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The effect of preparatory bridge simulator training on development of situation awareness skills of watchkeepers

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Abstract. The paper deals with the concept of situational awareness of Officer of the Watch (OOW). For the purpose of the paper 100 accident investigation reports were analysed and it was concluded that lack of SA was a main contributing factor in the most of accidents. The issue of simulator training is also considered in the article. The analysis of STCW competencies and methods of competency demonstration for initial OOW certification was performed and it was found that a major part of competencies can be acquired through simulator training, including some of bridge watchkeeping competencies. Nowadays candidates for the first certification (cadets) join ships for their fist on-board training (OBT) without having any watchkeeping experience, so they have to acquire all relevant skills on board. Taking this into account, the authors propose to arrange preliminary bridge simulator training for cadets prior to their first OBT in order to develop basic watchkeeping and SA skills. The authors also consider the idea to reduce OBT time through appropriate simulator training. To support these ideas a group of acting seafarers was questioned and the data was processed with the use of fuzzy logic. According to experts' opinion, preliminary bridge simulator training can be useful for cadets, allowing them to develop initial situational awareness skills by 40%. However, experts do not consider that simulator training can effectively substitute actual on-board experience and as for their opinions OBT time can be reduced by 5.3 weeks only. Thus, the issue such reduction requires further detailed research.
Keywords: situational awareness, bridge simulator training, fuzzy logic, safety of navigation, watchkeeping, maritime education, shiphandling, certification

Влияние предварительной навигационной тренажёрной подготовки на развитие навыков владения ситуацией у вахтенных помощников

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Аннотация. В статье рассматривается понятие «владение ситуацией» применительно к несению ВПКМ навигационной вахты. В целях статьи было изучено 100 отчётов по расследованию аварий, и был сделан вывод, что недостаток владения ситуацией у ВПКМ является основным способствующим фактором в большинстве аварий. Также в статье был рассмотрен вопрос тренажёрной подготовки. Анализ компетенций и методов демонстрации компетентности, предписанных ПДНВ, показал, что значительная доля компетенций для первичного дипломирования ВПКМ может быть освоена за счёт прохождения тренажёрной подготовки, включая некоторые компетенции, относящиеся к несению навигационной вахты. В настоящее время кандидаты на первичное дипломирование (курсанты) отправляются на свою первую плавательную практику без какого-либо опыта несения вахты, поэтому им приходится осваивать все соответствующие навыки лишь на борту. Принимая это во внимание, авторы статьи предлагают проводить предварительную тренажёрную подготовку для курсантов до прохождения ими плавательной практики в целях развития базовых навыков владения ситуацией и несения вахты. Авторами также рассматривается идея сокращения плавательной практики за счёт организации подходящих тренажёрных курсов. Для оценки этих идей была опрошена группа экспертов, и результаты опроса были обработаны посредством нечёткой логики. По мнению экспертов, предварительная тренажёрная подготовка будет полезна для курсантов и позволит им развить навыки владения ситуацией на 40%. В то же время эксперты не считают, что тренажёрная подготовка способна заменить действительную практику на борту и, согласно их оценкам, возможное сокращение срока плавательной практики составляет 5,3 недель. Таким образом, вопрос сокращения продолжительности плавательной практики требует дальнейшего подробного исследования.
Ключевые слова: владение ситуацией, навигационный тренажёр, нечёткая логика, безопасность мореплавания, несение вахты, морское образование, управление судном, дипломирование

Introduction

The latest EMSA overview of marine casualties and incidents shows persistent decrease in the number of accidents at sea over the period of 2014-2020 [1]. At the same time, loss of control being the predominant type of accident constitutes around 30% of all casualties reported and remains almost at the same level in figures. The EMSA report also states that 20% of safety recommendations developed by investigations bodies relate to human factor, 49% of them being in regard to training and skills. Since the human factor role in maritime industry is significant, especially in its contribution to accidents, training-related issues demand to be considered in deep. The proportion of accidents due to Human error is shown below on Figure 1.

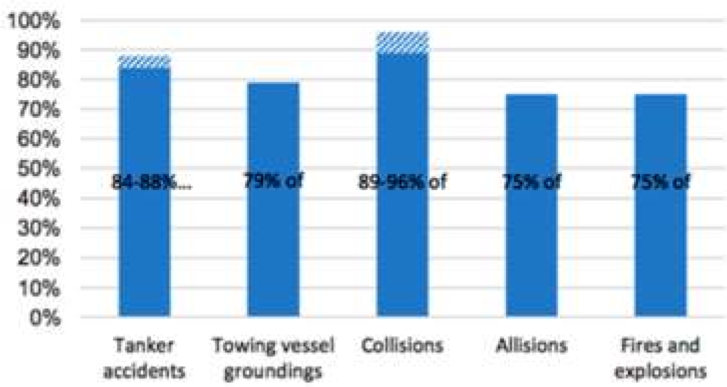

Fig. 1: Impact of Human error to accidents at sea
Source: [2]

The process of watchkeeper's decision making can be viewed from the perspective of situational awareness (SA), the concept of which was initially introduced by Endsley for Air Force domain [3]. To prove that situation awareness is a key safety factor for the officer of the watch (OOW), especially when performing high-risk operations, an intentional analysis of accidents has been completed and the results are presented in the article.

Nowadays, the practical training of deck officers comprises 12 months of on-board training (OBT), which is to meet the requirements provided by the STCW Code, section A-II/1, and shore-based training to acquire other corresponding competencies prescribed by the STCW Code. During on-board training, candidates for the first certification (cadets are to perform bridge watchkeeping duties under the supervision of the master or a qualified ship's deck officer over a period of at least 6 months. It must be noted that shore-based training, which relates to bridge watchkeeping (simulation bridge training), is usually arranged after cadets have already completed a part of on-board training.

So, when joining a ship for the first time, cadets usually do not have neither actual watchkeeping experience nor preliminary bridge simulator training completed and have to obtain the required skills during on-board training only. Depending on company requirements and the actual cadet's schedule on board, the effectiveness of their OBT may vary from ship to ship.

For the purpose of this article, a group of experts (acting seafarers) has been questioned regarding the effectiveness of simulator training arranged for cadets prior to their OBT, on the basis of SA-levels improvement potentially obtained as a result of such training. At the same time, an analysis of current STCW competencies, which candidates for first certification are to acquire, and the required methods to demonstrate these competencies, has been performed.The results of such a questionnaire can indicate the demand to modify the process of cadet training in order to enable them to acquire bridge watchkeeping and situational awareness skills prior to their on-board training, which would improve the effectiveness of their OBT. Taking into account the analysis of STCW competencies and demonstration methods, it could be assumed that some competencies could be acquired through shore-based simulation training and, therefore, the duration of OBT could be reduced.

The article contains the analysis of the questionnaire results with data processing methods and the outcomes relating to the above-mentioned issues.

Situational awareness: background and application to bridge watchkeeping

The concept of situation awareness (SA) was first introduced by Endsley M.R. in 1995, who defined it as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future."

Endsley considers SA to be a crucial part of decision-making, especially in complex and dynamic environments, and proposes a model that indicates the role of SA in the entire decision-making process (fig. 2).

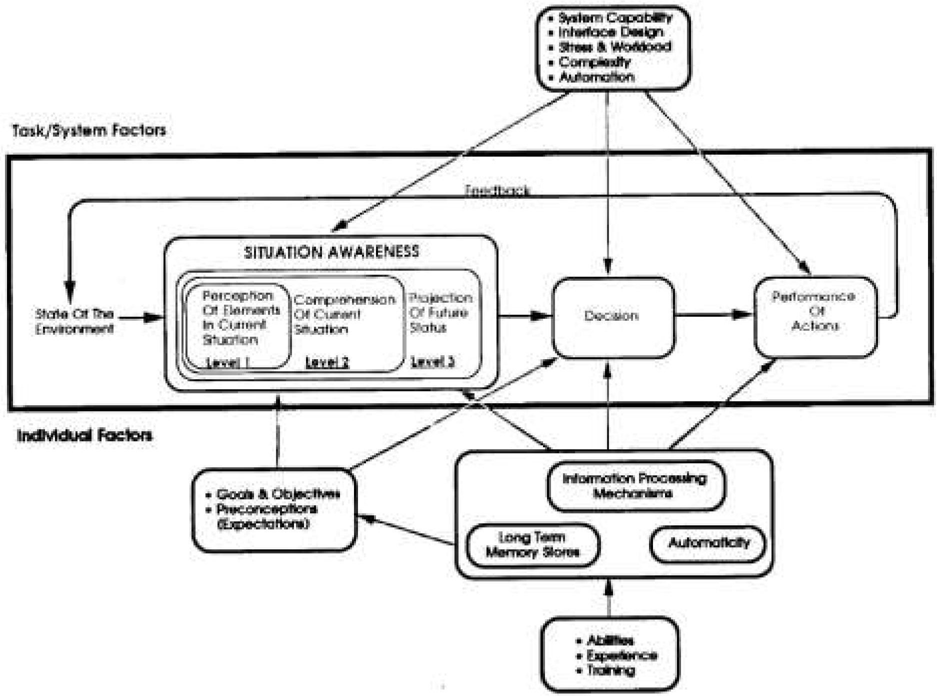

Fig.2: Model of situation awareness in dynamic decision-making [4]

As shown in Figure 2, situation awareness includes three levels: level 1 – perception of elements in the current situation; level 2 – comprehension of the current situation; and level 3 – projection of future status. Situation awareness is primarily based on goals and objectives to be achieved by the decision and depends on both environmental elements (e.g. system capability, interface design, stress and workload) and individual (human) information-processing abilities.

In Endsley's work, the concept of SA is being considered in the context of the Air Force domain. However, the theory itself and the model are applicable to many other activities, which incorporate the human element as a decision-making one, including the maritime sector.

The Officer of the Watch (OOW) on board a modern ship has to deal with a large amount of information every watch in order to be aware of the ship's position and her movement along the planned route, any dangers from the shipboard and external environments, functionality of the equipment, and so on. In other words, the OOW has always to be aware of the current situation and know the proper course of action to be followed in each period of time in order to attain the goal set.

Endsley's SA model for an OOW is presented in Fig. 3 and explained below.

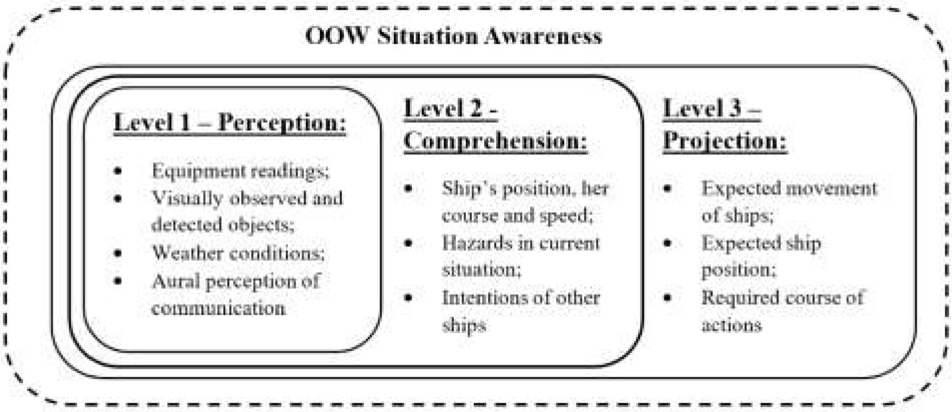

Fig.3: Endsley's SA model for OOW

Level 1 – being the first step to achieve SA, implies perception of elements. During the watch, OOW observes the surroundings both visually and with equipment, and can see other ships, land, coastal and navigational marks. Keeping GMDSS watch, the OOW receives information from shore stations, including navigational and weather warnings, and communication between other ships can also be heard. Looking at the ECDIS display, the OOW sees the chart information, including the plotted route, depth, and dangerous areas. Most important elements, such as ship's coordinates, course, and speed, can also be read either on the ECDIS display or from related equipment. Finally, readings from an echo sounder enable OOW to know under keel clearance.

Perception of elements is the main one among SA levels, since an important element unnoticed can lead to inadequate comprehension of the situation, false projection, and unsafe actions as a result.

Level 2 – Comprehension is the second step that implies integration of the information obtained at level 1. Perceived elements are assembled into an entire picture, enabling the OOW to comprehend and analyze the current situation. As a result, at this level, the OOW can realize if everything is going well so far, as expected, or if there is something new, or something to be concerned about.

For example, the OOW understands if the ship's position corresponds with an expected one, according to the plan, or if there is a deviation; if vessels in the vicinity present any imminent danger; and if the vessel is at a safe distance from land or if the under-keel clearance is sufficient.

Level 3 – Projection is the final level of SA before making a decision. At this stage, the OOW assesses the future development of the current situation, taking into account potential dangers to encounter which may turn into real ones. Prior to making a decision, the OOW considers different options to act upon and finally chooses the most appropriate one.

For example, realizing that the vessel is on a dangerous course towards the shore, the OOW can take the decision to alter the course, provided that the new one will keep the vessel safe. Or having assessed the movement of ships in the vicinity, the OOW can alter the course or change the speed to avoid potential danger, even if in the current situation there is no immediate threat.

According to the Endsley decision-making model shown in Figure 1, SA depends not only on environmental conditions but on individual qualities of the decision-maker as well. Therefore, the SA of individuals within the same conditions can differ depending on the officer's abilities, experience, and training. It is known that undesired states such as fatigue, stress, and overload impair the situational awareness of a human operator, increasing the risk of undesired events (near misses, incidents and accidents) [5].

Situational awareness: contribution to accidents

Accident statistics show that impairment or loss of situational awareness is a contributing factor in the majority of accidents. For the purpose of this study, the Global Integrated Shipping Information System (GISIS) has been addressed and data on marine casualties and incidents has been analyzed [6]. Thus, in this study, 100 investigation reports (see Table 1) on groundings and strandings have been examined to find out the main causes of accidents and contributing factors from the perspective of situational awareness. Among the reports studied, only one deals with a near-miss situation, while the rest relate to actual grounding (stranding) accidents. The results of the learning from the reports are summarized and presented below.

Table 1

Investigation reports analyzed in the study

Investigating body	MAIB (UK)	MCIB (Ireland)	PMA (Panama)	ATSB (Australia)	FBMCI (Germany)	SMSI (Sweden)	Misc. others
Number of reports	21	15	10	10	5	5	34

In fact, most accidents are complicated in their nature, being caused by various factors at different levels. At the same time, analysis of investigation reports allows one to derive primary causes and construct general scenarios for accidents.

The analysis of the investigation reports used in the study resulted in the following findings:

- In 12 cases (12%) OOW fall asleep on watch being fatigued or after alcohol consumption; also, in 2 cases OOW left the bridge;
- In 10 % inadequate anchoring took place, without due regard to current or expected weather conditions – there was no enough time for vessels to heave up anchor and proceed to safe waters;
- In 5% of reports an equipment or machinery failure is stated as the primary cause of grounding;
- In 6% vessels totally lost control having encountered adverse weather conditions;
- In 4% cases ships proceeded along a route, which had been plotted across shallow waters or just above a single danger; and
- in more than 50% of reports grounding accident occurred due to unsafe navigational decisions taken by OOW/Master or Pilot, who:
  - were not aware of immediate danger *(poor perception);*
  - did not monitor important factors, e.g. under-keel clearance or course over ground *(poor perception);*
  - exercised poor navigational watchkeeping without vigilant lookout *(poor perception)* and regular position fixing performed *(poor comprehension)*;
  - used inappropriate charts (which resulted in *poor perception*);
  - loss control on ship-handling *(*poor *comprehension)***;**
  - altered course without proper assessment of current and future situation *(poor comprehension & projection).*

The loss of the proper level of situation awareness by the OOW is related to the majority of maritime accidents. From this perspective, Table 2 summarizes the accident rate analysis. Inadequate perception of navigation information, i.e., a low quality environmental monitoring method, has the largest negative impact.

Table 2

Effect of SA on Navigational Accidents

Source	Loss of situation awareness (%)	Level 1: Lack of perception of information (%)	Level 2: Perceived information comprehension loss (%)	Level 3: Inadequate projection of the situation's development (%)
Grech & Horberry (2002), [7]	71	58,5 (of 71)	32,7 (of 71)	8,8 (of 71)
Sandhåland et al., (2015), [8]	78	72 (of 78)	22 (of 78)	6 (of 78)
Mohsen et al. (2014). [9]	>40	67 (of 40)	20 (of 40)	13 (of 40)
Endsley (1994a), [3]	88			
Wagenaar & Groeneweg (1987), [10]	93			

The findings above prove situational awareness of the operator to be a crucial factor for performing ship operations, especially high-risk ones which include coastal navigation, pilotage, and mooring. It also must be noted that, according to Ensley's model and data from Table 2, errors at the perception level lead to an incomplete understanding of the situation and therefore to inadequate projection, which eventually can lead to unsafe decisions.

First certificate of competency: STCW-provided competencies and methods of demonstration

According to STCW requirements [11], candidates who apply for the first Certificate of Competency (FCoC) in the course of training are to acquire competencies provided by the following paragraphs of the STCW Code:

- section A-II/1 (approved academic studies + on-board training)
- par. 2, section A-VI/1, par. 1-4, section A-VI/2, par. 1-4, section A-VI/3 and par. 1-3, section A-VI/4 (approved academic studies + shore-based training)

  For the competencies listed in section A-II/1 the following methods of competency demonstration are recognized by SCTW:

  1. Approved in service training (AIST);
  2. Approved training ship experience (ATSE);
  3. Approved simulator training where appropriate (ASTWA);
  4. Approved laboratory equipment training (ALET);
  5. Practical training (PT);
  6. Approved training on a manned scale ship model where appropriate (MMSM);
     and
  7. Modular training ashore (MTA) – used for competencies not listed in section A-II/1.

In the analysis of all competencies provided by Section A-II/1 and the corresponding methods of competency demonstration, the following ratios are obtained, see fig. 4:

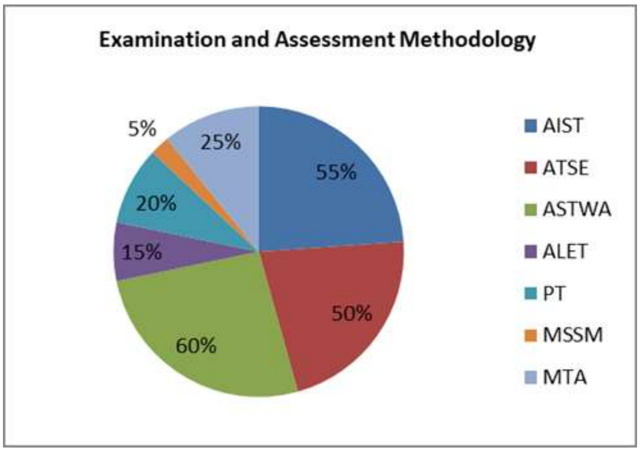

Fig.4: Methods of competency demonstration (STCW Code, Section A-II/1)

From Fig. 4, it is clear that the majority of competencies are obtained through approved simulator training where appropriate.

In accordance with STCW provisions, the functions of competency for the first certification are as follows, (see Table 3):

Table 3

Functions of Competency (STCW, Section A-II/1)

Function	Part of the total
Navigation	50%
Cargo handling	10%
Ship operation control	40%

A full range of examination and assessment methodologies can also be considered in relation to functions of competencies, the results being integrated in Fig. 5:

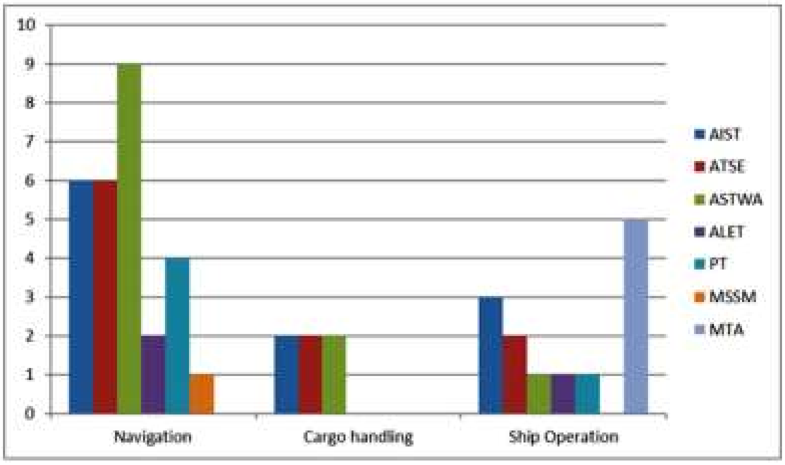

Fig. 5: Functions of competency with corresponding methods of competency demonstration

As seen from Fig. 5, about half of the "Navigation" competencies can be acquired through ASTWA, while the remaining ones require service on board training or non-training ship. Around 1/3 of competencies contained in "Cargo handling" function can be developed through simulator training. It should also be noted that a major part of the "Ship operation control" competencies can be acquired through modular training ashore.

Today, a move towards extensive simulation training that substitutes a part of sea-going service is observed in the UK, where a new cadet simulator training program and assessment were recently introduced [12]. According to the new arrangements, training in a full mission bridge simulator can be credited as on-board service based on the following ratios:

- 5 days in a full mission bridge simulator for 15 days of seagoing service;
- 10 days in a full mission bridge simulator for 30 days of seagoing service;
- 20 days in a full mission bridge simulator for 60 days of seagoing service

The simulator training is implemented as a part of the Bridge Watchkeeping Skills Simulator Course and implies intensive training within an artificial decision-making environment with a number of different scenarios that could not be encountered during on-board service.

Thus, cadets would be provided with appropriate knowledge and skills related to bridge watchkeeping duties in accordance with the relevant requirements. However, according to this system, a maximum of 2 months of on-board training can be substituted through simulator course attendance.

As a basis for the development of the program, Article IX "Equivalents" was used. It should be noted that this Article does not imply an explanation that the equivalents used are in accordance with the requirements of the STCW Convention.

Improvement of situational awareness as a result of preliminary simulator training: expert's opinion

Nowadays, equipment-related training (relating to the use of navigational equipment) is arranged for candidates after they have already completed a part of the training on-board. It means that when joining a ship for their first OBT, cadets have neither actual watchkeeping experience nor preliminary simulator training completed prior to joining, and they have to develop all their navigational skills from "zero". Taking into account the potential improvement of watchkeeping situational awareness in the effect of simulator training, it may be assumed that in the event that cadets attend qualitative bridge simulator training before joining a ship, their watchkeeping skills would be developed to some extent, which would enable them to acquire more required skills and experience by the end of their OBT.

To prove or refute this assumption, a group of experts who are acting seafarers have been questioned. The group consisted of 237 respondents, among whom 177 were Masters and Chief Officers with 10+ years of onboard experience, which makes their opinions quite valuable.

The questionnaire comprised several questions, but for the purpose of the article, only two of them are presented below, with experts' opinions illustrated, see Figures 6 and 7.

Question 1

«In your experience and compared to onboard training (OBT) of cadets, ***what is the simulator training contribution*** *(to choose % interval) in acquiring the following professional skills for performing the OOW duties:*

(a) ***perception of information****: it encompasses how OOW undertakes look-out duties, detects and correctly recognizes important objects in a timely manner, correctly concentrates attention…;*

(b) ***comprehension of perceived information****: it encompasses how OOW combines, interprets, stores, retains information, and identifies hazards /dangerous situations…;*

(c) ***projection of navigational situation development*** *for a certain time interval: what will happen if...?*

(d) ***ability of decision-making**: timely, effective and optimal decision-making;*
(e) ***carrying out the safety actions**: timeliness and correctness.*

Experts' opinions regarding question 1 are compiled in Figure 6.

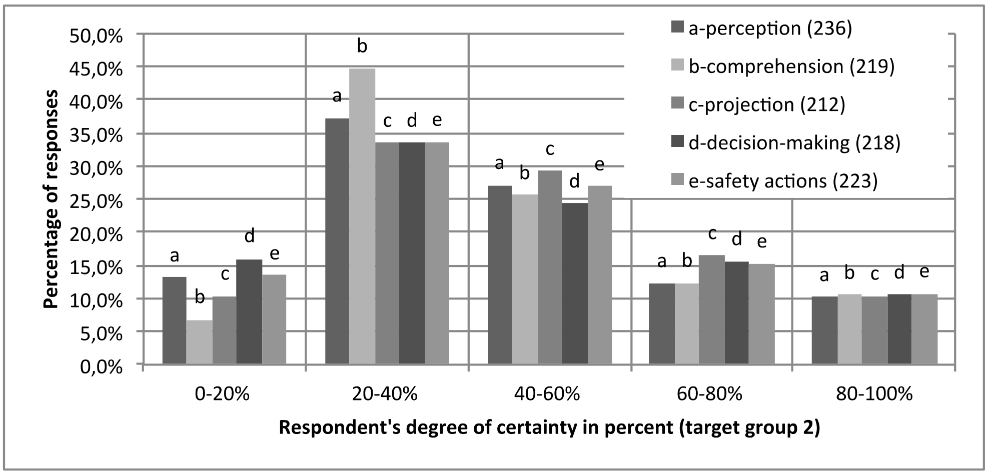

Fig.6: Improvement of SA as a result of simulator training, experts' opinion (Question 1:a,b,c)

Question 2

«Do you agree with the view that pre-training experience of prospective officers (cadets) with use of simulators allows the possible reduction of the STCW sea-time requirement for OBT (less than 12 months) for certification purposes (First CoC to OOW)? If you select "agree" or "strongly agree", enter the number of weeks for possible reduction of sea-time (e.g., M, 2 weeks).

Experts' opinions regarding question 2 are presented in Figure 7.

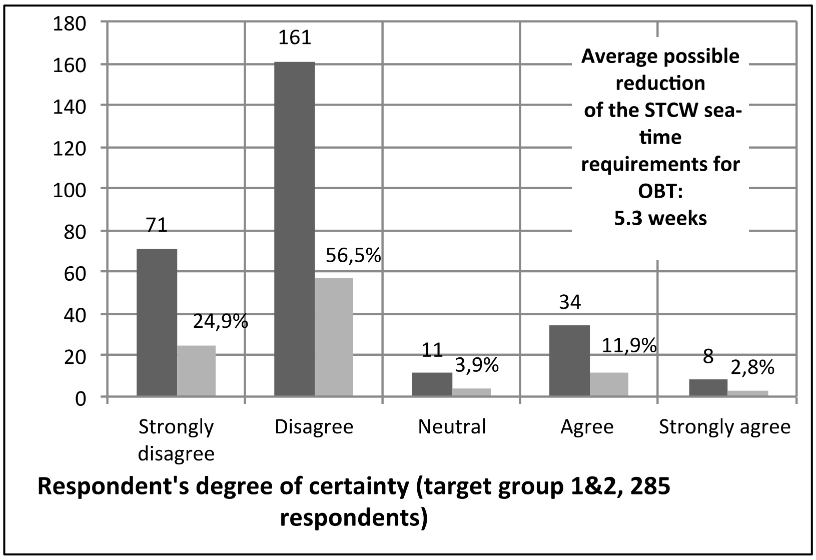

Fig.7: Experts' opinion on possible reduction of OBT following by simulator training (Question 2)

Data processing

For the purpose of the article, experts' opinions regarding Question 1 (a, b, c) have been processed in order to obtain a more distinct value for each level of SA and the overall SA improvement expected as a result of simulation training.

To achieve it, the following procedure was followed:

1. Since all experts were divided into three groups: Masters (M), Chief Mates (C) and OOW (O), and since it was known how many and which experts chose a particular answer, there was a possibility to assess the opinions of *each group regarding each level of SA separately*. For convenience, each level of SA is assigned a letter, in the same way as in Question 1: A stands for perception, B stands for comprehension, and C stands for projection.

Table 4 and explanations below demonstrate the methodic used in the analysis.

Table 4

Level of Perception (A), Masters

	0-20 (%)	20-40 (%)	40-60 (%)	60-80 (%)	80-100 (%)	In total
Quantity of answers	6	18	19	4	0	47
Weight	0,128	0,383	0,404	0,085	0	

Depending on the quantity of answers, each interval was weighted, which enabled us to calculate a weighted average interval (WAI), based on the current distribution of answers.

To obtain the WAI, extreme (min and max) interval values were calculated. For this purpose, min and max values of the given intervals were averaged out with regard to the pre-computed interval weight (see Table 4).

Thus, $A^M_{min} = 1{\cdot}0{,}128 + 20{\cdot}0{,}383 + 40{\cdot}0{,}404 + 60{\cdot}0{,}085 = 29{,}048 \approx 29{,}0$ %, and
$A^M_{max} = 20{\cdot}0{,}128 + 40{\cdot}0{,}383 + 60{\cdot}0{,}404 + 80{\cdot}0{,}085 = 48{,}92 \approx 49{,}0$ %
Therefore, WAI (Perception, Masters) ≈ [29, 49] %.

In the same manner, the rest of the 8 WAIs were calculated and the results are presented in Table 5.

Table 5

Weighted Average Intervals of Expected SA Level Improvement, group opinions

	Masters	Chief Officers	OOW
Perception	29– 49 %	30 – 50 %	23,5 – 43,5 %
Comprehension	30 – 50 %	30 – 50 %	24 – 44 %
Projection	31,5 – 51,5 %	28 – 48 %	31 – 51 %

2. The weights assigned to the intervals in Step 1 were computed with regard to answer distribution only, so the current task is to consider both the quantity of answers and expert competency.

On the basis of SCTW requirements for minimum service in rank, new weights can be assigned to these groups; for example, a candidate for a Master's license has at least three years of sea service, for a Chief Officer's CoC, only two years is required, and a candidate for an OOW certificate of competency is to have only 1 year at sea, as a cadet.

Therefore, the new weights are assigned as follows, see Table 6.

Table 6

Weight coefficients for ranks

Rank	Coefficient
Master	0,500
Chief Officer	0,333
OOW	0,167

A fuzzy model was then created to yield WAIs for each level of SA, taking into account both answer distribution and expert experience (see Figure 8).

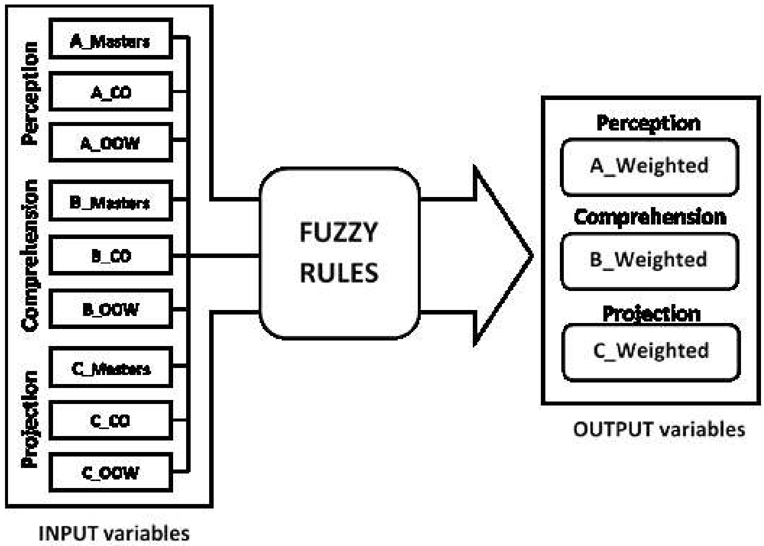

Fig.8: Fuzzy model for assessing improvement of SA levels in the course of simulator training based on experts' opinion.

The model, built on *Fuzzy Logic Toolbox* software, contains 9 input variables (opinions of each group on each SA level) and 3 output variables (which contain weighted values for each SA level).

Membership functions (MFs) for the model were chosen so that to fit the intervals given by the Questionnaire as the answer options (see Fig. 5), and triangular type of MFs proved to be the most appropriate one. The following considerations were taken into account prior to plotting the MFs:

- The top vertice of a triangular MF should match the middle point of the corresponding interval (in this point the degree of membership should be equal to 1), as it is assumed by the authors that when choosing the interval the experts focused on its middle, rather than extreme values;
- The degree of membership should be equal to 0.5 at the interval limits.

With regard to these points, MFs were plotted for the given intervals. The both input and output variables contain absolutely identical MFs. The example of MF is shown in Figure 9.

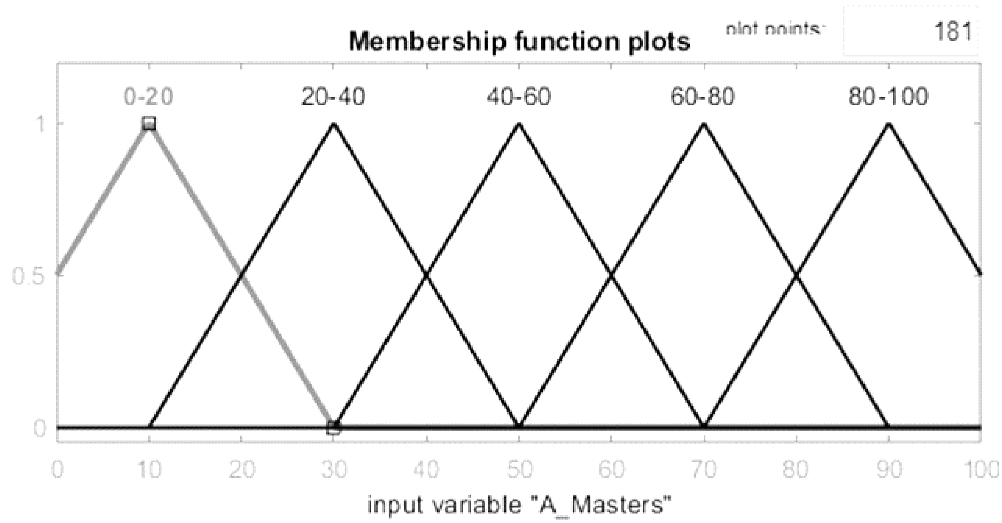

Fig.9: Input variable “A_Masters”: membership functions
Capture from Fuzzy Logic Toolbox (MATLAB)

For the model 45 rules were developed and weighted in accordance with Table 5; examples for the first input and output variable are shown below:

1. If «A_Masters» is 0-20, than «Weighted_Perception» is 0-20 (0.5);

2. If «A_Masters» is 20-40, than «Weighted_Perception» is 20-40 (0.5);

5. If «A_Masters» is 80-100, than «Weighted_Perception» is 80-100 (0.5);

In the same manner the rules were created for the rest variables in the model.

3. To obtain the crisp outputs in the model, the input crisp values were taken from Table 4 for all 9 variables. First, the minimum extreme values were entered into the system, and the resulting output values were noted, and the same was done for the maximum extreme values.

Finally, weighted average value of each SA level, defining the expected improvement was obtained: **A^W ≈ [29÷48] %; B^W ≈ [29÷49] %; C^W ≈ [31÷51] %.** Assuming that answers concentrate around the middle of intervals in the questionnaire (e.g. [20-40] % means something around 30%), the expected improvement of SA levels can be expressed in more distinct values: **A^W ≈ 38,5 %; B^W ≈ 39,5 %; C^W ≈ 41 %,** and it can be concluded that overall improvement of situational awareness by means of preliminary simulator training would be **around 40%.**

Discussion

Questionnaire data processing results show that, according to experts’ opinion, in the simulation training arranged prior to OBT, an overall improvement of situational awareness levels constitutes around 40%, and the same is true for each SA level.

However, most experts do not consider such improvement as a prerequisite for the reduction of OBT time, referring to Question 2 and Figure 6. The respondents were requested to explain their answers, and the major part of their arguments against the reduction of OBT time stated that simulator training could be appropriate for familiarization purposes only and that nothing would replace actual navigational watch experience. As some experts stated, the simulation environment is absolutely safe and in case of failure, any task can be restarted, unlike in real-world situations where the cost of an error could be much higher. Thus, the absence of real danger and psychological pressure automatically increases the trainee's confidence in simulated conditions. However, as for some experts' opinion, it has nothing to do with actual watchkeeping.

At the same time, some experts consider that preliminary simulation training can be effective for cadets but only restricted to bridge watchkeeping because all other activities can be effectively learned only in the course of OBT. Thus, based on experts' opinion, the overall reduction of OBT through preliminary simulator training constitutes only 5.3 weeks on average.

However, ratios presented in Figures 3 and 4 indicate that around half of the required competencies can be acquired through simulation training, including those, which relate to the "Navigation" function of competency.

As a positive outcome, it can be concluded that preliminary simulation training arranged for cadets prior to their OBT commences will be beneficial in developing the situation awareness skills of those who have never been on board. If the training system is revised, this issue should be taken into account.

Experts who took part in the questionnaire in general have incredulous opinions regarding the reduction of OBT, which leaves a demand for further research in this area.

Conclusion

Nowadays most of marine incidents and accidents are caused by human element and many of safety recommendations relate to seafarers' training and skills. It is consistent, because in the ever-changing world standards of education and training also have to be up to date.

In the article it is shown that navigational errors are the primary cause of most groundings and other accidents resulting from a watchkeeping officer's lack of situation awareness and the lack of perception of navigational information being the first stage of SA impairment of consistency of mental information processing by OOW. Ensley's decision-making model, presented in the article, indicates that the level of SA depends both on environmental factors and personal ones, which include abilities, level of training, and skills.

Today, candidates for first CoC are to complete 12 months of on-board training service followed by shore-based training modules. However, when joining a ship for the first time, cadets usually have no experience of watchkeeping and no relevant skills.

A group of more than 200 experts who are acting seafarers has been questioned regarding the potential improvement of SA-levels developed through preliminary simulator bridge training arranged for cadets before they join ships for their first OBT. In experts' opinion, such simulator training arranged before the OBT contributes to a 40% overall improvement in SA. However, in experts' opinion, simulators may be good for familiarisation purposes, but they cannot substitute actual on-board training. Overall, the reduction of OBT due to simulation training might be around 5.3 weeks on average, which consists of 10% of the STCW 78 requirements. In principle, this is a completely realistic assessment that can serve as a prerequisite for further research.

The STCW Code competencies for first OOW certification have also been analyzed in the article, and the obtained results indicate that around half of the competencies for "Navigation" and "Ship operation control" functions at operational level can be acquired through shore-based training, including simulators.

Onboard ships, cadets are the conductors of new ideas and technologies that they have received in MET institutions. That is why the passing of their simulator training ashore before training onboard can have a mutually positive effect, both for the cadets themselves and for the crews of the ships on which they are training, due to mutual enrichment by knowledge and the easier and more effective involvement of ship's officers in cadets' training programs.

To improve the overall effectiveness of the training programs, it may also be appropriate to slightly modify the structure of the cadets' Training Record Book by adding AST (simulator) appropriate items in it, taking into account the competencies that fit the watch keeping duties.

Considering the results obtained in the study, it can be concluded that simulation bridge training arranged for cadets prior to on-board training improves their situational awareness skills and the quality of their on-board training. However, the issue of reducing OBT by means of arranging qualitative simulator training requires further detailed research.

References

1. Preliminary annual overview of marine casualties and incidents 2014-2020 s.l. – Text : electronic // European Maritime Shipping Agency : website. – 2021, April. – URL: https://safety4sea.com/wp-content/uploads/2021/04/EMSA-Preliminary-Annual-Overview_2021_-04.pdf (date of application: 10.11.2021).
2. Strategy, planning and reform : trends, developments and challenges facing the IMO in the 2018-2023 period. – 2016, May. – C 116/4/1, COUNCIL 116th session. – 51 p. – Text : direct.
3. Endsley, M. R. A taxonomy of situation awareness errors / M. R. Endsley. – Text : electronic // Paper presented at the Western European Association of Aviation Psychology 21st Conference, Dublin, Ireland. – 1994a, March. – URL: https://www.researchgate.net/publication/14378491 (date of application: 12.01.2022).
4. Endsley, M. R. Toward a theory of situation awareness in dynamic systems / M. R. Endsley. – Text : direct. // Human factors : the journal of the human factors and ergonomics society. – 1995. – Vol. 37.1. – P. 32-64. – DOI 10.1518/001872095779049543.
5. Enhancing situational awareness / M. Pico, D. Hoogervegt, R. Bik [et al.]. – Text : electronic // Maritime Symposium Rotterdam : website. – 2015. – URL: http://www.maritimesymposium-rotterdam.nl/uploads/Route/ENHANCING%20SITUATIONAL%20AWARENESS.pdf (date of application: 12.01.2022).
6. Global integrated shipping information system. – Text : electronic // GISIS : website. – URL: https://gisis.imo.org (date of application: 15.12.2021).
7. Grech, M. Human error in maritime operations: situation awareness and accident reports / M. Grech, T. Horberry. – Text : direct. // Paper to be presented at the 5th International Workshop on Human Error, Safety and Systems Development, Newcastle, Australia, 2002.
8. Sandhåland, H. Situation awareness in bridge operations / H. Sandhåland, H. Oltedal, C. Eid. – Text : electronic // A study of collisions between attendant vessels and offshore facilities in the North Sea. – Department of Maritime Studies, Stord/Haugesund University College, Bjørnson, 2015. – DOI 10.1016/j.ssci.2015.06.021. – URL: https://www.researchgate.net/publication/281437894_Situation_awareness_in_bridge_operations__A_study_of_collisions_between_attendant_vessels_and_offshore_facilities_in_the_North_Sea (date of application: 16.12.2021).
9. Naderpour, M. A situation risk awareness approach for process systems safety / M. Naderpour, J. Lu, G. Zhang. – Text : electronic // Decision systems and e-service intelligence laboratory Centre for quantum computation & intelligent systems, school of software faculty of engineering and it, university of technology, Sydney PO Box 123, Broadway NSW 2007 Australia. – DOI 10.1016/j.ssci.2013.12.005 // Open Publications of UTS Scholars : website. – 2014. – URL: https://opus.lib.uts.edu.au/bitstream/10453/32967/4/2013001434.pdf (date of application: 16.12.2021).
10. Wagenaar, W. A. Accidents at sea: Multiple causes and impossible consequences / W. A. Wagenaar, J. Groeneweg. – Text : electronic // International journal of Man-Manchine Studies. – 1987. – Vol. 27. – P. 587-598. – DOI:10.1016/S0020-7373(87)80017-2. – URL: https://www.researchgate.net/publication/222872097_Accidents_at_Sea_Multiple_Causes_and_Impossible_Consequences (date of application: 16.12.2021).

11. IMO International convention on standards of training, certification and watchkeeping for seafarers, s.l. – Text : electronic // International Maritime Organization : website. – 2017. – URL: https://www.imo.org/en/OurWork/HumanElement/Pages/STCW-Convention.aspx (date of application: 21.01.2022).
12. IMO STCW.2/Circ. 92, s.l. – Text : electronic // International Maritime Organization : website. – 2020. – URL: http://shippingregs.org/Portals/2/SecuredDoc/Circulars/STCW.2-Circ.92.pdf?ver=2020-07-09-103844-953 (date of application: 23.01.2022).

Список литературы

1. Preliminary annual overview of marine casualties and incidents 2014-2020 s.l. – Text: electronic // European Maritime Shipping Agency : website. – 2021, April. – URL: https://safety4sea.com/wp-content/uploads/2021/04/EMSA-Preliminary-Annual-Overview_2021_-04.pdf (date of application: 10.11.2021).
2. Strategy, planning and reform : trends, developments and challenges facing the IMO in the 2018-2023 period. – 2016, May. – C 116/4/1, COUNCIL 116th session. – 51 p. – Text : direct.
3. Endsley, M. R. A taxonomy of situation awareness errors / M. R. Endsley. – Text : electronic // Paper presented at the Western European Association of Aviation Psychology 21st Conference, Dublin, Ireland. – 1994a, March. – URL: https://www.researchgate.net/publication/14378491 (date of application: 12.01.2022).
4. Endsley, M. R. Toward a theory of situation awareness in dynamic systems / M. R. Endsley. – Text : direct. // Human factors : the journal of the human factors and ergonomics society. – 1995. – Vol. 37.1. – P. 32-64. – DOI 10.1518/001872095779049543.
5. Enhancing situational awareness / M. Pico, D. Hoogervegt, R. Bik [et al.]. – Text : electronic // Maritime Symposium Rotterdam : website. – 2015. – URL: http://www.maritimesymposium-rotterdam.nl/uploads/Route/ENHANCING%20SITUATIONAL%20AWARENESS.pdf (date of application: 12.01.2022).
6. Global integrated shipping information system. – Text : electronic // GISIS : website. – URL: https://gisis.imo.org (date of application: 15.12.2021).
7. Grech, M. Human error in maritime operations: situation awareness and accident reports / M. Grech, T. Horberry. – Text : direct. // Paper to be presented at the 5th International Workshop on Human Error, Safety and Systems Development, Newcastle, Australia, 2002.
8. Sandhåland, H. Situation awareness in bridge operations / H. Sandhåland, H. Oltedal, C. Eid. – Text : electronic // A study of collisions between attendant vessels and offshore facilities in the North Sea. – Department of Maritime Studies, Stord/Haugesund University College, Bjørnson, 2015. – DOI 10.1016/j.ssci.2015.06.021. – URL: https://www.researchgate.net/publication/281437894_Situation_awareness_in_bridge_operations__A_study_of_collisions_between_attendant_vessels_and_offshore_facilities_in_the_North_Sea (date of application: 16.12.2021).
9. Naderpour, M. A situation risk awareness approach for process systems safety / M. Naderpour, J. Lu, G. Zhang. – Text : electronic // Decision systems and e-service intelligence laboratory Centre for quantum computation & intelligent systems, school of software faculty of engineering and it, university of technology, Sydney PO Box 123, Broadway NSW 2007 Australia. – DOI 10.1016/j.ssci.2013.12.005 // Open Publications of UTS Scholars : website. – 2014. – URL: https://opus.lib.uts.edu.au/bitstream/10453/32967/4/2013001434.pdf (date of application: 16.12.2021).
10. Wagenaar, W. A. Accidents at sea: Multiple causes and impossible consequences / W. A. Wagenaar, J. Groeneweg. – Text : electronic // International journal of Man-Manchine Studies. – 1987. – Vol. 27. – P. 587-598. – DOI:10.1016/S0020-7373(87)80017-2. – URL: https://www.researchgate.net/publication/222872097_Accidents_at_Sea_Multiple_Causes_and_Impossible_Consequences (date of application: 16.12.2021).
11. IMO International convention on standards of training, certification and watchkeeping for seafarers, s.l. – Text : electronic // International Maritime Organization : website. – 2017. – URL: https://www.imo.org/en/OurWork/HumanElement/Pages/STCW-Convention.aspx (date of application: 21.01.2022).

12. IMO STCW.2/Circ. 92, s.l. – Text : electronic // International Maritime Organization : website. – 2020. – URL: http://shippingregs.org/Portals/2/SecuredDoc/Circulars/STCW.2-Circ.92.pdf?ver=2020-07-09-103844-953 (date of application: 23.01.2022).

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