Partial Analysis of ECDIS EHO Research: Port State Control
Parcijalna analiza ECDIS EHO istraživanja: nadzor države luke

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Summary

The implementation of Electronic Chart Display and Information System (ECDIS) on board merchant ships involves several parties responsible for its proper use. These include inspection and maritime training institutes. Since ECDIS system is a new system and differs significantly with respect to different manufacturers, the question is how successfully inspections monitor the use of the ECDIS system. The results of concentrated campaigns by the regional port State control, previous research studies and reports produced by the International Hydrographic Organization were all analysed in this paper. The last part of the paper analyses the part of the international questionnaire that answers the question of how often respondents come across the ECDIS inspection, and what is the nature of that control. The results point to the lack of frequent control and oversight of some essential elements of the system by inspections. The results of the conducted questionnaire were compared with those of the concentrated inspection campaigns and with the results of previous research. A degree of coincidence between the obtained results reveals the need to further refine the ECDIS training process. The last chapter proposes activities aimed at improving the training of parties involved in the process for the purpose of improving navigation safety.

Sažetak

Primjena informacijskog sustava i prikaza elektroničkih navigacijskih karata (ECDIS) na trgovačkim brodovima uključuje nekoliko dionika odgovornih za njegovu pravilnu uporabu. Ovdje spadaju inspekcijski nadzor brodova te ustanove za izobrazbu korisnika sustava. Budući da je ECDIS novi sustav i značajno se razlikuje ovisno o proizvođaču, pitanje je koliko uspješno inspekcije nadziru upotrebu ECDIS sustava. U ovom se radu analiziraju rezultati namjenskih kampanji regionalnih nadzora države luke, prethodna istraživanja i izvješća Međunarodne hidrografske organizacije. Posljednji dio rada analizira dio međunarodnog upitnika koji odgovara na pitanje koliko se često ispitanici susreću s ECDIS nadzorom te kakav je to nadzor. Rezultati ukazuju na manjak čestih kontrola a pogotovo na slabiju kontrolu nekih bitnih elemenata sustava. Rezultati provedenog upitnika uspoređuju se s rezultatima namjenskih inspekcijskih kampanja i s rezultatima prethodnih istraživanja. Stupanj podudarnosti između dobivenih rezultata otkriva potrebu za daljnjim usavršavanjem ECDIS procesa obuke. Posljednje poglavlje predlaže aktivnosti usmjerene na poboljšanje obuke dionika u svrhu poboljšanja sigurnosti plovidbe.

1. INTRODUCTION / *Uvod*

Electronic chart display and information system is an advanced navigation computer system that changes the current understanding of navigation, improves safety at sea, and enables personalized display of navigation information on a navigational chart. As of July 1, 2018, the ECDIS system has become mandatory for most merchant fleets [1]. Many manufacturers of navigation equipment started developing their ECDIS systems earlier, so as a result, there are more than 30 different manufacturers on the market [2]. Since this is a relatively new system and considering the problems associated with the poor standardization of some ECDIS system functions, the question arises as to how successfully the inspectors control the use of the ECDIS system. Additional question is to what extent they are familiar with the ever-changing ECDIS system. The inspection of the ECDIS system use, being a control mechanism for its successful implementation, shows the importance of its proper functioning. Insufficient knowledge of the system brings about the issue of adequacy of the ECDIS educational framework. At the very beginning of the ECDIS implementation period, the ECDIS EHO project was launched, focusing on educating the system users. The project was implemented through research series focusing on the system users and their interaction with entire system. Identifying problems with the use of the system, analysing errors, and adjusting the educational framework remain one of the goals of the project. As part of the research project, an international survey was conducted. This paper

analyses its segment related to the ECDIS system inspection.

Former research studies provide additional information on the topic of this paper. Parties to the information system with an emphasis on inspection are presented in the paper, and a relationship between training institutions and inspectors is redefined. The Paris MOU and the Tokyo MOU reports on the port State control are analysed as they conducted the Concentrated Inspection Campaign (CIC) Safety of Navigation, including ECDIS. The obtained results lead to certain conclusions that give rise to possible proposals and solutions. The part of the paper entitled Research and methodology analyses the ECDIS EHO research, its objectives, and the issue of inspection. The results of questionnaire covering the topic of this paper provide answers to the question of frequency and segments of control and allow conclusions to be drawn and thus improve the inspection process. Further comparison of the results obtained both from concentrated campaigns and the EHO survey will show to what extent the ECDIS system inspection touches upon all segments of the ECDIS system, especially those related to navigation safety. Guidelines are proposed both for the implementation of a quality, constructive and safe inspection, and improvements of the ECDIS educational framework.

2. PREVIOUS RESEARCH / *Dosadašnja istraživanja*

At the very beginning of the implementation of the ECDIS system on board ships, certain problems were observed regarding its proper use [3,4,5,6,7,8]. As a result, numerous changes to the standards and regulations related to the ECDIS systems have been made with the aim to eliminate the deficiencies and facilitate the use of the system [5,9]. However, malfunctioning of the system remains an important issue that jeopardizes safety at sea. Improper use of the EDCDIS system resulting from the insufficient knowledge of the system has been defined as the cause of a number of maritime accidents [10,11,12]. The analysis of the ECDIS related accidents [13], leads to conclusion that the causes were not technical, but occurred mostly due to insufficient knowledge of the system. The ECDIS EHO research, initiated during the system implementation process, aims to respond to these issues through educational and research processes, and through practical application as well. Particular emphasis is put on the training of system users and interaction between users and ECDIS with the purpose to improve the teaching process and knowledge transfer. In addition to research focused on improving safety at sea through better training, certain technical solutions were proposed to further develop the system in terms of environmental protection [14,15]. The important part of the project was an international survey conducted among seafarers as end users of the system. The survey questions tackled the aforementioned problems. Survey results provide feedback from the ECDIS system users and allow us to draw conclusions and hence adjust the ECDIS training. Research results point to the need both for further education of all system users and the development of new courses aimed at specific categories of system users. The existing courses are general, while they should be specialized depending on the user needs [4,5,9]. Insufficient standardization of the ECDIS system is one of the problems and requires a specialized training programme. Manufacturers are given freedom when developing these systems; therefore significant differences occur in the ECDIS system use. As a consequence, navigational safety inspectors may not always be able to adequately assess the use of the ECDIS system by officers of the watch [16]. The need to develop the knowledge of port State inspectors has also been recognized by the International Hydrographic Organization (IHO). The IHO circular reveals frequent complaints made by officers of the watch as end users regarding problems they have with ECDIS system inspection. According to the circular, the port State inspectors not being familiar enough with ECDIS are the cause of the problem [17]. Subsequently, the IHO makes an interesting recommendation on the need to develop practical and more detailed guidance to improve current ECDIS inspection procedures. It is also recommended that port State inspectors participate in ECDIS-related forums and events [18]). Developing the knowledge and skills of all parties involved in ECDIS is a precondition for its successful integration having a reduced number of accidents and increased safety at sea as a result.

3. PARTIES TO THE INFORMATION SYSTEM AND INSPECTIONS / *Dionici informacijskog sustava i inspekcije*

The ECDIS system is much more than just a replacement for the traditional paper nautical charts. In addition to its navigational functions, it includes an extensive computer information system and other components. Apart from hardware, it also contains software. Meticulous use of the system is necessary, all in order to avoid misuse, misapprehension, system failures and accidents [19,4].

Since it is a complex interdisciplinary system, there are many parties involved in its proper use for the safety of navigation. For this reason, it is essential that all parties involved have a clear understanding of their roles and responsibilities [20].

Figure 1 shows a relationship between system users (officers of the watch) and other parties. The officer of the watch is a central entity being the end user of the system. This means that they are in direct contact with all parties in the process. It is necessary to mention the impact of the training providers on inspectors, and thus an amended scheme of mutual relation between parties is proposed (supplemented by the relation „Training – Inspection"). This added relation implies a need for a quality training of inspectors and a necessary feedback given to the training providers.

Accordingly, in order to properly supervise ships, port State inspectors have to undergo regular trainings. IMO Resolution guidelines A.1119 (30) require port State inspectors to attend seminars and courses on a regular basis [21]. The aim of such training is to acquire adequate level of knowledge and skills to carry out quality inspection controls. In line with the Convention, professional development is a requirement made by regional MoUs and national legislation respectively. In the Republic of Croatia it is regulated by the Ordinance on navigation safety inspection. The results of inspection have the potential to indicate specific areas of training that may need more attention. Such feedback would have a positive impact on the training of officers of the watch. In their work, Brčić et al. propose the development of quality feedback between training providers and other parties involved in order to further raise the quality of ECDIS training [4]. Inspection of ships has a direct impact on the safety of navigation as it verifies the compliance of a ship with international or internal company rules, and therefore a high quality inspection means greater safety of navigation [22]. The
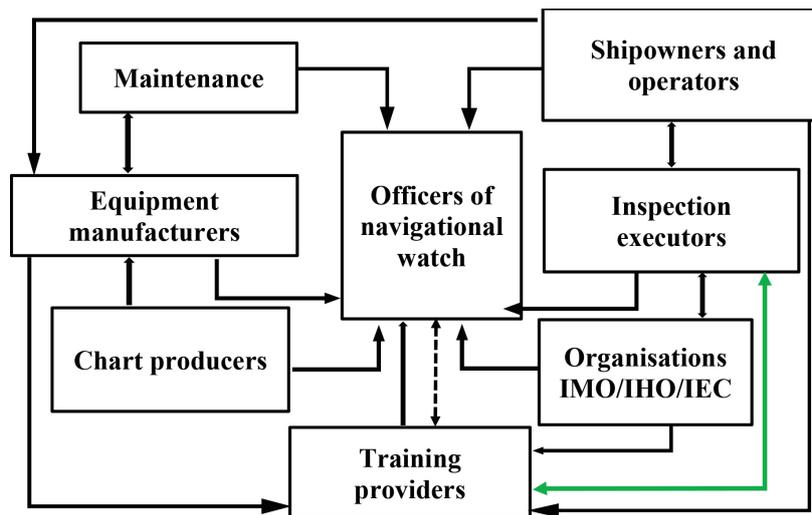
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Figure 1 Mutual relation between parties involved
Slika 1. Međusobni odnosi dionika sustava

Source: Authors

success of inspection is noticeable in the reduced deficiencies between two consecutive inspections in more than 63% of the ships inspected [23]. There is a number of organizations in charge of carrying out the ship inspection. In their work, Grbic et al. cite as many as 12 different inspections: Port State Control - PSC, Flag inspection, classification society inspection, marine insurance surveys, Oil Companies International Marine Forum (OCIMF) SIRE inspection, International Safety Management Code (ISM) audited internally and externally, International Ship and Port Facility Security Code (ISPS) audited internally and externally, Maritime Labour Convention (MLC) audited internally and externally, and "Green Award" inspection [24]. This paper shall look into the work of the port State control as the largest organization among the above mentioned ones, with greater power than the others, which includes the detention of the ship until the deficiency is rectified.

4. PORT STATE CONTROL / *Nadzor države luke*

Port State control is an inspection regime for countries to inspect foreign-registered ships in national ports to audit its compliance with requirements of international conventions on safety and pollution practices including employment conditions [25]. Inspections involve checking that the vessel is manned and operated in compliance with the applicable international law. These inspections were originally intended to be a back up to flag State implementation, but eventually they became a very important element of safety at sea. The International Maritime Organization adopted the Resolution A.682 (17) on regional co-operation in the control of ships [26]. Accordingly, port State controls in a large part of the world are signatories of Memoranda of Understanding. The Paris Memorandum of Understanding on Port State Control pioneered a coordinated inspection in a particular region. Signatories of Memoranda of Understanding commit to have an efficient and uniform ship inspection system, focusing on safety at sea, protection against pollution, and living and working conditions on board ships [27]. It is important to note that the aim of the Memorandum is to have a uniform system, which can lead to some uncalled-for consequences. Namely, the port State inspector has almost no influence on the choice

of the ship to inspect, but it is automatically determined by the THETIS database specifying which ships have a high risk rating. Memorandum specifies the process and focus of inspection, which may compromise the inspector's autonomy [28]. Occasionally, regional organizations carry out inspection campaigns focused on specific subjects. The Paris and Tokyo MoUs carried out concentrated inspection campaigns between September 1, 2017 and November 30, 2017, focusing on navigation safety including ECDIS. The goal of campaigns was to focus on specific areas that, in the organization's view, require increased attention. The implementation of the ECDIS system as a system that fundamentally changes the current understanding of navigation clearly deserves special attention.

5. ANALYSIS OF WORK RESULTS OF PORT STATE CONTROL / *Analiza rezultata rada nadzora države luke*

Safety of navigation with navigational equipment as its essential element, is regularly in the focus of port State control. Data analysis of the Paris MoU annual report for 2017 shows that the largest number of deficiencies observed on the inspected vessels, in the area covered by the Paris MoU, which includes the Republic of Croatia, relates to the navigation safety. Out of the total number of observed deficiencies, 13.66% accounted for navigation safety. In 2018 there was a certain drop in the observed deficiencies in the field of navigation safety, so in 2018 navigation safety accounted for 12.07% of the total number of reported deficiencies, while in 2019 it drops further to 11% (Graph 1), [29,30,31].

Further analysis available on the Paris MoU website reveals that only a minor proportion of deficiencies are related to the ECDIS system, and thus, 168 deficiencies in the ECDIS system category were identified in 2017 (Graph 2). The number of deficiencies related to the ECDIS system decreased in 2018, and a total of 118 such deficiencies were registered, while in 2019 number increased to 145, still less than in 2017 (Graph 3,4).

These categories are defined by the regional organization system. From the available data, it is evident that certain categories of deficiencies can also be the functions of the ECDIS system, provided that the ship has it. The following categories may also make part of the functions of the ECDIS
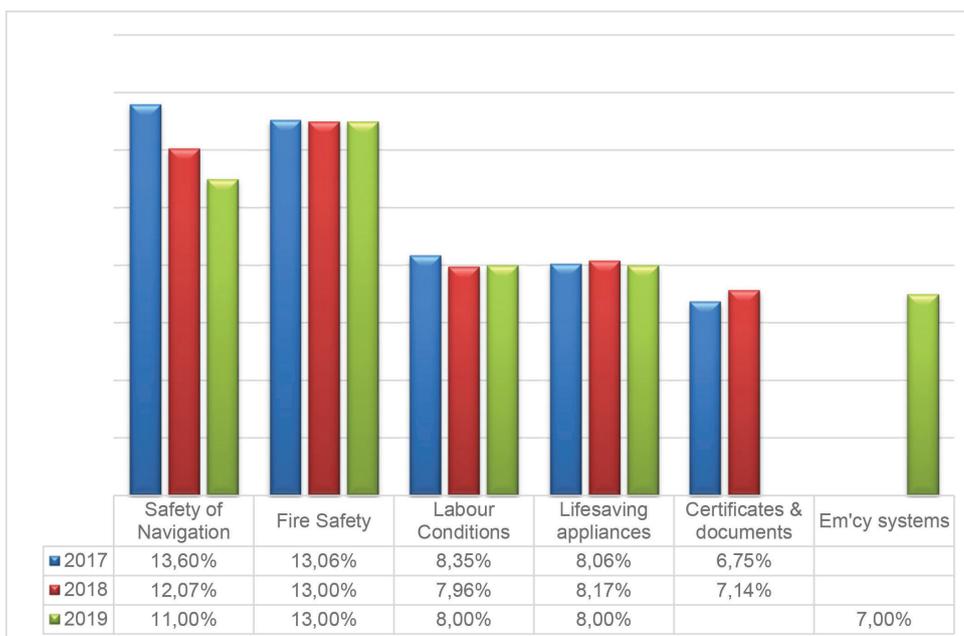
Graph 1 Top 5 categories of deficiencies in 2017, 2018 and 2019
Grafikon 1. Najčešćih 5 kategorija nedostataka u 2017., 2018. i 2019.

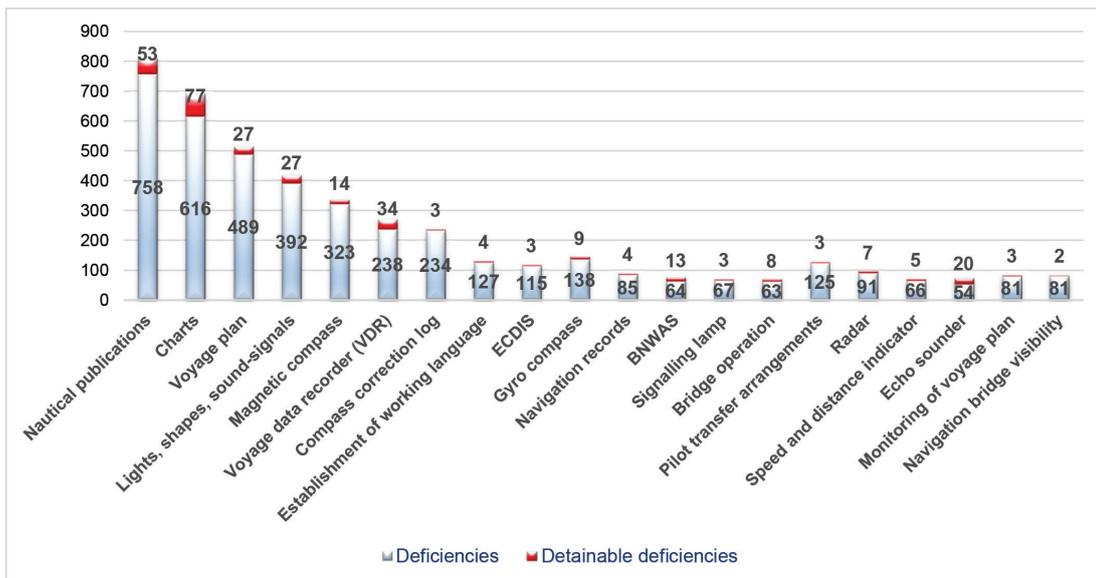Source: http://www.parismou.org/publications-category/annual-reports
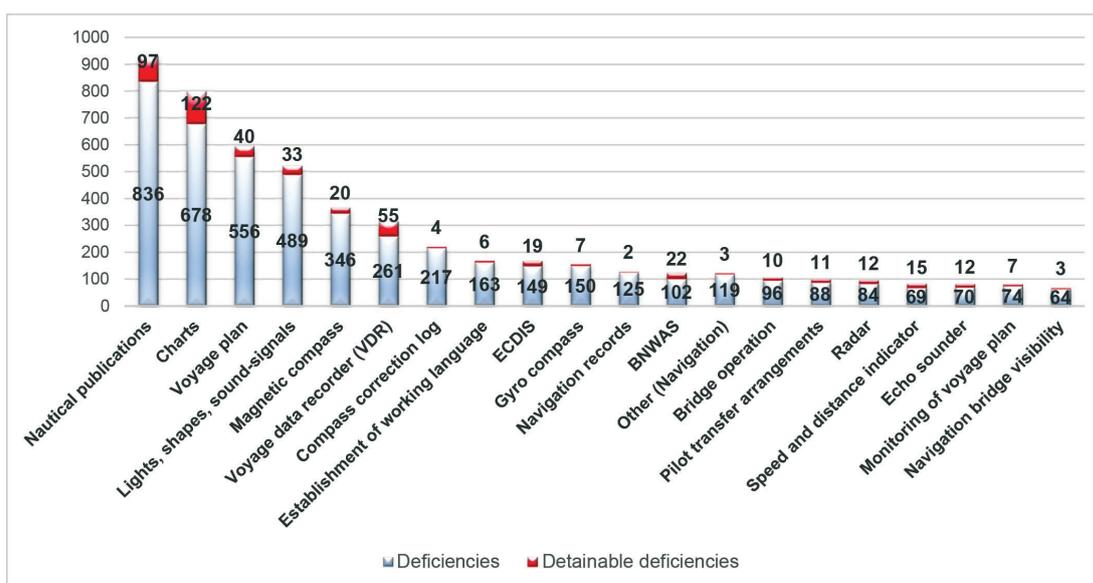
Graph 2 Top 20 deficiencies in the "Safety of navigation" category in 2017
Grafikon 2. Najčešćih 20 nedostataka u kategoriji „Sigurnost plovidbe" u 2017.

Source: http://www.parismou.org/publications-category/annual-reports

system: navigational charts, passage plan, log entry, operating the navigating bridge, and voyage monitoring. This opens up the possibility for a part of these deficiencies to be related to the ECDIS system. However, it should be noted that there is a relatively small number of observed deficiencies related to the ECDIS system since this is a new system whose incorrect use has already caused more serious accidents at sea. In 2018, there were twice as many perceived deficiencies as in the compass deviation book category.

As regional organizations have recognized the importance of the ECDIS system, a concentrated campaign was launched at the end of 2017 with a focus on navigation safety including ECDIS. The aim of the campaign was to check the compliance of the ships with the safety rules and the competence of the crew in charge of navigation, especially considering the ECDIS system. The focus of the campaign was on updating the electronic charts, compliance of navigational equipment with the Cargo Ship Safety Equipment Certificate, and voyage planning as well. The campaign was based on a standardized questionnaire. During the campaign in the area covered by the Paris MoU, 4288 inspections were made. The percentage of ship detentions relative to the subject of the campaign was 1.1% (47 ships detentions). The Paris MoU recommendations stated that the industry had to make more efforts to ensure that the voyage plans were up to date, given that the deficiencies associated with voyage planning made

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Graph 3 Top 20 deficiencies in the "Safety of navigation" category in 2018
Grafikon 3. Najčešćih 20 nedostataka u kategoriji „Sigurnost plovidbe" u 2018.
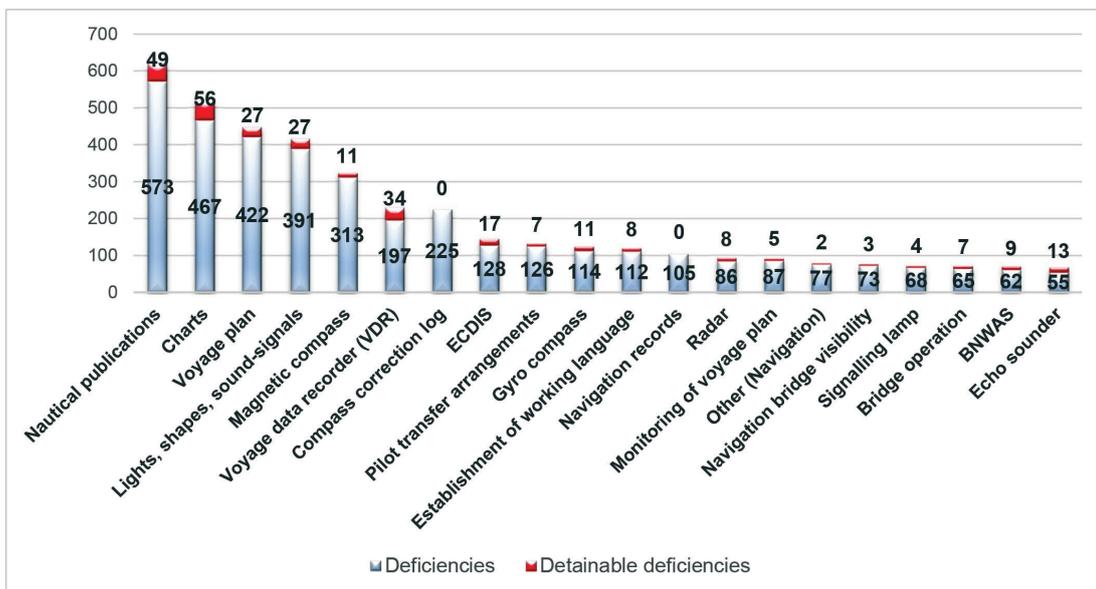
Graph 4 Top 20 deficiencies in the "Safety of navigation" category in 2019
Grafikon 4. Najčešćih 20 nedostataka u kategoriji „Sigurnost plovidbe" u 2019.

up the highest share of deficiencies during the campaign. The second recommendation stated that since the ECDIS system became mandatory on July 1, 2018, the industry should strive to implement it. Implementation the ECDIS system brings considerable benefits and the ECDIS system greatly simplifies voyage planning [32].

In the area covered by the Tokyo MoU, 6720 inspections were conducted in accordance with the standardized campaign questionnaire. The percentage of ship detentions relative to the subject of campaign was 0.54% (36 ships detentions). The Tokyo MoU recommended that member states continue to inspect navigation safety after a concentrated campaign, and that the skills and the training of port State inspectors should be improved [33].

6. RESEARCH AND METHODOLOGY WITHIN ECDIS EHO PROJECT / *istraživanje i metodologija u sklopu ECDIS EHO projekta*

Research within the ECDIS EHO project began in 2012, i.e. at the beginning of the implementation period for ECDIS systems. Research objectives were to improve the knowledge, the practical usage, and the training of all parties involved in the ECDIS system implementation process. International survey focusing on end users was conducted with a representative sample of respondents. The survey questionnaire consisted of 24 questions, some of which already analysed as part of the EHO research project. The questions could be divided into general or preliminary questions, and questions related to the use of the ECDIS system. Preliminary survey questions were used to profile

the respondents based on the position they were employed in, their work experience and experience in handling the ECDIS system. Profiling the participants based on preliminary questions helped to better understand the responses related to the use of the system. The International EHO Survey comprised responses from 350 respondents: 99 Masters, 77 First mates, 66 Second mates, 13 Third mates, 8 Staff captains, 1 Marine safety consultant, 3 Safety officers, 3 Environmental officers, 4 Dynamic positioning operators, 1 pilot, 1 superintendent , 1 supervisor, 14 port State control officers, 25 trainees, 1 Yacht Master and 33 persons of unspecified position making part of the navigational watch (Graph 5).

This paper will present an analysis of the responses related to the inspections. ECDIS inspections are essential for its successful use. The purpose of analysis was to answer the

question of how often the system users went through control and what it consisted of. To this end, the answers to question 12 are analysed:

Q12 – "Have you had any experience with ECDIS / ECS controls? If YES, please state what was asked of you."

The target group were active users of the ECDIS system, i.e. the responses of commanders and deck officers who are or were using the ECDIS system. Responses of other parties were not considered. General data were used to set the officers of the watch and commanders (potential end users of the ECDIS system) apart from the sample. In addition, question number 2 was used to set apart only those survey respondents who encountered the ECDIS system in practice:

Q 2 – "How long have you been using the ECDIS system (circle or add answer)?"
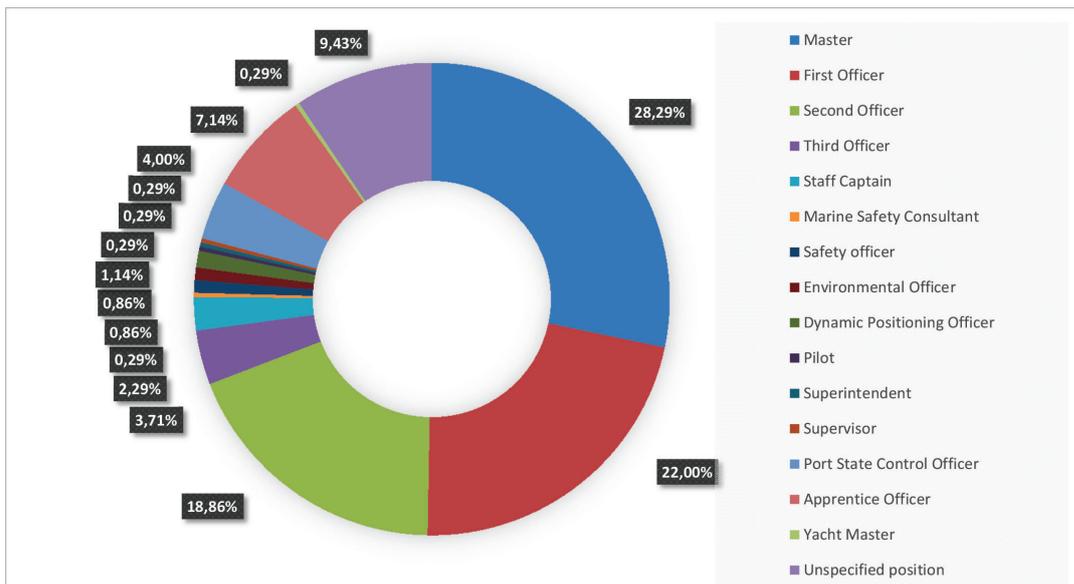
Graph 5 All ECDIS EHO survey respondents
Grafikon 5. Svi ispitanici u ECDIS EHO istraživanju

Source: Authors
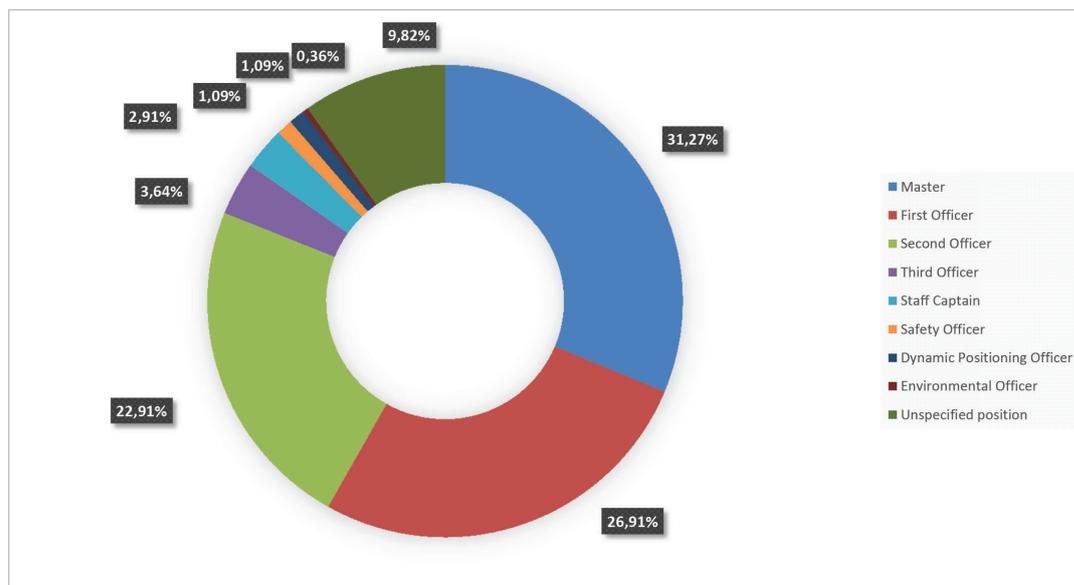
Graph 6 Target group of ECDIS EHO survey
Grafikon 6. Ciljna skupina ECDIS EHO istraživanja

Source: Authors

Based on the above mentioned questions, the target group was reduced to responses of 275 respondents: 86 Masters, 74 First mates, 63 Second mates, 10 Third mates, 8 Staff Captains , 3 Safety Officers, 3 dynamic positioning operators, 1 Environmental Officer and 27 persons of unspecified position making part of the navigation watch (Graph 6).

Masters accounted for the largest share of provided responses (31.27%), followed by the responses of First Officers (26.91%), which together accounted for more than half of the sample. These were also the most experienced staff given their position on board ship.

7. RESULTS / *Rezultati*

Research results are divided into two parts. The first relates to the first part of question 12:

"Have you had any experience with ECDIS / ECS system inspections?"

This question was answered positively by 118 respondents (42.91%) and negatively by 135 (49.09%). The responses of 22 respondents (8%) who did not answer the question were classified as "Unanswered" (Graph 7).
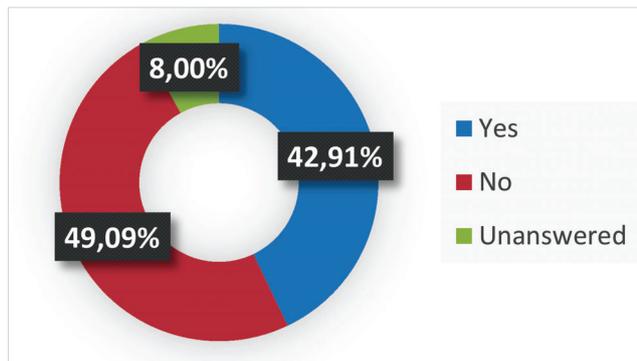
Graph 7 General share of responses to the first part of question no. 12
Grafikon 7. Opći udio odgovora na prvi dio pitanja br. 12

Source: Authors

The responses to the second part of the question which was "If YES, please state what was asked of you" were further analysed. Hence, 118 positive responses offered by participants who went through the ECDIS system inspection were analysed. They were classified into five categories according to the segments of control, i.e. what was required of them. The categories were specified in accordance with the port State control questionnaire, with one additional category "Other".

Categories:
- Validity of ship's and ECDIS users' certificates
- ECDIS system handling technique
- Updating electronic charts
- Voyage planning
- Voyage monitoring
- Other

The category "Other" referred to participants who did not answer the question (11 respondents) and to unclear responses (3 respondents). Each response may contain several categories determined by the way the control was conducted. Controls should ideally cover all of the ECDIS segments essential for the safety of navigation.

Results show the most common ECDIS system control segments (Graph 8). Most of respondents went through the control of chart updating (70 respondents). Up-to-date charts being a prerequisite for safe navigation make this answer a logical outcome. A small number of respondents who underwent the voyage planning control (28 respondents) and voyage monitoring (18 respondents) is of very high concern.

Voyage planning and voyage monitoring are critical segments of the ECDIS system, so the share of respondents should be significantly higher to ensure the adequate system handling and the navigation safety. A small number of respondents (24 officers) mentioned the control of ship's certificates as one segment of control. Control of the ship's certificates and in particular the conformity of the ship's equipment with the Record of Equipment for the Cargo or Passenger Ship Safety Equipment Certificate (Form E or Form P) is the introductory and routine part of controls. That being the case, it is possible that some respondents omitted to mention it, assuming that it was implied. A relatively large share of respondents (44) stated that the inspection had checked the ECDIS system handling technique.
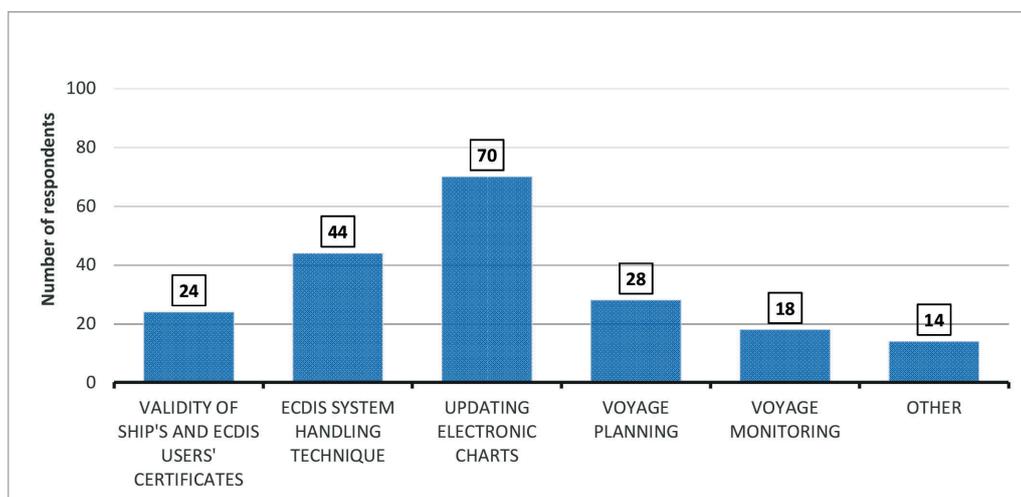
Graph 8 Results of the analysis of response to the second part of question no. 12
Grafikon 8. Rezultati analize odgovora na drugi dio pitanja br. 12

Source: Authors

8. DISCUSSION / *Razmatranje*

The analysed responses to the question number 12 reveal that still there is a smaller proportion of ECDIS system users who encounter the inspection of that system. According to the target group responses, almost half of participants (49.09%) did not undergo the ECDIS system inspection. Less than half (42.91%) of users encountered such inspection. Since this is a new system that has a significant impact on maritime safety, its control should be more frequent. Such a result is confirmed by one of the recommendations of the Tokyo MoU upon the completion of the aforementioned campaign. It states that Member States should continue to monitor compliance with the safety requirements for navigation after the campaign has been carried out. Analyses of the most common deficiencies pertaining to the Safety of Navigation category within the Paris MoU reveal a poor representation of ECDIS system deficiencies among the deficiencies observed. This is particularly emphasized by the fact that many of the deficiencies observed pertain to the equipment whose complexity and importance is not equal to that of the ECDIS system. This could also indicate the insufficient ECDIS system inspection.

The results of the second part of questions, intended to make the control segments known, show that unfortunately the ECDIS system is still perceived as a chart on the screen without taking into account all its performances. This particularly refers to voyage planning and monitoring. Defining the voyage safety parameters is one of the ECDIS key functions that form part of the voyage planning and monitoring. These parameters include setting depth contours and allowed deviation from the planned route, verifying the passage plan, Radar Information Overlay – RIO image (RIO) and many others. Conclusions drawn from the questionnaire results were confirmed by the recommendation produced by the Tokyo MoU after the concentrated campaign, which emphasized the need to improve the knowledge of port State inspectors. The Paris MoU concentrated campaign revealed most deficiencies in the field of voyage planning. Its recommendations emphasized the need for further work on voyage planning. Such a result is not in line with the results of survey questionnaire, where only a small number of respondents met with the voyage planning control. Namely, the concentrated campaigns were conducted at the end of 2017 when the majority of respondents had already filled in the questionnaire, so the discrepancy between the results can be attributed to this factor. It should also be taken into account that one of the objectives of concentrated campaigns was the control of voyage planning; thus a mandatory part of a standardized questionnaire used for the campaigns was the its inspection.

9. CONCLUSION / *Zaključak*

The paper investigates the role of inspector and his work regarding the ECDIS system use, with an emphasis on the frequency and quality of inspection. This paper is part of the ECDIS EHO project that, through conducted research, has always focused on educating the system users and implementing the acquired knowledge. Several conclusions can be drawn based on the analysis of available data with regard to the work of the port State control, previous research, and the ECDIS EHO survey results. According to the results of the first part of the ECDIS EHO survey questionnaire officers of the watch consider the use of ECDIS system to be rarely controlled, which is partly confirmed by the recommendations of the Tokyo Memorandum

and the Paris Memorandum of Understanding report analysis. The ECDIS system inspection and the control of its use must be more frequent to improve the navigation safety and environmental protection. Further analysis of the survey reveals some shortcomings of inspections. The results of the second part of the questionnaire show that the essential aspects of the ECDIS system are poorly controlled. This primarily implies voyage planning and monitoring. Poor voyage planning and monitoring can make a difference between a safe passage and a distress. Given the poor standardization of ECDIS, it is possible that some inspectors are not familiar with its different types, which reflects on the quality of inspection. IHO circulars imply that some navigational safety inspectors lack the knowledge of the ECDIS system use. Prior research emphasizes the need for further education and training organized for inspectors. This is confirmed by the guidelines provided by the Tokyo Memorandum of Understanding. All parties involved need to keep pace with a fast-changing maritime technology. The paper proposes a new relationship between inspectors and the training system. The objective of such a relationship is to improve the knowledge and skills of inspectors and, on the other hand, to provide the education system with the opportunity to adapt courses so as to tackle the identified deficiencies. The availability of inspection data enables the analysis of the necessary measures required for adapting and improving the training system. In addition to the availability, detailed reports are necessary to identify which system segments require more attention. The ECDIS training for inspectors is a prerequisite for adequate control of the system, so new courses are proposed in this paper in order to raise its quality. Specialized courses require a flexible educational framework to meet the needs of dynamic processes in modern navigation.

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