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New Capabilities of the NTPRO 4000 Full Mission Ship Handling Simulator in the Assessment and Evaluation Processes at Lithuanian Maritime Academy

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ABSTRACT: Nowadays the equipment used on ships is becoming more and more sophisticated, safety of shipping depends heavily not only on trustworthiness of high-tech products, but also on mariners' competence. It is necessary to find methods to enable seafarers to keep track with technical developments. Simulators as a tool combined with a properly developed course curriculum and qualified instructors provide an appropriate method not only for training, but also for measuring, assessing and evaluating individual mariner performance in order to test levels of competency and proficiency. According to Nieri (1995, p. 1/6), "The development of performance-based assessment tools would utilize the widely-recognized advantages of simulators and part-task trainers to generate a scenario in which the license candidate must demonstrate his knowledge of system relationships, knowledge of operational procedures, monitor systems and situations, respond to unexpected occurrences, identify and diagnose problems, and manage personnel, in a dynamic world". This paper discusses the usage of new capabilities of the NTPRO 4000 full mission ship handling simulator in the assessment and evaluation processes at Lithuanian Maritime Academy.

1 INTRODUCTION

Simulators are widely used for different educational purposes, such as learning, training, research, formative and summative assessment and evaluation, not only in maritime education and training, but also in aviation, nuclear power plants (Ham et al., 2008), medicine: surgery (Cosman et al., 2002; Maithel et al, 2006), nursing (Decker et al., 2008). Simulations are example of technology enabling learning to be done more easily and effectively (Biggs & Tang, 2008) in a safe and controlled environment. As technology is developing rapidly the simulators become more popular educational mean.

Over last few decades there was a huge growth of automated navigation systems. More and more systems making navigator's job easier came on the scene. It has begun with global positioning systems (GPS) and nowadays grown into electronic chart display and information systems (ECDIS). There is no doubt that new sophisticated systems facilitate navigator's job and ensure safer navigation. For example, the study of Gould et al. (2009) proved that ECDIS appeared to improve navigation performance compared to conventional navigation based on paper charts. Although this fact was proved under normal conditions and more investigations should be under high-workload conditions and in the presence of other stressors. Habit to use sophisticated (automated) systems sometimes have negative impact to the qualification of the navigator, as captain can lose his proficiency in using usual navigational means because of permanent usage of automated navigation systems. It is obvious for the experienced navigators that modern navigation equipment today still is not perfect.

Refusing the traditional means of navigation, question of navigational safety may arise in case of the failure or malfunctions of automated navigation system, because during initial study stage attention to the traditional navigational tasks slacks as student contemplates that use of traditional navigational tasks is not relevant, but this can be designated as lack of navigators qualification, where qualifications are well-defined in STCW (Standards of Training, Certification and Watch keeping) convention.

Improvement of navigational systems tended to facilitate safer navigation and load of the additional

tasks to the navigator increased requirements to the qualification of seafarers. As a consequence teaching process and teaching aids had to be improved. So navigational simulators able to simulate different navigational situations and to ensure that student is able to clarify different solutions of navigational task and implement the very best solution in certain circumstances were implemented to education and training process of navigators.

Usage of simulators is the best solution for the analysis of the actions taken by the students during the performed tasks and for the understanding of the competence of students. The diagnostics and analysis of mistakes will allow avoiding possible mistakes, which may arise in different navigational situations.

During the education and training process most of the mistakes are analyzed theoretically before the usage of the simulator. However nowadays the instructors are practically able to allow students to make mistakes using technologies of the modern simulators and show the possible consequences of the mistakes to students without real damage to the environment. Possibility to observe mistakes during performance of special navigational tasks helps to make appropriate decision about the competence of the student not only in routine, but also in emergency situations.

NTPRO 4000 full mission ship handling simulator is used continuously in the process of education and training of navigators in Lithuanian Maritime Academy. Two years ago the new capability in TRANSAS NTPRO 4000 called the TRANSAS Evaluation and Assessment System (TEAS) was implemented. The new capability allows assessing objectively the correctness of an exercise performance by a trainee on NTPRO 4000 navigation simulator. This opportunity is used continuously during all learning process for the formative assessment. According to Brown & Glasner (1999), good assessment (formative or summative) has to be valid, reliable, practical, developmental, manageable, cost-effective, fit for purpose, relevant, authentic, closely linked to learning outcomes and fair. In formative assessment, the results are used to improve learning: students can make mistakes: "the error detection is the basis for error correction" (Biggs & Tang, 2007, p. 164). It's completely different in summative assessment and evaluation: the results of such an assessment are used to grade or certificate students at the end of a course or program. According to Biggs & Tang (2007), error no longer is there to instruct, as in formative assessment: error now signals punishment. That's why much more attention should be paid for the final examination, where complex assessment evaluates not only how each part of knowledge is soaked up, but also how all knowledge and skills are implemented in close to real situation in real time. The TEAS gives this possibility.

For two years the TEAS of NTPRO 4000 full mission ship handling simulator has been used for summative assessment and evaluation during final examination at Lithuanian Maritime Academy. The authors are still searching the ways to improve objectivity, validity and reliability of the final evaluation of the students. Some results of this experience are presented in the article.

2 MANDATORY MINIMUM REQUIREMENTS FOR CERTIFICATION OF OFFICERS

It is well-know that mandatory minimum requirements for certification of officers in charge of navigational watch are well-defined in STCW code. The code clearly states the standards of competence that every candidate for certification shall be required to demonstrate: the competence to undertake at operational level, the tasks, duties and responsibilities are listed in column 1 of STCW code table A-II/1; the minimum knowledge, understanding and proficiency required for certification is listed in column 2 of STCW code table A-II/1; the level of knowledge of subjects listed in column 2 of STCW code table A-II/1 shall be sufficient for officers of the watch to carry out their watch keeping duties; every candidate for certification shall be required to prove evidence of having achieved the required standard of competence in accordance with methods for demonstrating competence tabulated in columns 3 and 4 of STCW code table A-II/1.

With reference to above mentioned TRANSAS NTPRO 4000 simulator (especially the TEAS) is an appropriate solution solving the student's certification problems in LMA.

2.1 *Possible competency assessment using NTPRO 4000*

Most of the educational programs during the process of education and training of navigators are accomplished with reference to STCW code. The same requirement corresponds to assessment and evaluation process. Assessment and evaluation in accordance to STCW code requirements can be improved using the NTPRO 4000 TEAS because this system allows assessing the navigator's competences stated in STCW code (table 1).

Table 1. The list of competences, which could be assessed using NTPRO 4000 TEAS.

1. Plan and conduct a passage and determine position:
   - 1.1. Ability to determine the ship‘s position by use of:
   - 1.2. Ability to use navigational charts and publications, such as sailing directions, tide tables, notices to mariners, radio navigational warnings and ship’s routing information.(ECDIS systems are considered to be included under the term “charts”);
   - 1.3. Ability to determine the ship‘s position by use of electronic navigational aids;
   - 1.4. Ability to operate echo sounders and apply the information;
   - 1.5. Ability to determine error of the magnetic and giro compasses and to allow for such errors;
   - 1.6. Knowledge of steering control systems, operational procedures and change-over from manual to automatic control and vice-versa. Adjustment of controls for optimum performance;
   - 1.7. Ability to use and interpret information obtained from shipborn meteorological instruments;
   - 1.8. Knowledge of the characteristics of the various weather systems, reporting procedures and recording systems;
   - 1.9. Ability to apply the meteorological information available.

2. Maintain a safe navigational watch:
   - 2.1. Thorough knowledge of the content, application and intent of the International Regulations for Preventing Collisions at Sea;
   - 2.2. Thorough knowledge of the basic principles of keeping a navigational watch;
   - 2.3. Thorough knowledge of effective bridge team work procedures;
   - 2.4. The use of routeing in accordance with the General provisions on Ship‘s Routeing.

3. Use of Radar and ARPA to maintain safety of navigation:
   - 3.1. Performance including:
     - 3.1.1. Factors effecting performance and accuracy;
     - 3.1.2. Setting up and maintaining displays;
     - 3.1.3. Detection of misrepresentation of information, false echoes, sea return, etc., racons and SARTs;
   - 3.2. Use including:
     - 3.2.1. Range and bearing; course and speed of other ships; time and distance of closest approach of crossing, meeting overtaking ships;
     - 3.2.2. Identification of critical echoes; detecting course and speed of other ships; effect of changes in own ship‘s course or speed or both;
     - 3.2.3. Application of the International Regulations for Preventing Collisions at Sea;
     - 3.2.4. Plotting techniques and relative and true motion concepts;
     - 3.2.5. Parallel indexing;
   - 3.3. Principal types of ARPA , their display characteristics, performance standards and the dangers of over reliance on ARPA;
   - 3.4. Ability to operate and to interpret and analyze information obtained from ARPA, including:
     - 3.4.1. System performance and accuracy, tracking capabilities and limitations, and proceeding delays;
     - 3.4.2. Use of operational warnings and system test;
     - 3.4.3. Methods of target acquisition and their limitations;
     - 3.4.4. True and relative vectors, graphic representation of target information and danger areas;
     - 3.4.5. Deriving and analyzing information, critical echoes, exclusion areas and trial manoeuvres.

4. Respond to emergences
   - 4.1. Emergency procedures:
     - 4.1.1. Precautions for the protection and safety of passengers in emergency situations;
     - 4.1.2. Initial action to be taken following a collision or a grounding; initial damage assessment and control;
     - 4.1.3. Appreciation the procedures to be followed for rescuing persons from sea, assisting a ship in distress, responding to emergencies which arise in port.

5. Respond to a distress signal at sea;
   - 5.1. Knowledge of the contents of the IMO Merchant Ship Search and Rescue Manual (MERSAR).

6. Use the IMO Standard Marine Communication Phrases and use English in written and oral form;
   - 6.1. Adequate knowledge of the English language to enable officer:
     - 6.1.1. To use charts and other nautical publications;
     - 6.1.2. To understand meteorological information and messages concerning ship‘s safety and operation;
     - 6.1.3. To communicate with other ships and coast stations;
     - 6.1.4. To perform the officer’s duties with a multilingual crew;
     - 6.1.5. To use and understand the IMO Standard Marine Communication Phrases.

7. Transmit and receive information by visual signalling;
   - 7.1. Ability to transmit and receive signals by Morse light;
   - 7.2. Ability to use the international Code of Signals.

8. Manoeuvre the ship;
   - 8.1. Knowledge of ship manoeuvring and handling:
     - 8.1.1. The effects of dead-weight, draught, trim, speed and under keel clearance on turning circles and stopping distances;
     - 8.1.2. The effects of wind and current on ship handling;
     - 8.1.3. Manoeuvres and procedures for the rescue of person overboard;
     - 8.1.4. Squat, shallow water and similar effects;
     - 8.1.5. Proper procedures for anchoring and mooring

In most cases the basic ordinary training and assessment systems are applied. The process of basic training and assessment system is presented in fig. 1.

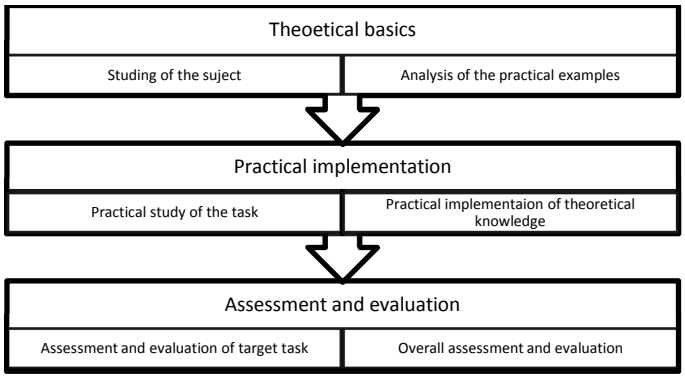

Figure 1. Basic training and assessment system in LMA.

The more detailed description of the certain exercise using NTPRO 4000 will be more complicated and will look like in fig. 2.

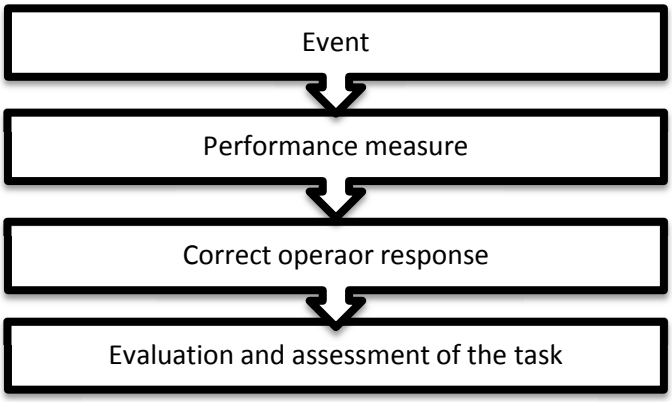

Figure 2. Detailed exercise.

Several exercises according to the number of competences intended to assess can be included to overall assessment (e.g. final examination). Evaluation of each exercise has its own particular weight and influences as a part of the overall assessment and evaluation the final decision about competency of the trainee.

The thorough explanation of typical example of above-mentioned detailed exercise is presented in fig. 3:

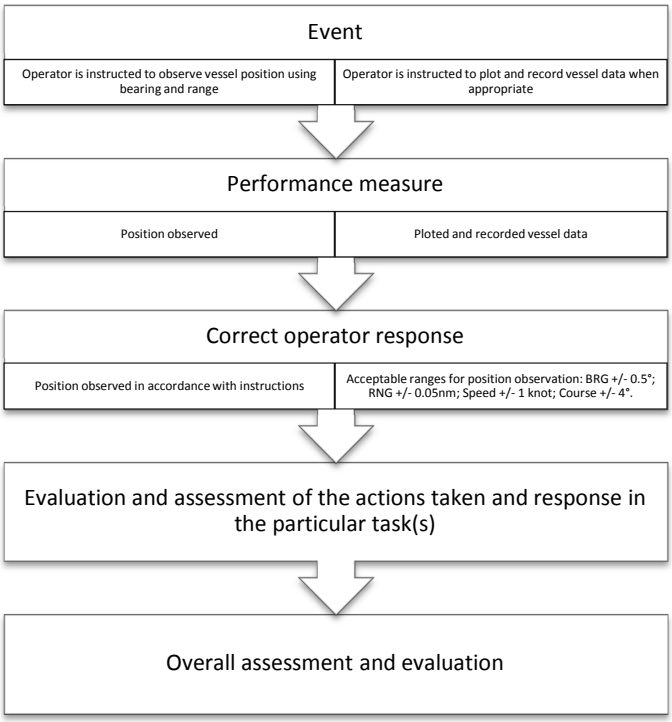

Figure 3. Example of detailed exercise.

It is important to mention that only above mentioned competencies (table 1) can be assessed and evaluated using NTPRO 4000 TEAS in present time, the other competencies defined in STCW code are evaluated in particular training during common examinations.

3 EVALUATION AND ASSESSMENT PROCESS USING NTPRO 4000 TEAS

Taking into consideration all the mentioned above, final decision for issuing the Certificate of Competency is made using the complex assessment.

Complex assessment involves competences mentioned in 2.1 (table 1) and additional competencies which were evaluated in particular training. The additional competences of the students, such as use of ARPA, ECDIS, usually are evaluated before the final examination using NTPRO 4000 by Lithuanian Maritime Safety Administration in accordance with IMO Model Course 1.07 for ARPA, and IMO Model Course 1.27 for ECDIS; and the results are the basis for the diploma of the competency. Although the assessment of mentioned competences is a part of complex assessment as the student must show his ability to implement all of competences required by STCW code, and especially use not only of automated navigation systems, but also the solutions of traditional navigational tasks in real time simulation.

The overall complex assessment and weight of assessed tasks can be presented in fig. 4.

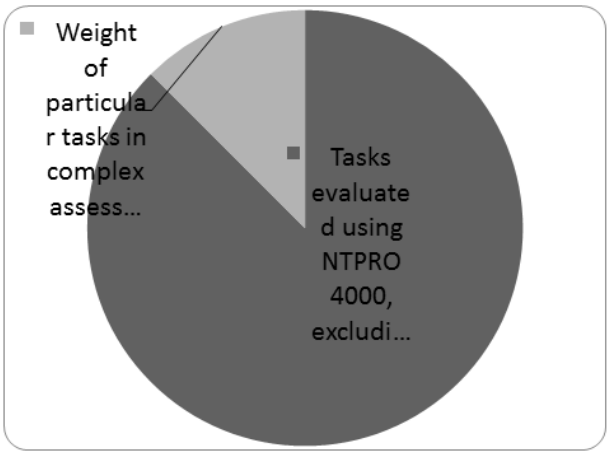

Figure 4. Overall complex assessment.

During all complex assessment process correct and incorrect actions and responses are electronically logged additionally and established paper log book is filled, as not all competences can be logged electronically.

It is important that employing TEAS the percentage system of evaluation should be applied; it means that student comes to assessment with the score of all competencies 100%, and later he gets penalty points for any failed navigational task. Penalty points are multiplied by weight of the task evaluated, so final evaluation result E can be expressed by formula:

$$E = 100 - (P_1 w_1 + P_2 w_2 + ... + P_n w_n) = 100 - \sum P_n w_n$$

Where: P_n – penalty point for appropriate task; w_n – weight of the penalty point.

If there is necessity in more accurate results of competence evaluation each task can be evaluated separately with its penalty points (applying the same formula), influencing final evaluation.

Detailed assessment chart is presented in fig. 5, extraction of the competence evaluation in overall complex assessment is presented in fig. 6.

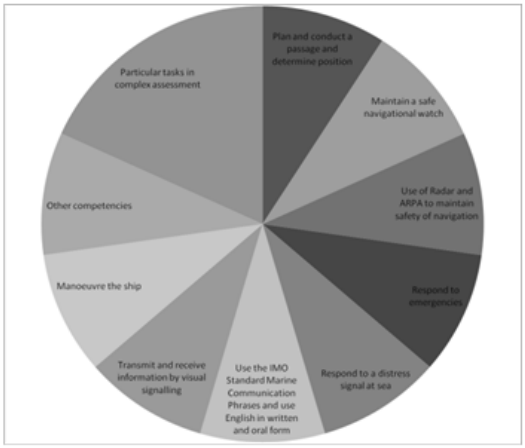

Figure 5. Detailed chart of complex assessment.

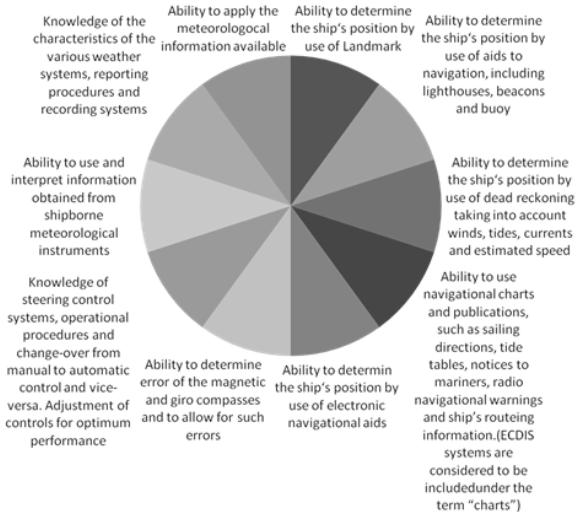

Figure 6. Extraction from overall complex assessment for "Plan and conduct a passage and determine position" competence.

During evaluation and assessment process all mentioned competencies in 2.1 (table1) are thoroughly checked, especially competencies used to solve traditional navigational tasks. As TEAS system electronic logbook, paper logbook is employed, the subjective assessors' opinion is minimized, and it allows making the very correct and objective decision about the competency and suitability for appropriate position of the student.

In other words the assessment using NTPRO 4000 is based on the on the check of the exercise fulfilment correctness with regard to the selected set of criteria. The criteria check consists in comparing the exercise "assessment parameters" to the set limit values according to the set "rule". At each moment of time a relative error is recorded (relative deviation of the "assessment parameter" from the limit values) and penalty points are calculated as a function of the relative error and the "error weight".

The overall sum of penalty points in the observation interval is calculated as a sum of penalties at each moment of time by each "assessment parameter".

The trainee competency is assessed in points (Score %) starting from 100% minus penalty score. The correctness of the exercise fulfilment can be assessed after the end of the exercise during the playback of the exercise log. The Training Report is created automatically at the moment when the log file is loaded. Competency assessment can be obtained in the process of the exercise and after its end as well. For the final assessment of the trainee competency, the "Passing score" is entered.

This process allows making objective judgement about student's competency and enable saving published the results for longer time.

4 PRACTICAL EXAMPLE

Extraction from practical evaluation and assessment of Use of Radar and ARPA to maintain safety of navigation is presented below. Ability to operate and to interpret and analyse information obtained from the radar, including factors affecting performance and accuracy of the trainee is tested.

The exercise is set in adverse visual and radar observation conditions (fog, rough se, rain). The trainee is assigned with a task to proceed in restricted waters with narrow passage making a 90° turn round the buoy (which becomes a reference point) at a set distance with a margin equal to the possible radar range measurement error. Penalty Charge value is entered.

The trainee must adjust the optimum radar picture quality, identify the buoy echo among the clutter and perform the required manoeuvre.

Evaluation is made through the exercise. Performance criteria – actual distance to reference point must be near the limit defined (if the actual distance exceeds defined limits, penalty charge are imposed, here in this example-30% if grounding occurs-70%).

Calculations of the assessment for this particular task will look as follows:

$$E_{radar} = 100\% - (P_l w_l + P_g w_g) = 100\% - (30 \cdot 1 + 100 \cdot 0{,}7) = 0$$

$$E_{radar} = 100\% - (P_l w_l + P_g w_g) = 100\% - (30 \cdot 1 + 0 \cdot 0{,}7) = 70$$

$$E_{radar} = 100\% - (P_l w_l + P_g w_g) = 100\% - (0 \cdot 1 + 0 \cdot 0{,}7) = 100$$

Where: P_l-penalty for exceeded limit, P_g-penalty if the grounding occurs, w-weight of the penalty in particular exercise.

As seen above, depending on the trainee's ability to accomplish exercise, he gets final evaluation for the particular task, which is a part of the complex assessment during final examination.

5 CONCLUSIONS

- During initial stage of study attention to the traditional navigational tasks slacks as student contemplates that use of traditional navigational tasks is not relevant.
- Use of navigation simulators enables to test all competencies in accordance with STCW code especially solving traditional navigational tasks, final examination using NTPRO 4000 TEAS based on methods described in the paper may be basis for certification of competency.
- Using TEAS the percentage system of evaluation is applied, it is predicted that student gets the score of 100% at the beginning of the assessment, and later points for any failed navigational task multiplied by weight are subtracted from initial 100 % in order to get final evaluation.
- Lithuanian Maritime Academy uses new capability of NTPRO 4000 not only during training process by performing formative assessment but also for the summative assessment and evaluation of students' competency during final examination.
- Assessors are representatives and persons approved by Lithuanian Maritime Safety Administration; this enables getting the Certificate of Competence after final complex assessment in Lithuanian Maritime Academy.

REFERENCES

Biggs, J., Tang, C. 2007. *Teaching for Quality Learning at University.* Berkshire: Society for Research into Higher Education & Open University press.

Brown, S., Glasner, A. 1999. *Assessment Matters in Higher Education: Choosing and Using Diverse Approaches.* Buckingham: Open University Press.

Cosman, P.H., Cregan, P.C., Martin, C.J., Cartmill, J.A. 2002. Virtual Reality Simulators: Current Status in Acquisition and Assessment of Surgical Skills. *ANZ Journal of Surgery 72:* 30-34.

Decker, S., Sportsman, S., Puetz, L., Billings, L. 2008. The Evolution of Simulation and its Contribution to Competency. *The Journal of Continuing Education in Nursing, 39(2):* 74-80.

Ham, D., Park, J., Jung, W. 2008. Evaluation of Human Interaction with Complex Systems Using a Full-Scope Simulator: Lessons Learned and Methodological Issues. *International Journal of Human-Computer Interaction, 24 (4)*: 361-384.

Gould, K.S., Roed, B.K, Saus, E.R., Koefoed, E.F., Bridger, R.S., Moen, B.E. 2009. Effects of navigation method on workload and performance in simulated high-speed ship navigation. *Applied ergonomics 40 (2009):* 103-114.

International Maritime Organisation. 2001. *International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended in 1995, (STCW 95).* London: Author.

Maithel, S., Sierra, R., Korndorffer, J., Meumann, P., Dawson, S., Cellery, M., Jones, D., Scott, D. 2006. Construct and face validity of MIST-VR, Endotower, and CELTS. Are we ready for skills assessment using simulators? *Surgical Endoscopy (2006) 20:* 104-112.

Matveevskii, A.S., Gravenstein, N. 2008. Role of Simulators, educational programs, and nontechnical skills in anesthesia resident selection, education and competency assessment. *Journal of Critical Care (2008) 23:* 167-172.

Nieri, D. S. 1995. Certification and licensing of mariners based on performance assessment. *Proceedings of the second international conference on engine room simulators ICERS 2, 05-09 June 1995:* 1-9. Rimouski: Canada.

Transas. 2005. *Navi-Trainer 4000 (v.4.5.1) Instructor manual.* Transas Ltd.