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Contemporary Approach to the Training of Deck Officers for the Use of Loading and Stability Instruments

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Abstract: The International Maritime Organization (IMO) has established minimum standards of competence for seafarers to ensure safe shipping and reduce the negative impact of maritime transport activities. However, the current IMO standards for the education and training of deck officers do not adequately address the increased demand for familiarization with onboard loading computer systems (LCS). This study analyzes the effectiveness of the "Cargo stowage and handling" syllabus for bachelor degree nautical students at the Nikola Vaptsarov Naval Academy (NVNA) in Bulgaria. The syllabus was updated in 2020 to include familiarization with the IMO and International Association of Classification Societies (IACS) regulations concerning LCS and practical classes using loading software for different vessel types.

An analysis of the effect of the applied contemporary syllabus on the quality of trainees' education in "Cargo stowage and handling" showed a significant improvement in students' final evaluation results. The study concludes that continuous improvement in maritime education and training is necessary, particularly in areas where technological advancements have outpaced the existing regulatory frameworks. The success of the NVNA's updated syllabus suggests that similar approaches could be beneficial if implemented more widely in maritime education institutions globally.

Keywords: *Loading Instrument; Stability Instrument; Maritime training; STCW.*

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I. INTRODUCTION

The main objectives of the International Maritime Organization (IMO) are to maintain a safe shipping environment and preserve the oceans and air cleanliness by reducing the negative impact of maritime transport activities[1],[2]. It has been recognized that to achieve these goals, all seamen performing duties on board have to be properly trained. Minimum standards of competence were established in the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers 1978 (STCW), as amended in 1995 and in 2010[3], [4]. Its provisions are mandatory for maritime administrations, which are required to implement convention standards by creating national regulatory instruments. The backbone for the training syllabi for deck officers worldwide is tables with competences in sections A-II/1 (for watchkeeping officers on board ships of more than 500 GT) and A-II/2 (for master and chief mate on seagoing ships of 3000 GT and more) of the STCW Code. This study reviews the relevant requirements applicable to the “Function 2” (Cargo handling and stowage), both for the operational and management levels. Functions 1 and 3 and the GMDSS competence (A-IV/2) are not subject to this study but are referred to as good examples of implementing regulatory instruments for training in the use of computer systems on board ships.

Owing to the growth in the global amount of shipped goods in recent decades, cargo ships have developed in both size and complexity[5]. Innovative ship designs have also been developed. The rates of loading and discharging solid and liquid bulk cargoes and break-bulk cargoes increased rapidly[6]. This has resulted in the implementation of various techniques and specialized equipment to facilitate conventional time-consuming manual calculations during the stowage planning and cargo operation monitoring process[7]. The current systems used for stowage planning and ship condition calculations are only computer based. Nevertheless, the IMO still refers to these systems as

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"Loading Instrument" and "Stability Instrument", being two separate functionalities of the loading software.

This paper analyzes whether current IMO standards for education and training of deck officers correspond with the increased demand for familiarization of officers responsible for cargo planning with the various aspects of the safe use, maintenance, and certification of on-board loading computer systems (LCS).

II. METHODS

This study applies qualitive method approach to assess the training effectiveness of the "Cargo stowage and handling" syllabus for bachelor degree nautical students, equivalent to the STCW "operational level" for deck officers according to the standard of the Bulgarian Maritime Administration.

The data collection used for statistical processing was derived from the Nikola Vaptsarov Naval Academy (NVNA) annual evaluation reports on graduates' grades at state exams.

The results of the study were verified by processing the answers to a survey form completed by graduates of NVNA.

III. RESEARCH RESULTS AND FINDINGS

A. Recent Accidents with Ships Related to the Improper Stowage Planning and Calculation of Ship's Condition

The IMO and other shipping industry regulatory organizations are continuously focusing on improving the safety of maritime operations. An integral part of these efforts is to reduce the negative impact of the human factor on shipping[8], [9], [10], [11]. Nevertheless, accidents related to improper stowage planning and incorrect calculations of ship's condition prior departure continue to occur, involving various types of vessels. Recent examples of such accidents include those of YM Efficiency[12], MV Amnah[13], and MV Sea Express[14].

Improving crew and personnel education and training is one possible tool to reduce the probability of such cargo-related accidents in the future[15]. Investigation reports from the above accidents confirmed that the crew did not properly use the loading computers available onboard.

B. International Maritime Organization and International Association of Classification Societies regulations concerning on-board loading computer systems

A computer tool to assess the technical and operational condition of a ship, such as stability or longitudinal strength, has become the standard equipment on board cargo vessels[16]. There is a great variety of such instruments available in terms of both calculation method and visualization. Cargo programs on modern ships combine at least two independent functions.

The first function is the "Loading Instrument", which is the official name adopted by the IMO for a computer system capable of calculating the ship's overall longitudinal and local strength parameters in accordance with Regulation 10 of LL'66[17]. At present, the IMO requires all bulk carriers to be fitted with a loading instrument (SOLAS XII/11, MSC/Circ.891). The International Association of Classification Societies (IACS) introduced identical requirement for container ships larger than 100 m. In addition, the IACS requires that any onboard software, even if optional, comply with the established requirements of the classification society.

Every Category I cargo ship over 100 m should be provided with a tool that allows the stability parameters to be calculated and analyzed, which is the second software function referred to as "Stability Instrument". The IMO has developed specific regulations for Stability Instruments, which are incorporated into Part C of the 2018 International Code on Intact Stability (IS Code)[18]. The Code's Section 4.1.2 distinguishes between passive and active software systems. Active systems can automatically receive the data necessary for stability calculations through an appropriate interface. These systems are exclusively regulated by the administration and relevant classification society.

Apart from the above two main functions, the loading software for some specific vessels includes additional functionalities, such as automatic container lashing calculations and analyses, automatic checking for dangerous cargo stowage and segregation. The calculation methodology, the software and hardware requirements for the additional functionalities, if any, are entirely left to the discretion of the classification society and the administration. A single integrated software called the "Loading Computer System" can perform all the aforementioned functions, along with some additional optional ones.

C. Current STCW Standards for Training in Use of Onboard Loading Computer Systems

Table A-II/1 of the STCW Code contains the required competences to be covered by the training syllabus for watchkeeping officers on board ships of more than 500 GT, named "Cargo handling and stowage at the operational level". On reviewing the competences in Column 1 and the required knowledge, understanding and proficiency topics in Column 2, it has been noticed that there is no training requirement for the safe use of on-board LCS.

The relevant competences for master and chief mate in Table A-II/1 of the Code have also been reviewed together with the syllabus for the "Cargo handling and stowage at the management level". There is a training requirement for the use of automatic data-based equipment; however, there is no requirement for training in the safe use, maintenance, and certification of LCS.

The IMO has further developed IMO Model courses 7.01[19] and 7.03 [20] as guides to the training institutes to assist them in organizing their training courses[21]. These model courses are non-mandatory, but they are widely implemented in the course syllabi of training institutes worldwide. The proposed detailed teaching syllabi for both

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courses have been studied and it has been concluded that the IMO has not included any recommendation for familiarization of deck officers and the master with the safe use of LCS. Paragraph 2.1.2 of course 7.01 states that in the case of available loading instrument, trainees should be given an opportunity to use it, but there is no requirement for the trainer to introduce the relevant IMO and IACS hardware and software regulations concerning the certification, safe use, and performance verification of the LCS.

The IMO adopted a completely different approach to the transition from paper charts to electronic chart display and information systems (ECDIS). The generic course for the use of ECDIS is now part of the minimum standard syllabus for deck officers[22]. The "IMO Model Course 1.27 on the Operational Use of ECDIS" offers comprehensive instructions for such training. Additionally, IMO requires that each OOW pass type-specific training for the type of software used onboard.

D. Contemporary Training Approach Implemented in the Revised Syllabus in Cargo Handling and Stowage Course at the Nikola Vaptsarov Naval Academy

Analyzing the IMO regulatory gap regarding the LCS training and in view of their status of mandatory equipment on board of the most types of seagoing vessels, the syllabus in "Cargo stowage and handling" course in the NVNA has been updated in 2020 introducing mandatory training in the IMO and IACS regulations concerning LCS, and including series of practical classes with the use of loading software for different types of vessels.

The updated training concept is based on Inquiry-Based Learning (IBL)[23], with a focus on Active Learning[24], [25], and Collaboration and Communication. Students are encouraged to discuss and exchange ideas and findings during cargo stowage-planning tasks. Real-world Relevance increases trainees' perceptions of theoretical training[26]. A flowchart of the contemporary training syllabus is shown in Fig. 1.

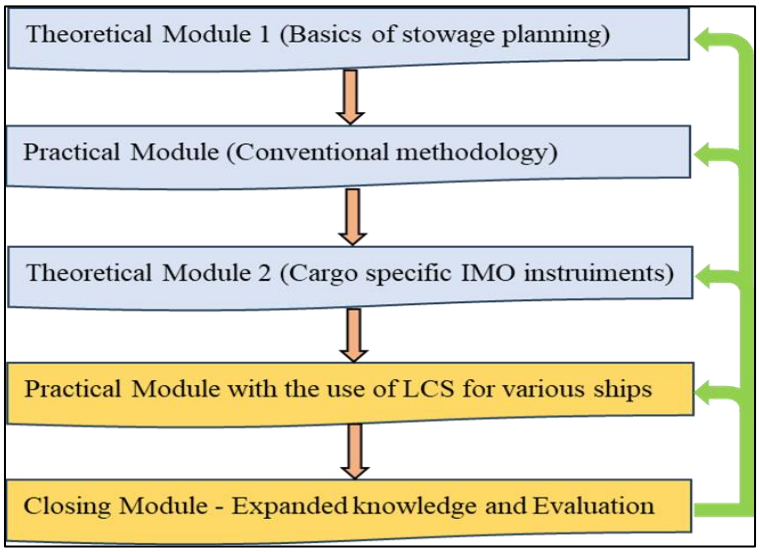

Fig 1 Flowchart of the Contemporary Training Syllabus

The *First training module* provides the necessary basic theoretical background. The *Second module* consists of practical classes during which trainees practice the conventional stowage-planning methodology using manual calculations, ship booklets, and drawings. The *Third module* is again theoretical and provides students with advanced knowledge of the IMO regulations, recommendations, and practices for the safe stowage and carriage of the main types of general cargo, liquid, and solid bulk cargo. The relevant IMO instruments are reviewed and explained to the trainees. The *Fourth module* is the contemporary innovative practical module, that introduces the LCS as the main tool for stowage planning. Students practice stowage planning for various types of vessels and cargo using approved loading software created for existing ships. Exercises developed by master mariners with extensive sea service are based on real-life voyage conditions and create a working environment as close as possible to the conditions faced by deck officers during stowage planning on board. Training is completed by the *Fifth module*, which provides the necessary flexibility to enable the trainer to evaluate the knowledge and competence achieved by the trainees and expand their practical and theoretical knowledge, as needed. References are made to the first four modules to improve the final training results.

E. Analysis of the Effect of the Applied Contemporary Syllabus on the Quality of Trainees' Education in Cargo Stowage and Handling

The new training approach proved to be very successful for both trainees and trainers, as it provided the necessary environment for IBL. Active Learning and the Real-world Relevance of the training contributed significantly to the learning objectives and expanded students' interest in the subject.

The average results of the trainees' final evaluations during the state examinations for the covered period from 2011 to 2024 are shown in Fig. 2. The Bulgarian evaluation system uses scores ranging from two (minimum) to six (maximum).

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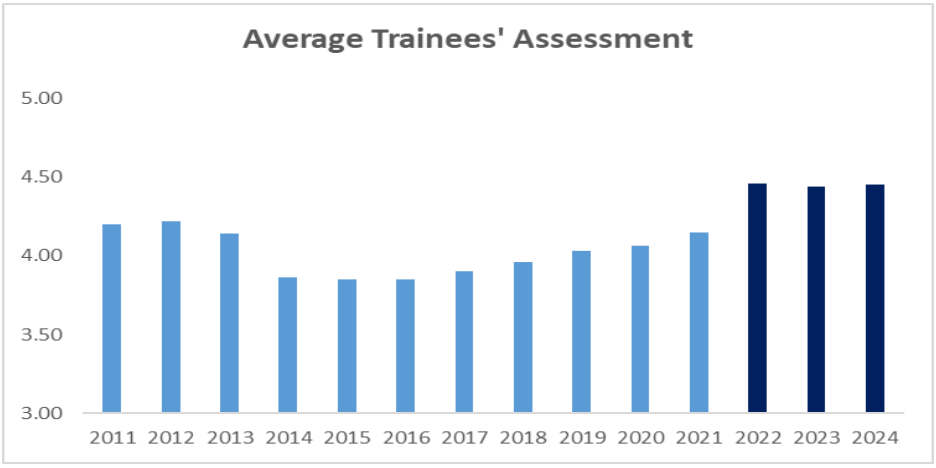

Fig 2 Average Training Assessment Results 2011-2024

There was a significant decrease in the results demonstrated by the students in 2014. The trainers responded by implementing modern teaching facilities, primarily multimedia applications. The training results improved, but not sufficiently, to restore levels prior to 2014. In the search for solutions, a contemporary approach was introduced in 2020. Initially, the positive effect was insignificant, with a small rise in 2021, possibly due to the objective disturbances of Covid 19. A noticeable positive effect was observed in 2022. Since then, this trend has remained relatively stable. The latest evaluation results were calculated for 2024.

As part of the quality system of the NVNA, students' opinions about the new syllabus were surveyed with the following question: "How useful do you think the practical classes on Loading Computer Systems have been for your training in Cargo stowage and handling?". The students were given the following possible answers:

- *Very useful*: The practical classes provided significant value and contributed greatly to my understanding and skills in Cargo stowage and handling. I feel confident applying the knowledge gained from these sessions to real-world situations.
- *Moderately useful*: The practical classes were helpful to some extent and contributed to my learning in Cargo stowage and handling, but there were areas where the impact was not as strong or could have been more comprehensive.
- *Neutral:* I neither feel that the practical classes were particularly helpful nor unhelpful in terms of my training in Cargo stowage and handling. The classes had some relevance, but overall, they did not have a significant impact on my learning or skills development.
- *Not very useful*: The practical classes had limited relevance or benefits to my training in Cargo stowage and handling. Some aspects of the classes did not fully address the practical skills needed or did not contribute significantly to my learning experience.
- *Not useful at all:* The practical classes did not provide any meaningful contribution to my training in Cargo stowage and handling. I found the classes irrelevant or ineffective in enhancing my understanding or skills in this area.

The survey results are shown in Fig. 3. The vast majority of students verified the effectiveness of the new syllabus (48% answered "very useful" and 39% "moderately useful").

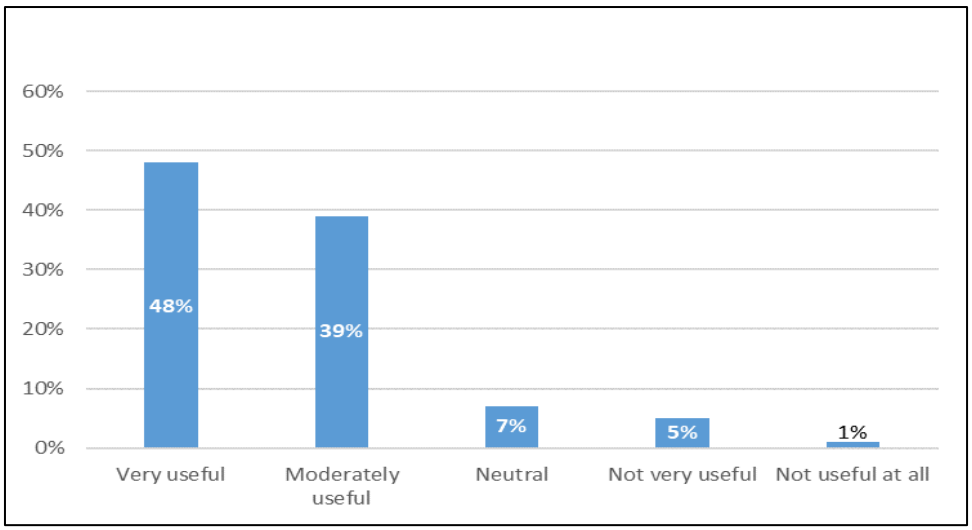

Fig 3 Survey Results on Students' Opinion on the Contemporary Syllabus in Cargo Stowage and Handling

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The analysis demonstrates that the implementation of the contemporary syllabus has significantly enhanced the quality of education in Cargo stowage and handling, with both evaluation results and qualitative student feedback affirming its effectiveness in fostering practical skills and real-world readiness among trainees.

IV. CONCLUSION AND RECOMMENDATIONS

This study highlights the importance of updating training methodologies for deck officers in cargo handling and stowage, particularly in the use of LCS. The contemporary approach implemented at the NVNA addresses the regulatory gap in IMO standards regarding LCS training. By incorporating mandatory training on IMO and IACS regulations concerning LCS and practical classes using loading software for various vessel types, the updated syllabus has shown promising results.

In conclusion, this study emphasizes the need for continuous improvement in maritime education and training, particularly in areas where technological advancements have outpaced existing regulatory frameworks. The success of the NVNA's updated syllabus suggests that similar approaches could be beneficial if implemented more widely in maritime education institutions globally.

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