HUMAN ERRORS IN ECDIS RELATED ACCIDENTS

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ABSTRACT

With the mandatory introduction of ECDIS navigation system (starting on 1st July 2012 for the new passenger ships over 500 GT and new tankers over 3000 GT, in force until 1st July 2018, terms depending on the type of vessel and GT), its role has become dominant in the process of maritime voyage planning and realization. Maritime accidents caused by navigational errors are in many ways related to the use of ECDIS. This includes its insufficient usage in planning and realization of the voyage, inadequate implementation of ECDIS in SMS, or ECDIS features that allow unwanted interaction of specific security functions and therefore cause their inoperability. The purpose of this paper is to determine the deck officers' level of knowledge and usage of ECDIS by means of analysis of their ability to use the system and their understanding of the ECDIS safety functions settings. With this in mind, a single-blind study was designed and implemented, during which participants using Transas ECDIS system showed their skills in a practical example of voyage planning and realization. Also, they gave answers to the questions in the corresponding survey. The practical task included the creation of the navigational route Rotterdam PS - Ceuta PS for the ship (a chemical tanker with predefined draft, speed), and chart plotting of the content of NAVTEX message related to the shipping area. Having analyzed the results, correlation between their previous training, experience, and achieved results was observed. Consequently, certain conclusions were made, and guidelines for further ECDIS course training for seafarers have been proposed. The acquired knowledge can be applied in the training of full-time students under the mandatory STCW courses.

KEY WORDS

ECDIS assisted accidents, ECDIS training and familiarisation, Alarm settings, Route check procedure

1. INTRODUCTION

The introduction of the navigation system ECDIS, Electronic Chart Display and Information System, has been the most significant innovation in the process of voyage planning and realization since the introduction of radar on the merchant fleet ships, although, in the meantime, other electronic systems have been introduced into the service, such as AIS, VDR system, or satellite communications systems. While such devices perform functions on ships that are completely new and do not succeed to previous devices of similar or identical purpose, unlike them, the introduction of the ECDIS has not ended the use of paper navigational charts. The use of ECDIS with support of other independent system (retaining paper navigational charts as the second independent auxiliary system for the completion of the voyage) has been made possible since 2002, as specified in SOLAS V / 19-2.1.4 resolution. With amendments to the Rules 19-2 in 2009, the ECDIS became mandatory for all newly built tankers above 3000 GT and newly built cruise ships over 500 GT. Introduction period for existing ships and the newly planned ones depends on their purpose and size, and it is required for all existing ships above 10 000 GT after July 2018. Exemption is made for vessels that are to be permanently withdrawn from the service within two years of the date of mandatory ECDIS introduction for their category. [8] ECDIS has revolutionized the process of voyage planning, and it has set new challenges

for the deck officers, as well as shipping companies and onshore support staff, seafarers training centres, and all other participants in the process of safe and efficient marine navigation.

The benefits of the introduction of the system are significant with regard to the realization of navigation. A report from 2012 [1] states that the new technology has enabled reduction of navigation risks by *leaving the navigators more time to focus on their tasks, improving the visual representation of the fairway and enabling more efficient updating of charts.* The same author cites reduction in the number of stranding from 11% - 38% (depending on the area of navigation), as well as reducing the risk of collision by 3%, primarily *due to liberation of time to focus on monitoring traffic picture.* In addition to the positive results, the introduction of a new comprehensive navigation system pointed out the shortcomings in the approach to the training of officers, since the introduction of ECDIS has not been followed since the beginning by adequate regulations related to the training of seafarers who need to use it. Although 1995 IMO Resolution A817 (19)[1], among other things provided the minimum training requirements for proper use of ECDIS (Model course 1.27), only the STCW Convention[2] with Manila Amendments[3] in 2010 (entered into force on 1st Jan. 2012) made this training mandatory for all deck officers. The Convention stipulates the obligation of generic type ECDIS or general training for the use of ECDIS, while training for a particular type by a specific manufacturer that will be used by officers (so-called specific type ECDIS) is only recommended, and decisions and organisation of training are left to the shipping companies and flag states to decide [4].

Since the implementation of ECDIS, using the experience of the introduction of radar on ships the investigation of marine accidents pays particular attention to the role of ECDIS in these accidents [3]. The analysis carried out result in recommendations to ECDIS equipment manufacturers, the recommendations to the shipping companies related to Ship Management System (SMS) procedures and ECDIS check lists, proposals addressed to the IMO and to other international organizations, and other interested participants.

Especially valuable data are given in the reports of Marine Accident Investigation Branch (MAIB), the government agency from Britain, which investigates and publishes reports on maritime accidents, with specific classification of so called 'ECDIS assisted accidents'. In those accidents, use of ECDIS, in a certain way, had supported the development of the situation which resulted in maritime accident. The connection of ECDIS to accidents is evident in the analyses of their reports on accidents of RoRo ship 'Pride of Centerbury' (2008)[12], CFL 'Performer' (2008) [9], LT 'Cortesia "(2008) [5], MV" Maersk Kendal' (2009) [10], BC 'Thames' (2011) [7][2] and in the last such report of the chemical tanker 'Ovit' in 2013 [11].

The fundamental objective of the research is to determine at what level the active deck officers use ECDIS, and how much they are familiar with all its functions, capabilities and limitations. Therefore anonymous single-blind study was created that involved creation of concrete navigational route and use of additional functions of TRANSAS Navi Sailor 5000 ECDIS. Participants were asked to create a navigational route from the set position PS Mass (port of Rotterdam) to the PS port of Ceuta, and in addition to, on predefined position on the map, draw the contents of the NAVTEX message relevant to their voyage. Additionally, participants were asked to fill out a survey questionnaire.

2. PARTICIPANTS AND DATA COLLECTION

Data related to route creation included: position of PS Mass (lat 51°59.0'N, long 003°47.0'E) and position of Ceuta PS (lat 35°54.2'N, long 005°18.7'W) and information about the area

[1] Performance Standards for Electronic Chart Display And Information System.
[2] The International Convention on Standards of Training, Certification and Watch keeping for Seafarers (STCW) 1978.
[3] The 2010 Manila Amendments to the STCW Convention.

prohibited for navigation that should be charted (canter in position lat 46°15.8'N, long 008°23.0'W, with a diameter of 115 nm.) Also, values for max draught (9.0 m) and max speed (14 kn) were given. The questions of the additional questionnaire were related to:

1. experience in the position of a deck officer,
2. current rank,
3. having a generic ECDIS type certificate,
4. having Transas specific type ECDIS certificate,
5. experience in using Transas ECDIS.

Altogether 21 active deck officers participated in the research, all of Croatian nationality and all were participants of Alternative studies for active deck officers organized by the Maritime Faculty of the University of Split. The time for solving the survey task was not limited. The limitation in the implementation of data collection is reflected in the number of participants and the fact that they all are of the same nationality.

The structure of participants is shown in figures 1 and 2.

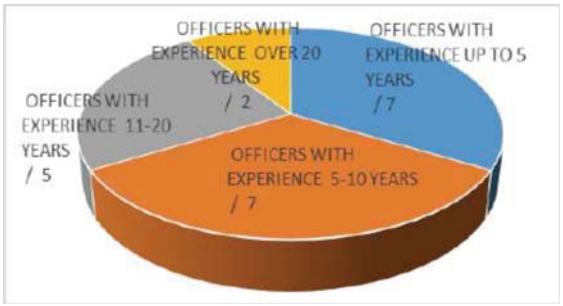

Figure 1. The structure of participants according to their active sea experience

Figure 1 shows equal participation of mates with active navigation experience in the categories of up to five years and 5 to 10 years (by seven participants), and five mates have from 11 to 20 years of experience. Two participants have more than 20 years of service.

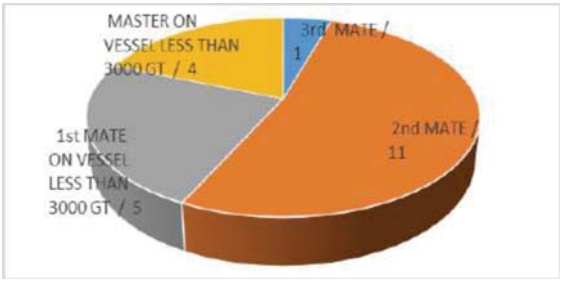

Figure 2. The structure of participants according to their officer's rank

By observing their structure according their current rank in figure 2 it is evident that most of them are serving as the second deck officers (11 participants), five participants are serving as the first mate on ships of 3000 GT or less, and four participants hold the master's position on ships of 3000 GT or less. One participant serves as the third deck officer.

3. SURVEY RESULTS

The results of investigation on 'ECDIS assisted accidents' undoubtedly show that of all ECDIS associated errors that deck officers committed in these accidents, the most common ones are related to the incorrect setting of voyage safety parameters, ignorance of alarm systems and their adjustment, and the lack of checks and route corrections. Therefore, the additional questionnaire was created to verify the survey results and individually evaluate the following: accuracy of the safety setting, accuracy of the drawn content of the NAVTEX message, a selection of an appropriate route from the Traffic Separation Scheme (TSS) area, number and type of errors committed and checking of the route. The results are shown according to active sea experience and current rank of the participants, with separate results related to the NAVTEX message.

3.1. SURVEY RESULTS REGARDING THE NAVIGATIONAL EXPERIENCE OF PARTICIPIANTS

The results show the share of successfully configured safety parameters (safety contour,

safety depth, safety frame), X Track Distance (XTD) parameters, and the share of correct checks and selection of the appropriate route with regard to navigational experience of participants. The share and the type of committed navigational errors are also shown.

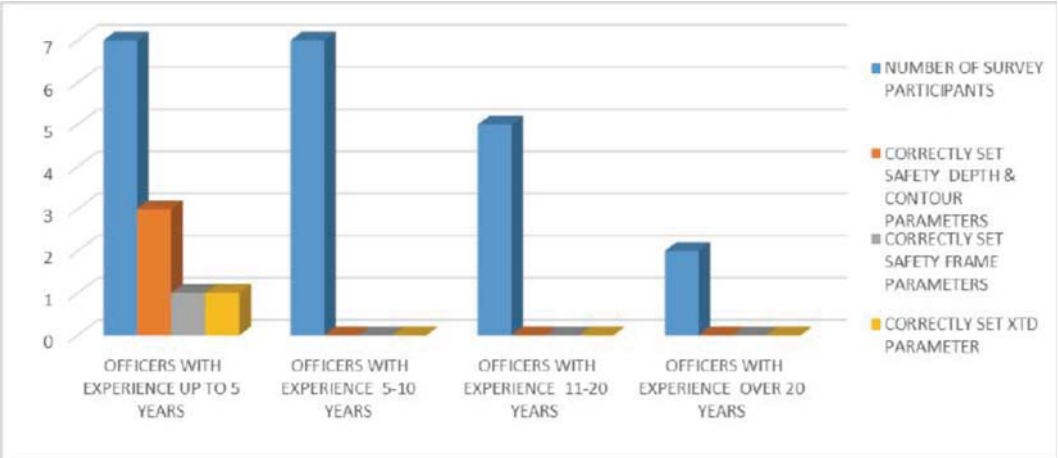

Figure 3. Share of successfully configured security parameters according to navigational experience

Figure 3 shows that of seven deck officers in group up to five years of experience, three deck officers successfully configured safety depth & contour parameters, one deck officer successfully set safety frame parameters, and one deck officer successfully set XTD parameters. Other participants with experience from 5 to 10, 11 – 20 years, as well as over 20 years of experience didn't successfully set any of listed security parameters.

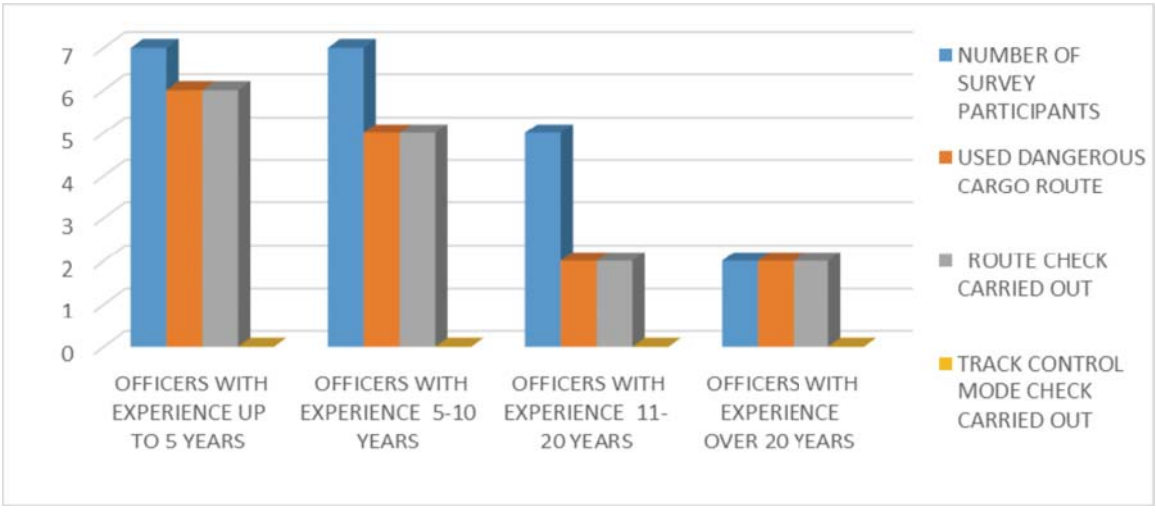

Figure 4. Share of successfully performed checks and selection of route according to navigational experience

Figure 4 shows that six of seven deck officers up to five years of experience successfully selected dangerous cargo route during voyage planning. In this group six deck officers successfully carried out route check, while none of them carried out track control mode check. In group with experience five to ten years, five deck officers successfully selected dangerous cargo route during route creation. Also six deck officers successfully carried out route check, while none of them carried out track control mode check. In group with experience 11 – 20 years two deck officers successfully selected dangerous cargo route during route creation. Two deck officers successfully carried out route check. None of them carried out track control mode check. Two deck officers with experience over 20 years selected dangerous cargo route and carried out route check, however none of them carried out track control mode check.

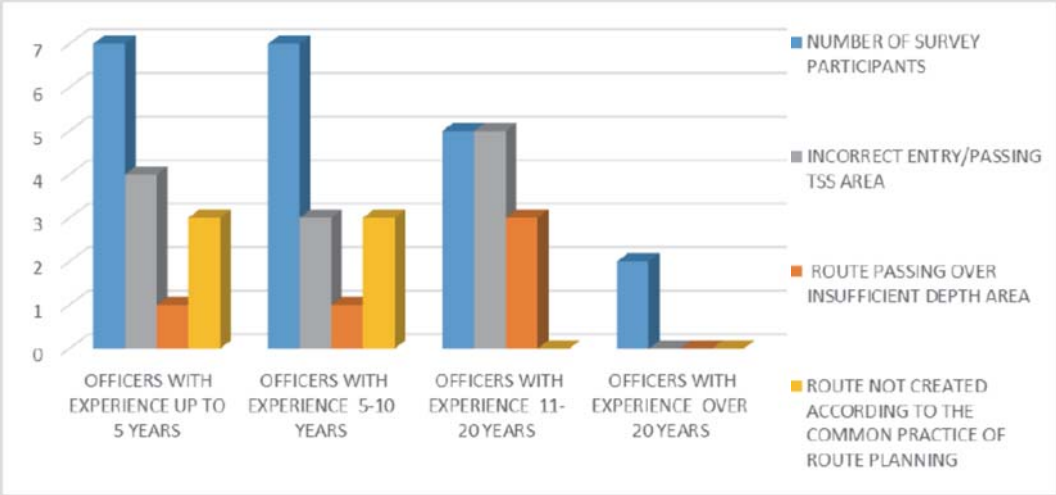

Figure 5. Share and type of committed navigational errors according to navigational experience

From figure 5 it's evident that, in group of deck officers with experience up to five years, four deck officers created route that incorrectly entered/passed TSS area, one deck officer created route over area with insufficient depth, and three deck officers didn't create the route according to the common practice of route planning. In group of deck officers with experience five to ten years, routes created by three deck officers incorrectly entered/passed TSS area. Three deck officers didn't create the route according to the common practice of route planning, while one deck officer created route over area with insufficient depth. In group with experience 11– 20 years all five deck officers created route that incorrectly entered/passed TSS area, three of them created route over area with insufficient depth. All participants in this group created route in accordance with the common practice of route planning. Deck officers with experience over 20 years didn't commit any navigational error.

3.2. SURVEY RESULTS REGARDING THE RANK OF PARTICIPIANTS

The results show the share of successfully configured safety parameters (safety contour, safety depth, safety frame), X Track Distance (XTD)[4] parameters, and the share of correct check and selection of the appropriate route with regard to navigational experience of participants. The

[4] X Track Distance is the term for the boundary lines of the area to the port and starboard of the planned route which enables safe navigation, anticipated aberration from ideal route lines.

share and the type of committed navigational errors are also shown.

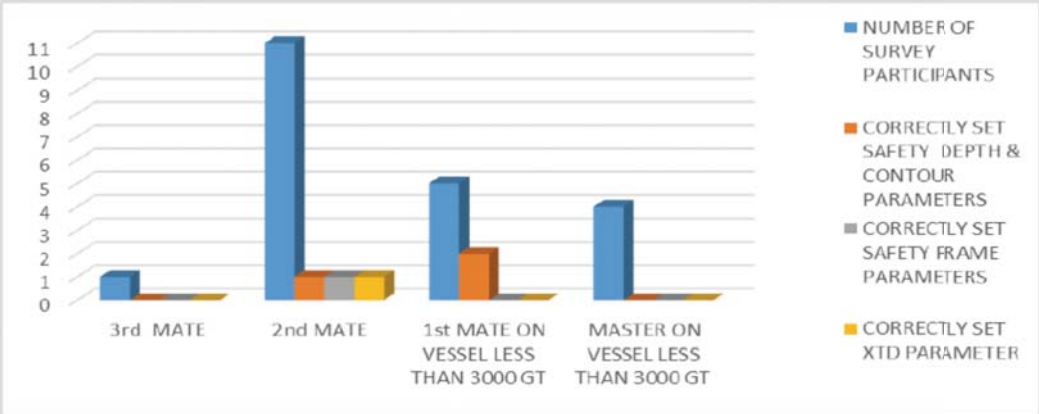

Figure 6. Share of successfully configured security parameters according to the rank of participants

Figure 6 shows that none of participants with rank of a master on vessel less than 3000 GT didn't successfully configure any safety parameter. In group deck officers who serve as a first mate on vessels less than 3000 GT two participants correctly set safety depth & contour parameters, while none of them successfully set safety frame and XTD parameters. One of seven participants that serve as a second mate successfully set safety depth & contour parameter, safety frame and XTD parameter. A participant who serves as a third mate didn't correctly set any of security parameters.

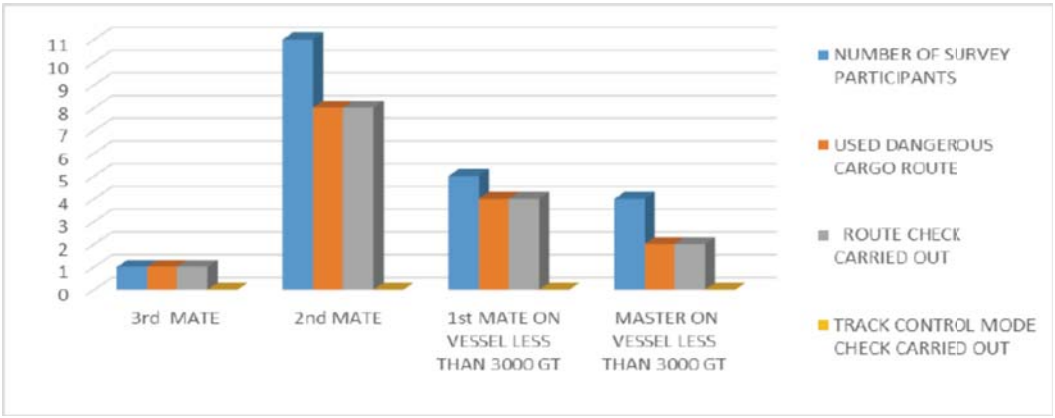

Figure 7. Share of successfully performed checks and selection of routes according to the rank of participants

Figure 7 shows that in group of deck officers in rank of master on vessels less than 3000 GT, two of four participants successfully selected dangerous cargo route and carried out route check. None of participants in this group didn't carry out track control mode check. In group of participants who hold the first mate's position on vessels less than 3000 GT four officers successfully selected dangerous cargo route and carried route check as well. None of them didn't carry out track control mode check. In group of participants who serve as a second mate eight of eleven participants successfully selected dangerous cargo route and carried out route check. None of them didn't carry out track control mode check. Participant who serves as a third mate successfully selected dangerous cargo route and carried out

route check, however didn't carry out track control mode check.

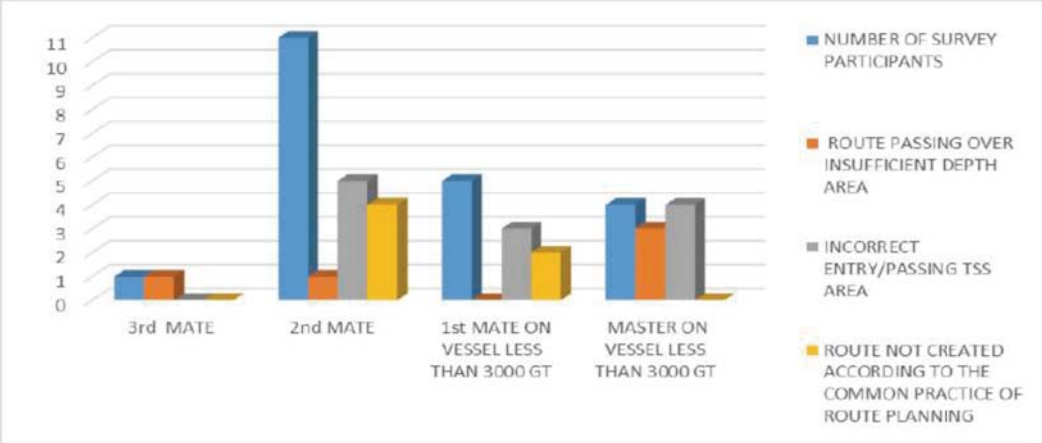

Figure 8. Share and type of committed navigational errors according to the rank of participants

Figure 8 shows that in group of deck officers in rank of master on vessels less than 3000 GT, three deck officers created route over area with insufficient depth. Three deck officers created route that incorrectly entered/passed TSS area. In group of deck officers who serve as a first mate on vessels less than 3000 GT, three deck officers created route which incorrectly entered/passed TSS area. Two deck officers didn't create route according to the common practice of route planning. In group of officers who serve as a second mate, five officers created route that incorrectly entered/passed TSS area, one of them created route over area with insufficient depth, and four of them didn't create route according to the common practice of route planning. Deck officer who serves as a third mate created route over area with insufficient depth.

3.3. SURVEY RESULTS RELATED TO THE CONTENT OF NAVTEX MESSAGE

The results show successfully drawn content of the NAVTEX messages according to navigational experience and the rank of participants, and according to whether they have Transas ECDIS certificate and / or experience in working with the same.

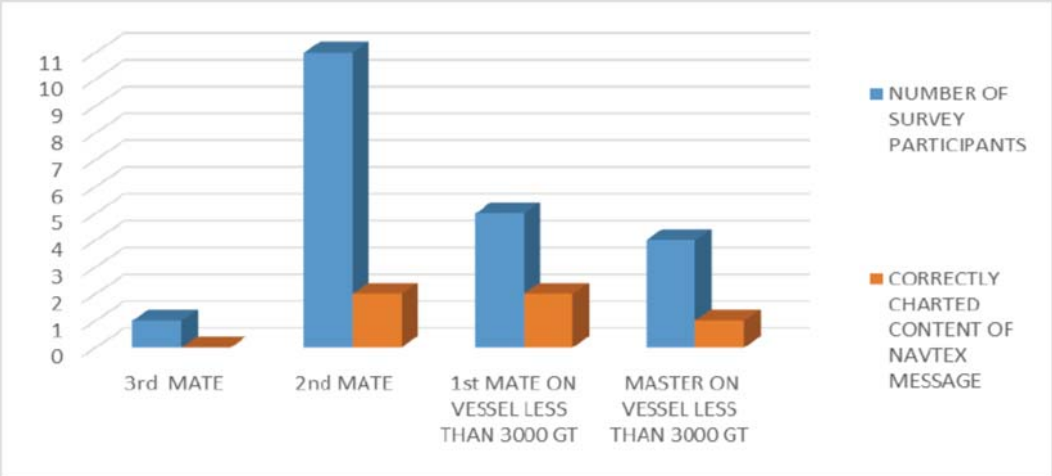

Figure 9. Number of correctly drawn content of NAVTEX messages according to navigational experience

Figure 9 shows that in group of deck officers with experience up to five years two officers successfully drew content of message. In groups with experience 5 to 10, 11 – 20 years and over 20 years one participant in each group successfully drew required content of NAVTEX message.

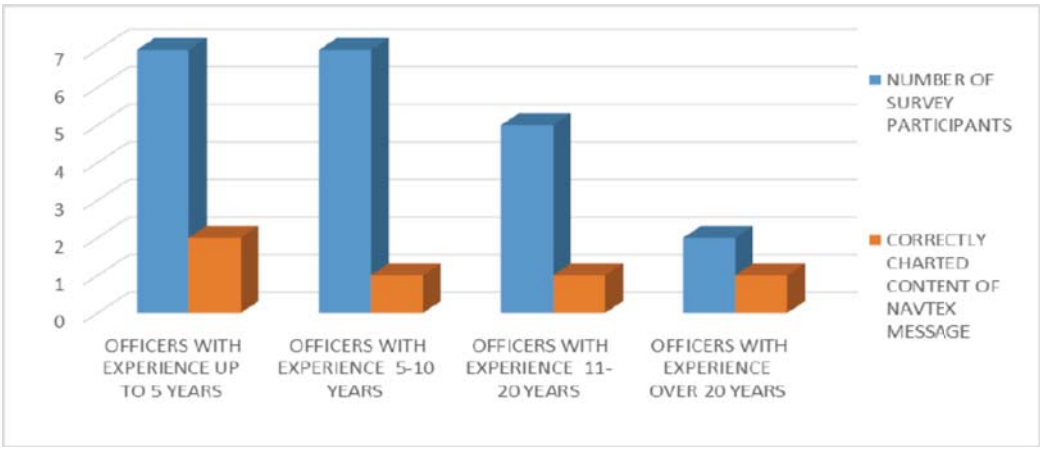

Figure 10. Number of correctly drawn content of NAVTEX messages according to the rank of participants

Figure 10 shows that in group of deck officers who hold master position one participant successfully drew content of message. In groups of deck officers who serve as first mate and second mate, one participant per group successfully drew required content of message. Deck officer who serves as a third mate didn't successfully draw content of the message.

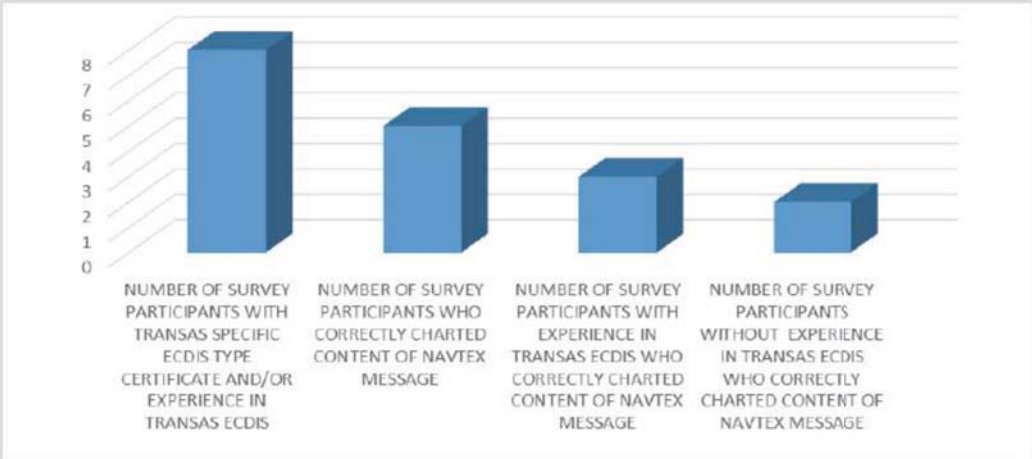

Figure 11. Number of correctly drawn content of NAVTEX message according to experience in using Transas ECDIS

Figure 11 shows that, from total number of participants, eight of them had a Transas ECDIS specific certificate or experiance in working with it.Three of five participants who correctly drew content of message, had experience in using Transas ECDIS, while two participants who successfully drew content of the message didn't have any previous experience in use of Transas ECDIS.

3.4. ANALYSIS OF SELECTED PARAMETERS OF THE SURVEY

Safety parameters which must be set when creating a route are definitely safety depth safety contour, safety frame and XTD parameter.

Safety depth depends on the draft of the ship, squat of the ship, tide, minimum values of under keel clearance (UKC) and additional coefficient. These values are precisely specified in the SMS of shipping companies, and serve as the basis of any voyage planning.

Safety contour represents the value whose alterations change the contours of the areas safe for navigation from the ones that can be unsafe, so it is the mandatory ECDIS function and alarm. By adjusting the safety contour according to these data, and activation the 'four shades' function, changes on screen appearance of the safety contour line that divides the area open for navigation from the area potentially dangerous for navigation. In doing so, the depths are marked in four categories:

1. Dark blue marks shallow waters that are shallower than the draught of vessels, and this is an area prohibited for navigation. On paper charts they are usually marked as NoGo Area.

2. The adjacent areas with deeper, but still potentially unsafe waters are marked with light blue. The line that separates the areas with shallow water from unsafe areas is called shallow contour. Entering the correct values for safety contour and safety depth changes the display of this area on the ECDIS screen. For the survey route default safety contour value was set at 15.85 m.

3. By entering that value ECDIS would set the next higher value of 20 m (the following larger rounded value) as the border of safe and potentially dangerous areas for navigation, and it would be displayed in gray. At the same time, security alarms would also be set to the same value.

4. The following greater depths are shown in white.

By setting the safety contour & depth parameters security alarm setting is changed, since any

crossing of the safety contour lines activates the alarm. Maker's value for the safety contour is 30m.
Safety frame is an option that enables the creation of the area around the vessel whose limits will trigger alarms in case of danger of grounding and collision. The distance from the bow is defined in minutes and thus depends on the speed of the ship, while the distance to the port and starboard side of the ship is defined in miles (by default) to 0.2 m and five minutes ahead. Parameters of safety frame should be set *as large as possible as circumstances allow* [6]

XTD are the distances to the port and starboard of the planned route line that form the boundaries of the planned route, they are expressed in nm and considered allowable deviation from the route. The value that will be set for XTD depends on the navigation area, speed and characteristics of the ship. The exit from the area bounded by XTD values triggers the mandatory ECDIS alarm. The XTD parameter is set by default to 0.1nm.

Described parameters form the basis of safety settings for creation and checking of routes, without which a route cannot be used. The results show that of 21 participants one second mate successfully created the route and set the corresponding parameters. Additionally, two first mates adequately set the values for the safety depth & contour parameters, but not for the safety frame. All three officers have navigational experience of less than five years each. Other participants did not change the values set by the manufacturers (default set of parameters).

The second group of control points of the survey includes control of route checking performance. The check is activated by means of 'check route' function which enables the program to check the route according to parameters set for checking, of which some can be included/excluded for verification (for example, multiple types of zones and areas where the route passes, the check according to the objects on the seabed etc.) while certain navigational alarms cannot be excluded from checking. Additional checking of the route includes the so-called 'track control mode' route checking. During this verification, the ECDIS checks only the entered XTD values and the turning radius of a ship. By choosing a specific type of ship ECDIS determines these values by itself, and they just need to be entered manually. This function checks whether the autopilot can function with regard to course alterations in the route, ie. whether the ship's autopilot can steer the ship on a given route given the applied XTD value and turning radius, since the value of the turning radius of the ship is defined by wheel over point (WOP).

Route verification also includes the selection of appropriate navigation area when passing through TSS. Since the vessel in the survey is a chemical carrier, a 'dangerous cargo route' is to be selected within each TSS areas. If the TSS area does not specify a designated part intended for the passage of ships with dangerous cargo, the passage from the 'outside' - further side should be used. In the given route, all TSS areas have marked the lanes for the passage of ships with dangerous cargo. The results show that out of 21 participants, 15 successfully carried out the navigation route checking and chose a 'dangerous cargo traffic lane'. They were evenly represented in all groups given their navigational experience and ranks. The fact that none of the participants used a 'track control mode' check route is alarming.

The content of the NAVTEX message was supposed to be plotted and marked on the chart using the ECDIS tools within the system. It was necessary to plot and mark the area prohibited for navigation of 115nm in diameter at the given position. The Transas ECDIS has the option 'maps' for this purpose and participants were informed about this possibility. Another possibility is to use the 'manual correction" function, but given the nature of the survey, participants were instructed to use the first option for entering the marks on the map. Five participants successfully marked the requested area (exact location and the exact size and mark of the messages). The 'maps' option is not mandatory option for entering symbols and changes on the map (mandatory option is 'manual correction') and the lower level of success in solving the task was expected. However, out of eight participants with a specific type Transas certificate and/or working experience in Transas

ECDIS system, three successfully solved the task, while two participants who successfully solved the task had no previous working experience in Transas ECDIS system.

4. INTERPRETATION OF THE SURVEY RESULTS

The results obtained from the survey fit into the research results published in the MAIB reports of maritime accidents associated with inappropriate use of ECDIS, which is primarily related to the ignorance of the meaning of safety parameters.

It is evident that the majority of participants (85%) are not familiar with the basic safety functions, alarms, and particularly with safety frame and XTD function. Checking the route after its creation was carried out by 71.4% of participants, however, they did not subsequently repeat the check since default safety parameters generate dozens of safety contour and safety depth alarms. The explanation lies in the fact that after creating a route and start the check, participants visually examined and zoomed routes on the screen, and thus concluded that the route was correct.

However, given the fact that nearly one in four participants (23.8%) reported as a valid the route that passes through areas where groundings have taken place (due to the insufficient depth) it is obvious that the visual inspection of the route was hasty. This enhances the fact that the officers with navigational experience of over 20 years, regardless of their current rank, paid more attention when checking routes and avoided this error (regardless of their level of knowledge of handling ECDIS system). Other errors were observed when passing or entering the TSS (errors committed by 57.1% of all participants and 45.5% of second deck officers). In creation of the route, contrary to the principles of navigational economy and efficiency, errors were committed by 28.6% of participants. It is evident that these errors were not committed by participants with navigational experience of 20 years and more, nor those serving as masters, while it was committed by 36.4% of second deck officers.

Manual checks of the route is in any case necessary and desirable, but ignorance and subsequent ignoring of activated safety alarms leads to maritime accidents, which was clearly stated in investigation reports. The explanation of the fact that none of the participants used the track control mode in their check may be because it is a new feature that was not present in earlier versions of Transas ECDIS, and participants were not familiar with this function. Entering corrections, Temporary and Preliminary Notices to Mariners, and any other written messages on paper charts is an essential part of the duties of every deck officer, regardless of the type of a vessel. Since the transition to ECDIS, methods of updating and correction making on the display of electronic charts have significantly changed (the system will automatically install the 'Notices to Marines' via the Internet or media for data transfer). Also, ECDIS is integrated with a NAVTEX receiver which enables an automatic display of the corresponding text message and a NAVTEX symbol at the position that the message refers to. However, in case where the message text refers to the area that needs to be represented graphically on a map and set up alerts important for navigation, manual entering of symbols and text is applied. In the given case the route was passing through the areas marked prohibited for navigation, so the route needed to be changed accordingly. The task message was successfully charted by 23.8% of the participants, which definitely is an unsatisfactory result, particularly as 52.4% of the participants sail as a second deck officers whose duty is to update ECDIS and thus to have the knowledge of the means for entering changes.

In accordance with the purpose of research and conducted survey, authors of the study propose specific guidelines for future work with participants of training programs for the use of ECDIS. It is obvious that a significant number of the active deck officers know the capabilities and limitations of ECDIS in the lowest possible level, and they use the system with minimum options. Therefore it is proposed:

- to devise, within existing frame of IMO Model course 1.27 training, additional exercises that would address the

mandatory safety functions including setting up depth, contour and associated alarms.
- Participants should confirm their knowledge and understanding by answering a specially designed set of test questions specific to the safety settings of the system.

The proposed changes introduced to the performance of exercises and placing additional emphasis on the safety settings and features of ECDIS should increase the level of its use on ships, and significantly contribute to increasing the safety of navigation in terms of use of electronic navigation systems.

5. CONCLUSION

Since ECDIS is not only an electronic version of a paper chart, but more comprehensive navigation and information system, complete mastery of its resources and knowledge of the system limitations is of crucial importance for safe navigation. Studies of maritime accidents, which mention the improper use of ECDIS as one of the causes shows that, although the system itself is not completely free of defects, critical mistakes are made by officers with their misuse of ECDIS. The most important among them are mistakes related to the system of safety and alarms settings. Results of the survey confirm the findings in the reports of investigation agencies, which is not entirely surprising since the transition from paper navigational aids to electronic system with its multiple aspects, poses a challenge to active seamen who have used paper charts throughout their active career. The conducted survey revealed alarmingly low level of use and knowledge about the capabilities of the ECDIS, which directly endangers the safety of navigation. The obtained results undoubtedly suggest that it is necessary to introduce appropriate changes in the training and to intensify the exercises of those segments of ECDIS usage in which deck officers showed the worst results. In addition, it is necessary to conduct the evaluation of acquired knowledge continuously, which would certainly be a guideline addressed to shipping companies, as they equally share the responsibility and are obliged to organize training of their seafarers. Also, deck officers should be enabled to continuously improve their knowledge, since the new versions of ECDIS devices bring new features and changes that do not always have to be fully adopted by the seafarers.

REFERENCES

1. Asyali E., 2012, 'The Role of ECDIS in Improving Situation Awareness', 2012 IAMU Conference paper, pp 124.
2. Khattab T.M., Eslam M.G.,2016, 'Electronic Chart Display And Information System (ECDIS) Legal aspects and case study on CLM Thames', International Journal of Mechanical Engineering (IJME),Vol. 5, Issue 1, pp 96.
3. Mads R.N., 2016, 'How a ship's bridge knows its position – ECDIS assisted accidents from a contemporary human factors perspective', Lund university, pp 14.
4. Ott C., Drablos K., 2014,'Electronically guided Accidents', Sklud PI, pp 93, 94.
5. Pleskacz K.,Uriasz J.,2011, 'Understanding Information Systems', Annual of Navigation, Maritime University of Szczecin, pp 5.
6. Zakirul B., 2012,'ECDIS Display, Safety Settings and Alarm Management', 2012, IAIN Conference, pp 6.
7. 'Grounding of CSL THAMES', MAIB Accident Report 2012, available from https://assets.publishing.service.gov.uk/media/547c6f8240f0b60244000021/CSLThames.pdf
8. IMO - SOLAS Chapter V Regulation 19.2, available from http://www.ecdis-info.com/media/msc-282-86----chap-v-reg-19.pdf
9. 'Report on the investigation of the grounding of CFL Performer Haisborough Sand North Sea 12 May 2008', Report No 21/2008, Southampton 2008, available from https://assets.publishing.service.gov.uk/media/547c7001e5274a428d000063/CFLPerformerReport.pdf
10. 10.'Report on the investigation of the grounding of mv Maersk Kendal on Monggok Sebarok reef in the Singapore Strait on 16 September 2009', Report No 10/2010,

Southampton 2010, available from https://assets.publishing.service.gov.uk/media/547c6fc9ed915d4c10000041/MaerskKendalReport.pdf

11. 'Report on the investigation of the grounding of Ovit', MAIB Accident Report 2013, Southampton 2014, available from https://assets.publishing.service.gov.uk/media/547c6f2640f0b60244000007/OvitReport.pdf

12. 'Report on the investigation into the grounding of Pride of Canterbury, MAIB Accident Report No 9/2009', Southampton 2009 , available from https://assets.publishing.service.gov.uk/media/547c700ded915d4c0d000071/PrideofCanterburyReport.pdf