixture formation occurs.

During the operation of the engine, the valve timing does not remain unchanged. The main reasons for their change are the wear of the paddles and the increase in the gaps in the valve drive. As a result, the duration of the valve opening phases is shortened, the cleaning is reduced and the air charge of the cylinders is reduced. According to the results obtained, an increase in clearance in the valve drive to 1.0 mm (third cylinder) has little effect on the quality of the combustion process in the range of loads studied. We can say that the level of this influence does not exceed the errors in measuring the temperature of the exhaust gases. When the gap is increased to 1.5 mm (the fourth cylinder), in modes close to the nominal one, the tendency of deviation of the measured values of the temperature of the exhaust gases from the calculated ones is quite clearly shown in accordance with the condition  $t_{go3} > t_{gop}$ .

The list of faults that occur in the elements of the air-gas tract of marine diesel engines is quite diverse. However, the most common are faults associated with the appearance on virtually all elements of the tract of various types of deposits and contaminants. As a result, the degree of consistency between the characteristics of the diesel engine and the

turbocharger, achieved in the design and refinement, is partially violated, the air excess ratio during combustion decreases, the heat stress of the cylinder-piston group parts increases, the reliability and economy indicators deteriorate.

The described mechanism for the manifestation of faults in the elements of the air and gas tract suggests that the reaction of the invariant standard to these faults must be monotonous, i.e. For a single or joint action, the actual operating conditions of individual cylinders must be shifted in accordance with the condition  $t_{go3} > t_{gop}$ .

Figure 6 shows the results of an engine test with a 50% cut-through section of the air filter. It can be seen that in the investigated range of loads this malfunction is manifested on all cylinders approximately in the same measure in accordance with the condition  $t_{go3} > t_{gop}$ .

In connection with the results of practical diagnostics, it is appropriate to discuss in more detail certain features and diagnostic possibilities of invariant standards.

First of all, attention is drawn to the fact that none of all the factors considered that caused a change in the conditions for the combustion of fuel in cylinders are explicitly included in equations (5) - (6), but nevertheless, their influence on the work process is revealed in the engine cylinders. This fact testifies to the fact that in the structure of the standards (5) - (6) there is a parameter that is inherently generalized, the role of which is fulfilled by the temperature of the exhaust gases along the cylinders.

Indeed, equations (5) - (6) can be regarded as identities in which only the definite, unique numerical values of the solutions  $x_i = f(n_0)$  can be assigned to the given values of the parameters  $t_{go}$ ,  $n_0$  and  $h_0$ , which are independent variables in the statement of the problem, i.e. Values that are dependent variables. This strictly unambiguous relationship between independent variables and solutions is possible only for certain conditions for the combustion of fuel in cylinders. If the combustion conditions change, the uniqueness of the relations between independent variables and solutions is violated and the dependence  $t_{goe} = f(t_{gop})$ , corresponding to the new conditions, deviates from the standard.

In conclusion, it should be noted that in the presence of technical means for the operational control of the average indicator pressure on the cylinders, invariant standards can be

constructed in which the temperature of the exhaust gases is replaced by an average indicator pressure [3].

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## Active Learning in Maritime Education - Lecture in the Classroom -

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**Abstract** In recent years, education research has highlighted active learning as an important element for the ‘conversion to study from education’; in other words, active learning has been promoted as a more effective education technique. Professor Mizogami of the Kyoto University Centre for the Promotion of Excellence in Higher Education defined the benefits of active learning as follows: ‘active learning overcomes passive one-sided knowledge transfer-type lessons’. Active learning requires students to participate in ‘writing’, ‘talking’, and ‘presenting’, thereby ensuring that their cognitive processes are engaged. Maritime education has generally comprised a lecture in the classroom and on-board training, which could be considered a type of active learning. We introduced active learning into the maritime education classroom to improve the education effect. Student assessments were conducted twice to receive feedback about the active learning-type lessons. The student assessments of the first exercise, which involved pair and group discussions, showed that approximately 87 percent of the students found the lesson to be ‘very good’ or ‘good’. After giving a presentation following the group discussion, approximately 89 percent of the students felt that the lesson was ‘very good’ or ‘good’. The following categories were determined following qualitative analyses of student comments: (1) The effect of thinking, (2) The effect of group work, (3) The effect of dialogue, (4) The effect of presentations, (5) The effect of idea creation, (6) The importance of explanation, (7) Problem recognition. As part of the assessment, students were encouraged to give detailed comments, which were later analysed qualitatively using a grounded theory approach (GTA). From these analyses, the following hypothesis was drawn: ‘By performing dialogues in a group and conducting group presentations in this lesson, critical thinking was encouraged, which promoted idea creation’.



This will form the basis for further study. Moreover, when developing effective future lessons, ‘group work’, ‘presentations’, and ‘creative thinking’ should be considered.

**Keywords:** active learning, group work, group discussion, group presentation

## **1. Introduction**

In recent years, education research has highlighted active learning as an important element for the ‘conversion to study from education’; thus, active learning is a more effective education technique. In 2012, the Central Council for Education in Japan defined active learning as ‘a general term for teaching and learning methods that involve the participation of the student in active study unlike one-way lectures from a teacher. When a student learns actively, he/she is engaged cognitively, ethically, and socially with the learning, culture, knowledge, and experience. Discovery methods, problem-solving, experiential studies, and investigative studies are included. Debates and group work are examples of classroom methods for effective active learning’. Professor Mizogami of the Kyoto University Centre for the Promotion of Excellence in Higher Education defined the benefits of active learning as follows: ‘active learning overcomes passive one-sided knowledge transfer-type lessons’. Active learning requires students to participate in ‘writing’, ‘talking’, and ‘presenting’; this ensures that students’ cognitive processes are engaged. Active learning is not a specific study method but a teaching and learning process in which students are required to actively perform with a purpose.

## **2. Implementation of an active learning-type lesson**

Maritime education generally comprises a classroom lecture and on-board training, which could be said to be a type of active learning. We introduced active learning into the maritime education classroom to improve the education effect.

In 2016, active learning-type lessons were conducted with 63 students from the Tokyo University of Marine Science and Technology, School of Marine Technology, Undergraduate Maritime Systems Engineering course. From a viewpoint of providing the same service to the student of the same class, since comparison with the one-sided lecture (from instructor) and active learning was difficult, the student's questionnaire and comment were analyzed about the active learning type lesson.

### **2.1 First lesson**

The composition of the first lesson was as follows:

- (1) Setup and explanation of the target (10 minutes),
- (2) Exercise in ship operations (50 minutes),

- (3) Explanation of the exercise content (10 minutes),
- (4) Debriefing (a questionnaire was included) (15 minutes).

‘Acquisition of seamanship’ was set as the lesson target. The definitions for seamanship from Captain Chiba, Professor Sugisaki and the National Institute for Sea Training were first introduced. In each case, seamanship included not only knowledge and skills but also actions, functions and capabilities. When conducting the exercise, the following three-point explanation was provided:

- 1) Students set up and recorded their own target. The target of the lesson was not restricted; thus, students could describe the target freely, making the set up easy.
- 2) A pair discussion was conducted in which students’ ideas were conveyed and taught.
- 3) In the time given, students conveyed and taught their ideas to other teams.

The exercise included the following two questions:

- 1) Enumerate the uses of Buys Ballot’s law.
- 2) Indicate the cause of a marine accident and develop countermeasures for it.

During explanation time, students presented their ideas. They were asked about what they had considered during the exercise and were encouraged to think deeply about the issues from various perspectives. The target of the lesson was shown again as a ‘debriefing’, which allowed the students to reflect on whether the lesson target had been achieved.

## **2.2 Second lesson**

The composition of the second lesson was as follows. The exercise content was more limited than that in the first lesson; however, the presentation time was extended. The students were positively encouraged to participate by asking them to decide the presentation content.

- (1) Setup and explanation of the target (10 minutes),
- (2) Exercise (20 minutes),
- (3) Presentation (40 minutes),
- (4) Debriefing (a questionnaire was included) (15 minutes).

The target, as with the first lesson, was the ‘acquisition of seamanship’ and was specifically aimed at developing ‘creative thinking’ as part of seamanship. The exercise asked students to invent and develop a new type of ship; concrete themes, such as ‘hull shapes’ or ‘propellers’, were given to guide and make student discussions easier. The exercise had the following structure:

- 1) Groups of 4 to 6 people were formed,
- 2) A leader was chosen,
- 3) Each of three proposals was considered,

4) Each member presented the proposal they preferred; the presentation included the main features and key advantages. While the presentations were being given, the other members of the group neither evaluated nor criticised the presentation.

5) With the encouragement of the leader, the groups decided on the proposal or elements of the proposal that they all preferred; next, a new group proposal was developed, which included further additions and improvements. Finally, a group proposal was determined.

6) The group then developed figures and drawings to easily explain ‘the group proposal’.

7) A final group presentation in which all members were involved was prepared and given to the class.

Proposals for the new ship had to be creative and had to consider possible new concepts for elements such as form, propulsion and operations. Even if the type of ship considered was not possible at present, innovative and out-of-the-box proposals were encouraged as the construction of such ships may be possible within the next 50 years.

Thirteen groups gave 3-minute presentations on their new ships; then, in a ‘debriefing’, students reflected on the lesson target and completed the questionnaire.

### 3. Results

#### 3.1 Student assessments

##### (1) First lesson

The student assessments of the first active learning lesson are illustrated in Fig. 1. Eighty-seven percent thought that the lesson was ‘very good’ or ‘good’. Comments from students who assessed the lesson as ‘very good’ were as follows:

- It was very intelligible.
- The thinking required in the lesson was very satisfying.
- It was good to consider an actual marine accident case.
- In today’s lesson, there was time to discuss by ourselves and think deeply.
- There was an active exchange of opinions when doing the exercise.
- The more I thought, the more ideas I had.
- I noticed that there was a limit to my own ideas, so by working in pairs I could understand what I did not know completely.

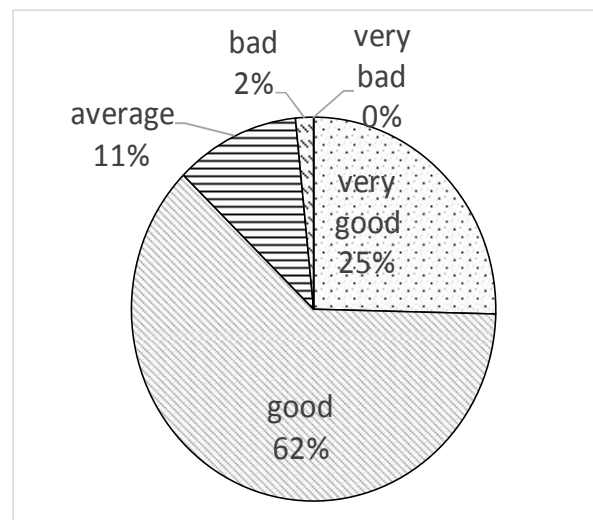


Fig. 1 Student assessment results for the first lesson

- I am happy to have such lessons. I think that there should be more opportunities for discussion.
- I thought that it was a very good lesson as exchanging opinions with another person can deepen the understanding of the subject under discussion and lead to sharing of ideas.
- It was a very significant lesson.

In contrast, comments given by students who assessed the lesson as ‘bad’ did not include a clear statement.

## (2) Second lesson

The main feature of the second active learning lesson was that all students were given the opportunity to prepare a presentation.

The student assessments of the second active learning lesson are illustrated in Fig. 2.

Eighty-nine percent of the students rated the lesson as ‘very good’ or ‘good’, with no one assessing the lesson as ‘bad’ or ‘very bad’.

This active learning lesson created some tension as all members were required to participate in the presentation.

In the exercise in the second lesson, a ‘creative way of thinking’ was set as the concrete target for seamanship.

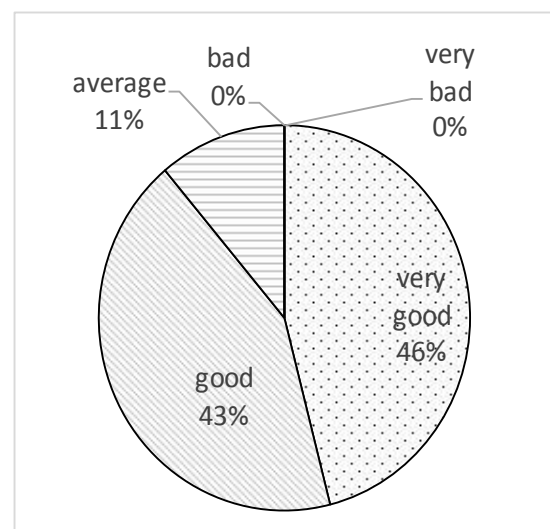


Fig. 2 Student assessment results for the second lesson

### 3.2 Qualitative data analysis of the comments on the lesson

A generally positive assessment was made of both the first and second active learning lessons. To investigate these positive assessment results further, students’ comments were analysed using a grounded theory approach (GTA). The first and second active learning type lessons were analysed by GTA. This paper shows the analysis result of the second lesson. On the other hand, the difference in the learning effect by the lesson (the first and second lessons) from which the contents differ is to present at Japan Creativity Society.

After each comment was analysed, it was classified according to a process called ‘sectionalisation’. Then, the characteristics and dimensions of the data were shown and further processing, termed coding, was conducted to identify a label name that expressed the general focus of the comments. An example of the coding done for the comments on the second lesson is shown in Table 1.

Table 1 Example of the coding for the second lesson

No.	Data	Property	Dimension	Label name
1	<ul style="list-style-type: none"> <li>• Critical thinking turned out to be satisfying.</li> <li>• The future was considered through complex critical thinking.</li> </ul>	<ul style="list-style-type: none"> <li>• Thinking is satisfying.</li> </ul>	<ul style="list-style-type: none"> <li>• Time in a lesson to think.</li> </ul>	(1) The effect of thinking.
2	<ul style="list-style-type: none"> <li>• I thought that the group work was full of ideas.</li> <li>• Within the group, various ideas emerged, which was interesting.</li> </ul>	<ul style="list-style-type: none"> <li>• The effect of group work.</li> </ul>	<ul style="list-style-type: none"> <li>• Idea creation from group work.</li> </ul>	(2) The effect of group work.
3	<ul style="list-style-type: none"> <li>• Talking with another person allows for new discoveries.</li> <li>• There were many things I had previously not thought of.</li> </ul>	<ul style="list-style-type: none"> <li>• Discovery through dialogue.</li> </ul>	<ul style="list-style-type: none"> <li>• The number of discoveries made through dialogue.</li> </ul>	(3) To discover and develop using dialogue.
4	<ul style="list-style-type: none"> <li>• The ideas from the other groups were very interesting.</li> <li>• It was good to hear other people's opinions.</li> </ul>	<ul style="list-style-type: none"> <li>• The effect of presentations.</li> </ul>	<ul style="list-style-type: none"> <li>• Idea sharing through presentations.</li> </ul>	(4) The joint effect of the other group proposals through presentations.
5	<ul style="list-style-type: none"> <li>• Various ideas and opinions were heard, which was significant.</li> </ul>	<ul style="list-style-type: none"> <li>• The effect of a dialogue and a presentation.</li> </ul>	<ul style="list-style-type: none"> <li>• The effect of others' opinions on the self.</li> </ul>	(5) Self-growth through dialogue and presentation
6	<ul style="list-style-type: none"> <li>• I felt the difficulties and pleasures of creation.</li> </ul>	<ul style="list-style-type: none"> <li>• The effects of creation.</li> </ul>	<ul style="list-style-type: none"> <li>• Difficulties and the pleasures of creation.</li> </ul>	(6) Creating ideas.
7	<ul style="list-style-type: none"> <li>• The importance of explanation was shown.</li> </ul>	<ul style="list-style-type: none"> <li>• Importance of explanation.</li> </ul>	<ul style="list-style-type: none"> <li>• An understanding of the importance of explanation.</li> </ul>	(7) An understanding of the importance of the explanation in a presentation.
8	<ul style="list-style-type: none"> <li>• I thought that it was interesting because various ideas emerged.</li> <li>• Many ideas emerged in the group.</li> </ul>	<ul style="list-style-type: none"> <li>• A variety of ideas.</li> </ul>	<ul style="list-style-type: none"> <li>• The amount of ideas.</li> </ul>	(8) Creation of several different ideas. (9) Comments about idea creation.
9	<ul style="list-style-type: none"> <li>• People had ideas, and it was a wonderful idea to combine them.</li> </ul>	<ul style="list-style-type: none"> <li>• Many ideas created and the combined effects.</li> </ul>	<ul style="list-style-type: none"> <li>• Comprehension of combining ideas.</li> </ul>	(10) Idea creation and idea combination.
10	<ul style="list-style-type: none"> <li>• When inconsistencies in opinions arose, a new idea was developed.</li> </ul>	<ul style="list-style-type: none"> <li>• Opinion concentration and the creation of new thinking.</li> </ul>	<ul style="list-style-type: none"> <li>• Opinion concentration</li> <li>• The amount of new thinking created.</li> </ul>	(11) Conflicting opinions and the effect of correspondence. (12) Concentrating opinions and developing new thinking.
11	<ul style="list-style-type: none"> <li>• By considering a possibly new ship, the demerits of the present ship were clearly understood.</li> </ul>	<ul style="list-style-type: none"> <li>• The effect of critical thinking.</li> </ul>	<ul style="list-style-type: none"> <li>• Understanding the demerits of the present ship.</li> </ul>	(13) Grasping the present situation through critical thinking.
12	<ul style="list-style-type: none"> <li>• It was good to realise that critical thinking was difficult.</li> </ul>	<ul style="list-style-type: none"> <li>• Understanding the pliability of critical thinking.</li> </ul>	<ul style="list-style-type: none"> <li>• The pliability of critical thinking.</li> </ul>	(14) Noticing the pliability of critical thinking.
13	<ul style="list-style-type: none"> <li>• Noticing the existing challenges showed me that I would like to have more from now on.</li> </ul>	<ul style="list-style-type: none"> <li>• Discovering how to challenge oneself.</li> </ul>	<ul style="list-style-type: none"> <li>• The effects of challenges.</li> </ul>	(15) Overcoming the challenges faced in the lesson.

For example, data no.1 in Table 1 were ‘critical thinking turned out to be satisfying’ and ‘the future was considered through critical thinking’, which were assigned the property of ‘thinking is satisfying’ and the dimension ‘time in a lesson to think’. A property expresses the characteristics of the data in the exercise. As the exercise content was to ‘consider a new ship’, this presupposed the property of ‘thinking is satisfying’, with the dimension ‘time in a lesson to think’ indicating the assessment grade and degree. Therefore, the label name—‘the effect of thinking’—was developed from these. Although there was a comment about a new type ship, the point of almost all comments was the thinking and the creativity by group work and a presentation. From the main comments about the second lesson, 15 distinct labels were

identified. Comments that were similar or common in the coded data were then summarised under each category. The 15 items shown in Table 1 were then summarised into seven categories. The relation of each category is illustrated in Fig. 3. First, the categories were extracted by sorting the 15 labels into seven categories. For example, the label names ‘(1) The effect of thinking’, ‘(12) Concentrating opinions and developing new thinking’, ‘(13) Grasping the present situation through critical thinking’ and ‘(14) Noticing the pliability of critical thinking’ were grouped under category (A) ‘A lesson in which critical thinking is encouraged’.

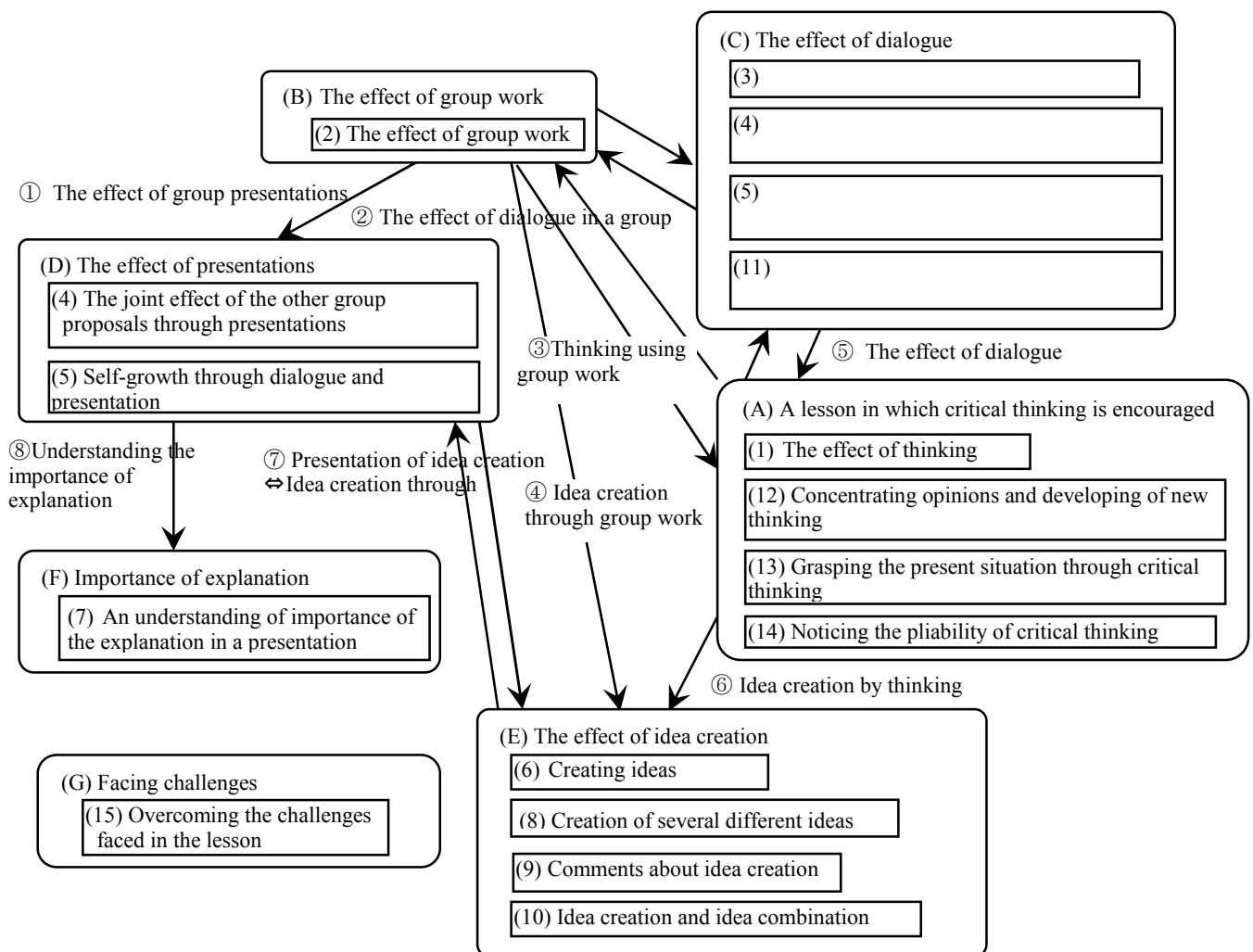


Fig. 3 Categorization using GTA

The categories related to group work and presentations were directly related to active learning. For example, (C) ‘The effect of dialogue’ indicated the effect of the group work discussions and, although there was few comments that assessed the lesson as whole, ‘(A) A lesson in which critical thinking is encouraged’ was considered to be a good assessment of the critical thinking required for active learning to occur.

Although there is no arrow showing the relation with '(G) Facing challenges', this was considered to be a comprehensive summary of the entire lesson because it was connected with all the actions taken throughout the lesson, such as '(B) Effect of group work' and '(D) Effect of presentations'.

The following hypotheses about students' comments were derived from the coding and the category classification shown in Fig. 3. 'By performing dialogues in a group and conducting group presentations in this lesson (the second lesson), critical thinking was encouraged, which promoted idea creation'. 'The dialog in a group was promoted by the presentation, and many thinking and idea creation were performed by it'. From these hypotheses, it can be guessed that not only fixing of a student's knowledge but the thinking for problem solving was cultivated.

### **3.3 Utilisation of the lesson content**

In the second lesson, in addition to the general comments on the lesson, students were also asked to assess their future use of what they learnt in the lesson. The following responses were provided for this question:

- The group dialogue was a reference for future critical thinking. I plan to refer to others' opinions, consider others' opinions and combine opinions from now on using dialogue.
- The effect of group work was very positive and mirrored reality. I plan to utilise group work in the future to make discoveries and solve problems.
- The difficulty of summarising an idea was learnt through the presentation. Therefore, I plan to continue training in summarising ideas clearly when giving a presentation.
- The ideas were coherently arranged when preparing for the presentation. I plan to utilise skills for preparing individual and group presentations when thinking critically in the future.
- From the presentations, many interesting ideas emerged. I plan to exercise my thinking so as to develop the ability to conceptualise a range of ideas.
- Creative critical thinking was excellent. I plan to apply this creative critical thinking to my future work.
- I enjoyed the difficulties associated with complex critical thinking. I plan to apply such thinking to my future study and to my life.
- There were many good ideas that were difficult for me to imagine. I plan to apply such type of analysis into my thinking processes so that it becomes a custom.
- My interest in ships increased, and the faults in the present ship were identified. I would like to continue to improve.

- I would like to think that a safe and useful ship can be developed.

Fig. 4 summarises these ideas. By considering a new type ship, the students were able to acquire the knowledge about a hull shape or a propulsion. More than it, there is an overall understanding of the importance of creative thinking and how group work and presentations can be used to encourage creative thinking as I ideas can be suggested, selected, combined, added to and deleted, all of which require the current concrete target of ‘creative thinking’, through conversations (dialogue) and presentations.

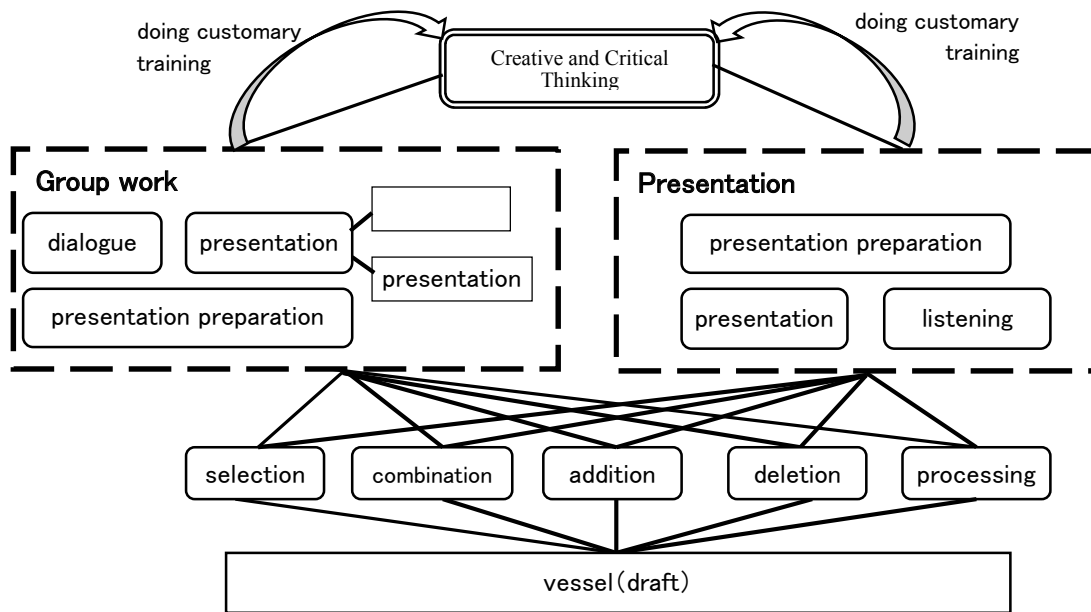


Fig. 4 Utilization of the content acquired from the lesson

The group work and presentations exemplified the effect of the active learning in the lessons. By using these techniques, students could develop a complex understanding of the ‘vessel’ and the improvements that would positively affect operations. The group work and presentations improved students’ motivation and encouraged effective critical and creative thinking. And students think that they would like to routinize or train critical thinking and creative thinking.

### 3.4 Improvements to the lesson

The following negative comments were given: ‘it was boring’, ‘I did not understand well’, ‘the tempo was bad’ and ‘it was too long’.

To guide further improvement, an analysis of the following comments was conducted.

(1) Consider the exercise content: I think that it is necessary to consider more suitable exercise content and the volume, combination, etc. of the subject content. When performing two or more exercises, I think it is necessary to also consider the relevance of the question,



and modify the difficulty.

(2) Examination of the time distribution: Since the time for several questions was short, it is necessary to consider the time distribution for the subject.

(3) Classroom improvements: A classroom where it is easier to perform group work is required.

(4) Suitable explanation and facilitation

(5) Proper group setting: Groups including various members are a good idea.

(6) Suitable utilisation of information and communications technology (ICT).

#### **4. Summary**

Two active learning-type lessons were conducted as part of a maritime education course; an overall positive student assessment of about 90% was obtained for each lesson. Student comments regarding the lessons were generally positive, with most students being able to understand the effects.

To investigate the reasons for the positive assessment results, the student comments were analysed using a GTA. The theoretical hypothesis extracted from the GTA for the second lesson was 'By performing dialogues in a group and conducting group presentations in this lesson (the second lesson), critical thinking was encouraged, which promoted idea creation'. And 'The dialog in a group was promoted by the presentation, and many thinking and idea creation were performed by it'.

A group work and a presentation lead to a valid dialog and thinking, and it is thought that it can contribute to a student's improvement in some kinds of capability. Moreover, we would like to improve an active learning type lesson.

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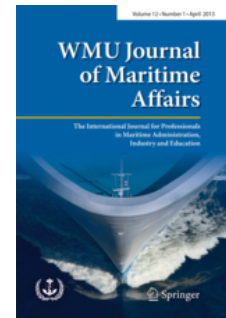
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# SHARE YOUR KNOWLEDGE, EXPERIENCE AND RESEARCH WITH A WIDE ACADEMIC READERSHIP BY PUBLISHING IN *THE IAMU SECTION OF THE WMU JOURNAL OF MARITIME AFFAIRS*



## **Background**

The International Association of Maritime Universities (IAMU) and the World Maritime University (WMU) have an agreement for the inclusion of a dedicated IAMU Section, which focuses on Maritime Education and Training (MET), in the *WMU Journal of Maritime Affairs* (JoMA). This provides a great opportunity for everyone involved in MET (academic staff at IAMU member universities) to not only publish high-quality peer reviewed articles based on research but also to have their articles abstracted/indexed in SCOPUS, Google Scholar, EBSCO Discovery Service, OCLC, SCImago, Summon by ProQuest, Transport Research International Documentation (TRID).

## **About JoMA**

The *WMU Journal of Maritime Affairs* (JoMA) is an international peer reviewed journal that covers the subject areas of maritime safety, marine environment protection and shipping operations and gives, in this context, special attention to human factors and the impact of technology, and maritime education and training. JoMA is for scientists, academics and professionals in maritime administration, industry and education. It aims to serve the international maritime community by presenting fresh ideas and current thinking on subjects of topical interest, reporting on relevant research findings and addressing interrelationships between safety, environment protection and efficiency of maritime transport. The journal accepts Articles as well as Book Reviews for publication.

## **Scope of the IAMU Section**

JoMA has a section dedicated to the activities of IAMU. The focus of the IAMU Section is on Maritime Education and Training (MET). The IAMU Section follows a similar editorial review procedure as JoMA and accepts a range of papers for publication including: Articles, Issues of Contemporary Interest, Reports and Comments, and Book Reviews.

Articles, in principle, should present genuine research findings. However, overview articles summarising the status of knowledge in a specific research area may be considered for publication. Issues of Contemporary Interest are not always covered by traditional research and valuable lessons can be learnt through reports on best practice or critical discussions from the practitioner's point of view. This is why IAMU encourages experts to express their views on issues of contemporary interest. Reports and Comments can be published to facilitate research activities within the scope of the IAMU section. This allows members to voice their reasoned opinions on published manuscripts and also to stimulate discussions on areas that require further research.

Book reviews relevant to the scope of the IAMU Section can also be considered.

## **Focus of the IAMU Section**

The focus for papers submitted for publication in the IAMU Section of JoMA is Maritime Education and Training (MET). In this context MET is considered to include the wide range of issues associated with all forms of education and training which are related to maritime activities carried out by persons both at sea and onshore. This could include, but not be limited to:

- Systems of maritime education and training e.g. international, national, higher education, vocational training;

- Impacts on maritime education and training e.g. international conventions, maritime industry needs, government regulation;
- Curriculum development e.g. processes, review, innovations, balancing conflicting requirements, objectives;
- Course delivery e.g. classroom based learning, competency based training, e-learning, flexible learning, blended learning, flipped classroom approach;
- Teaching practise e.g. teacher centred, student centred, education and training technologies, multi-cultural students, teaching exemplars;
- Assessment e.g. linking objectives and assessment, methods, evaluation of results, assessment exemplars;
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- Issues impacting MET e.g. life-long learning, changing educational environment, attractiveness of the teaching profession and recruitment.

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