IAMUC AGA21

June 29th, 2021

Dear Sir/Madam

we would like to submit our manuscript entitled *"ECDIS EHO: Handling the ECDIS failure at sea"* for publication in the proceedings of the conference IAMUC AGA21.

The article presents the results of the research carried out within the ECDIS EHO project and research, funded by the University of Rijeka. The research method relies on the ECDIS Survey Analyses: Experience, Handling and Opinion (EHO) among the seafarers on the international scale.

The aim of research is to determine navigators' response in case of ECDIS total failure, and to identify if their reaction is supported or guided by company procedures. This research analyses part of the questionnaire which refers to the behaviour of navigators in ECDIS failure emergency and seek for procedure clarification by respondents. Answers are presented and discussed, revealing certain drawbacks in failure response and procedures. Along with presented results, survey of practice among shipping companies was carried out, supporting the results of questionnaire.

We declare that the manuscript is original, has not been published before and is not currently being considered for publication elsewhere.

We also submit the biography of the presenter Assistant Professor Srđan Žuškin, PhD who is also corresponding author for the manuscript.

Thank you for your consideration of this manuscript.

Sincerely,

Srđan Žuškin, PhD
Assistant professor
Department of Nautical Science
University of Rijeka, Faculty of Maritime Studies
Studentska ulica 2, 51 000 Rijeka
Croatia

ECDIS EHO: Handling the ECDIS failure at sea

Miho Kristić[a], Srđan Žuškin[b], David Brčić[b], Maro Car[a]

[a] University of Dubrovnik, Nautical Studies, 20000 Dubrovnik, Croatia
[b] University of Rijeka, Faculty of Maritime Studies, 51000 Rijeka, Croatia
email: miho.kristic@unidu.hr, szuskin@pfri.hr

Keywords: maritime navigation, electronic chart display and information system, ECDIS EHO

Abstract: The meaning of navigational safety is changing together with everlasting evolution of technology on ships at high seas. The Electronic Chart Display and Information System (ECDIS) as a most recent breakthrough in shipping, changed drastically not only layout of the navigational bridges but also navigational methods and routines. The safety reasons dictate compulsory redundancy of ECDIS system, recognising its central role in modern day navigation. If a ship's ECDIS back-up arrangement is realized by installation of second independent system, it is known as paperless ship. Duplication increases the reliability of the system, but even a duplication doesn't guarantee full reliability of the system at all times. In emergency situation as ECDIS total failure, navigator should rely on company procedures and guidelines.

The aim of research is to determine navigators' response in case of ECDIS total failure, and to identify if their reaction is supported or guided by company procedures. The research is based on international survey in form of questionnaire conducted among wide spectra of ECDIS stakeholders. This paper analyses part of the questionnaire which refers to the behaviour of navigators in ECDIS failure emergency and seek for procedure clarification by respondents. Answers are presented and discussed, revealing certain drawbacks in failure response and procedures. Along with presented results, survey of practice among shipping companies was carried out, supporting the results of questionnaire. The findings are emphasized in concluding chapter followed by proposal for further research and activities.

1. INTRODUCTION

Two and half years have passed since deadline for mandatory implementation of ECDIS onboard merchant ships. The system's introduction was preceded by preparation for it, in view of policies and procedures implementation, necessary for a smooth transition to a revolutionary navigational aid. After the actual implementation of ECDIS, new navigational routines have been developed, and the system continued to evolve. System integrated other navigational devices and had become the central navigational element of the modern navigational bridge. As electronic equipment failures are inevitable, adequate redundancy for the system is compulsory. When this redundancy is achieved by second independent ECDIS, there is no obligation for a ship to carry Paper Navigational Charts (PNC). The proposed paper focuses on navigator response to a failure of both ECDIS units: primary and back up unit. The research aims to analyse the navigator's response in case of ECDIS failure and identify the availability of adequate industry guidelines as support to the navigator in such case. In the background chapter, general arrangement of ECDIS on a paperless ship is presented, supplemented by previous research and investigations of some recent ECDIS failures.

Following background chapter is the analyse of four shipping companies' navigational procedures. Chosen shipping companies are different by the size of the fleet and type of the ships they operate. Results obtained point to insufficient penetration of failure response procedures among shipping companies observed.
The survey chapter analyses one of the questions from the international survey conducted from 2014 till 2018. The questionnaire, as a foundation of the survey, was internationally distributed mostly among navigational ranks serving on different types of vessel. Answers of target group consisting of only navigational ranks which had sailed on the paperless vessels were analysed and summarised. In order to identify potential difference between respondent's subgroup, target group was clustered based on ship's type. Difference between respondent's subgroup were identified and presented. Findings were further discussed, revealing some problems in both the implementation of emergency procedures and response to ECDIS failure. In the last chapter, results and finding are summarized, providing guidance for future research with regards to the subject.

2. BACKGROUND

The term paperless ship stands for the vessel navigating with ECDIS without paper navigational charts. The paperless ship's idea was not easily accepted by traditionalists, as paper charts were successfully serving international shipping for centuries. Several studies conducted on ECDIS acceptance among navigators revealed that there is still a significant number of supporters of PNC [1-4]. The mandatory deadline for implementing the ECDIS system as required by SOLAS ended on 1st July 2018 [5, 6]. For ECDIS to satisfy SOLAS requirements, it must be type-approved, use up-to-date Electronic Navigational Charts (ENC), be maintained according to the International Hydrographic Organization (IHO) standards and have an adequate backup arrangement. The International Maritime Organization (IMO) performance standard [9] specifies the meaning of adequate independent back up an arrangement as the one enabling safe takeover of the ECDIS function in order to ensure that ECDIS failure does not result with the critical situation and providing safe navigation for the remaining of the voyage. This phrase allows different interpretation, but according to IHO publication S-66 [10] normally accepted options are:

i. A second ECDIS powered by an independent power supply and with separate position source,
ii. Appropriate portfolio of updated paper charts,
iii. Chart radar if allowed by the flag state administration.

This paper focuses on a vessel sailing with second ECDIS as a backup option, so the other two options are not further analysed. Typical ECDIS back up arrangement is shown in Figure 1. The system consists of a minimum of two ECDIS workstations, primary and independent back up unit. Onboard the ships it is usual to have identical ECDIS units from the same maker, as companies have a single provider contract. This reduces expenses but also improves the implementation of ECDIS on board [9].

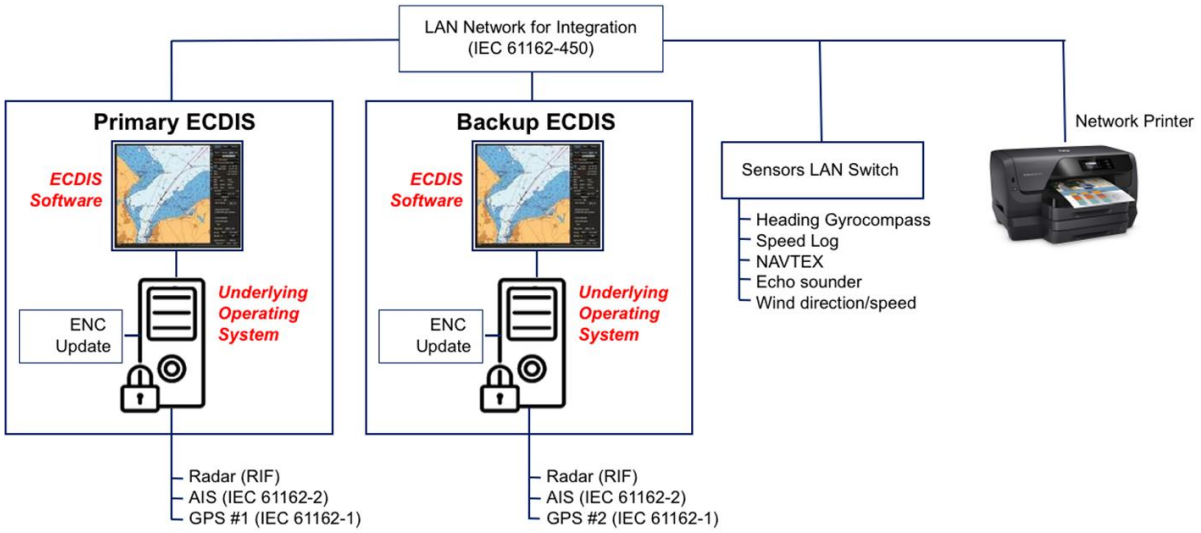

Figure 1: Primary and backup ECDIS arrangement

Such an arrangement should normally provide adequate redundancy in the case when one ECDIS workstation in any case fail. However, as almost no electronic system is failsafe, there is a possibility that both systems fail. Failure of both ECDIS unit can be a result of internal or external causes. Internal causes could be loss of sensors' feed, Hard Disk Drive (HDD) or Solid-State Disk (SSD) failure, power source failure or software failure. External causes could be caused by cyber-attack or by intentional disruption of satellite positioning signals. In his work Sumic et al. [10] proposed adding a cold stand-by ECDIS that should prevent total failure due to updating and upgrading the system device. Research on reliability of ECDIS back up configuration by Blokus et al. [11] concludes that development of systems with additional redundancy workstations is not appropriate solution, as it does not increase reliability respectively. In same research, usage of cold stand-by ECDIS as proposed by Sumic et al. is confirmed as solid option.

Upgrading and updating ECDIS software by the technical representative was a cause of the incident on board ship with integrated navigation bridge [12]. During the incident, almost all navigational systems failed, at the worst moment, in poor visibility and dense traffic. The ship navigated for two days by use of one radar only and portfolio of paper charts. The investigation found that the obsolete operating system was not able to run newly installed software and crashed. In another report, a ship arriving in Port Hedland, Australia, reported that one ECDIS's hard disk failed after the weekly update. The report indicates that such a failure is quite common on several years old ECDIS units of one global manufacturer [13]. Researches on cybersecurity onboard ECDIS equipped ships confirmed a risk to ship navigational systems [14-16]. To adequately respond to ECDIS failure emergency, shipping companies are to prepare procedures in case of emergencies, based on their navigational policy and detailed risk assessment. As each ship's navigational systems' layout is unique, generic solutions should be modified to suit particular vessel.

3. MARITIME INDUSTRY PRACTICE

The adequate handling of the ECDIS failure at sea is a matter of navigational policy and procedures implemented onboard the vessel. The shipping companies should implement policies and procedures in case of emergencies onboard according to the International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code)

[17,18]. Procedures in a case of ECDIS failure as a response to an emergency should be part of such shipping company procedures. As ECDIS is a relatively new device, mandatory for most SOLAS vessels after July 1st 2018, procedures and policies regarding ECDIS are still evolving. Bridge Procedures Guide issued by the International Chamber of Shipping (ICS) is traditionally used as a reference for safe shipping procedures by shipping companies and maritime professionals. While it recognises the requirement to understand ship procedures in a case of ECDIS failure, as part of ECDIS familiarisation procedure, there is no ECDIS failure procedure included in the last edition of this valuable publication [19].

Procedures in case of ECDIS failure usually vary depending on the shipping company profile. In this paper, four shipping companies' procedures, different by type of vessels and size, will be analysed (Table 1).

Shipping company “A” is a large shipping company managing different type of ships including Container vessels, Bulk carriers, Very Large Crude Oil Carriers (VLCC) and Liquefied Natural Gas Carriers (LNGC). ECDIS failure procedure is included in navigational procedures and contains guidance for ECDIS abnormalities, one ECDIS failure, and ECDIS failure. There is also a risk-mitigating policy suggesting creating mapping on radars and input waypoints and cross-track limits in GNSS. Setting appropriate bridge watch level in case of this emergency is not a part of the procedure.

Shipping company “B” is a large company operating cruise ships. The company implemented a procedure in case of ECDIS failure but did not consider some important actions i.e. setting the engine setting the engine to stand by, use of manual steering or transmitting safety message. Also, there is no risk-mitigating procedure as a part of the navigational policy.

Shipping company “C” is based on Cruise Ships Company operating fleet of four ocean-going vessels. Company requests from vessels to develop recovery procedures in the case the ECDIS system crash, but has no uniform company procedure in the case of ECDIS failure. ISM code clearly requires the company to implement procedures, but also work instructions, checklist and other forms [2].

Shipping company “D” is a container shipping company operating a globally significant fleet of container vessels. Company ships are equipped with two independent ECDIS workstation, and additionally with folio of port approach paper charts. However, company has no procedure in case of ECDIS failure. This was explained by low probability of failure of both ECDIS units at same time.

	Company "A"	Company "B"	Company "C"	Company "D"
Inform Master	Yes	Yes	No	No
Inform Chief Engineer	Yes	Yes	No	No
Engine standby	Yes	No	No	No
Determine ship position	Yes	Yes	No	No
Determine navigational hazards	Yes	Yes	No	No
Verify traffic condition	Yes	Yes	No	No
Manual steering	Yes	No	No	No
Reduce speed	Yes	Yes	No	No
Stop the vessel	Yes	No	No	No
Use redundancy ECDIS/ECS	Yes	Yes	No	No
Take-me-home PNC	Yes	No	No	No
Transmit Safety message	Yes	No	No	No
Set appropriate bridge level	No	Yes	No	No

Table 1: ECDIS failure procedures of analysed companies

Analysis of the above-mentioned shipping companies' procedures leads to the conclusion that ISM requirement of providing emergency policies and procedures is not yet fully implemented worldwide. Two companies analysed in this paper, have procedures in place, but two other are without procedure in case of ECDIS failure. Additionally, the ICS, as the industry recognised organisation, even recognising a necessity of ECDIS failure procedure, fail to provide a framework for such a procedure.

4. THE SURVEY RESULTS

The proposed paper is part of the larger survey started in 2014. International questionnaire as a main source of the survey was used initially as a part of ECDIS courses for merchant seamen at the Faculty of Maritime Studies in Rijeka. Survey evolved by increasing the number of questions and number of respondents. For the survey to reflect global trends, questionnaire was spread among international shipping companies. Results provide insight into opinions and practice of ECDIS stakeholder, assist to identify problems and possible solution, and finally provide some new topics for future research.

1.1. A questionnaire overview

The international questionnaire named “ECDIS Survey Analyses: Experience, Handling, Opinion” or ECDIS EHO consist of 26 questions. These 26 questions can be grouped into three categories: introductory profile defining questions, ECDIS handling questions and finally set

of opinion questions. Responses regarding response to ECDIS technical failure during the navigation were collected in the period 2014 – 2018.

1.2. Respondents target group

The questionnaire contains answers from wide spectra of maritime professionals, from active seafarers sailing on different types of ships to shore staff. Responses from 350 respondents were collected and classified by rank: 99 Masters (M), 77 Chief Officers and First mates (1/O), 66 Second mates (2/O), 13 Third mates (3/O), 8 Staff captains (SC), 1 Marine safety consultant (MSC), 3 Safety officers (SO), 3 Environmental officers (EO), 4 Dynamic positioning operators (DPO), 1 pilot (P), 1 superintendent (SI), 1 supervisor (SV), 14 port State control officers (PSCO), 25 trainees (T), 1 Yacht-Master (YM) and 33 persons of unspecified position making part of the navigational watch (U) (Figure 2).

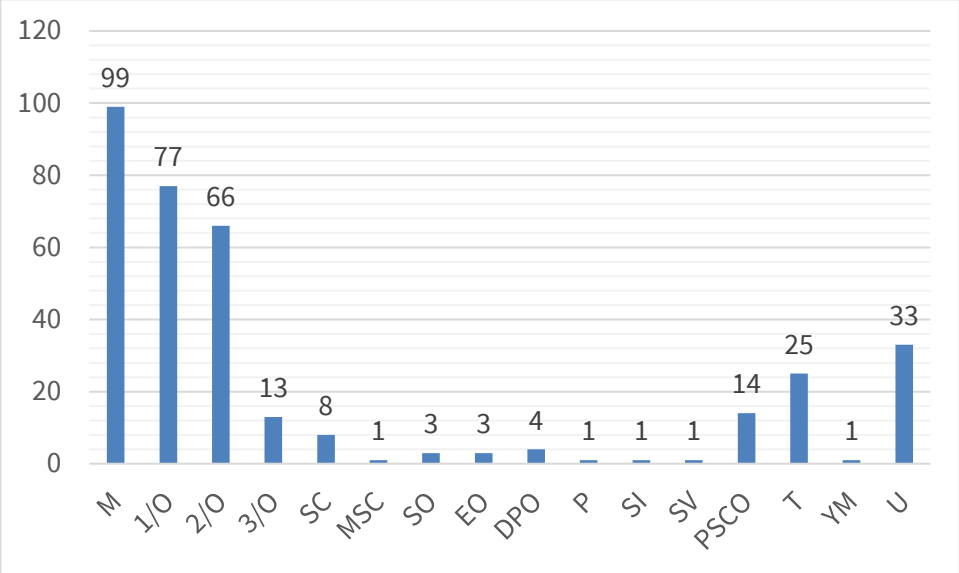

Figure 2: All ECDIS EHO survey respondents by rank

Question elaborated in this paper requires an answer of active seafarers sailing on a vessel that uses ECDIS as primary means of navigation. It is achieved by filtering the initial sample to a representative sample by using introductory questions:

1. *Is the ECDIS system used as the primary means of navigation on your ship (if ECDIS system was used as the primary means of navigation on one of your previous ships, please indicate so)?*
2. *What is your rank on board?*

Only persons that have sailed on the vessel using ECDIS as primary means of navigation and navigational ranks were considered for future analysis. The result is the target group containing 115 respondents (Table 2).

Master	Staff Captain	First officer	Second officer	Third officer	Trainee	Total
28	5	34	29	6	13	115

Table 2: Target group distribution by a rank

Target group consist of 28 Masters, 5 Staff Captains, 34 First officers, 29 Second officers, 6 Third Officers and 13 Trainee.

1.3. Results and analysis

Target group was furthermore used for evaluating the following question:

Q1: Assuming that you sail on a paperless ship, what would you do in case of an ECDIS systems technical failure during the navigation (if there are guidelines prescribed by the company in accordance with the ISM, please specify them)?

The question consists of two parts, the first part describes the respondent's action in case of ECDIS failure, and the second part defines if a company has a procedure in accordance with ISM and describes it.

The first part of the question was answered by 66 participants (57.4 %), while 49 participants (42.6 %) provided unclearly or no answer. Answers from 66 respondents that gave clear answers were further analysed. (Figure 3). Some of the respondent answers considered multiple actions, so their answers were included into more than one category.

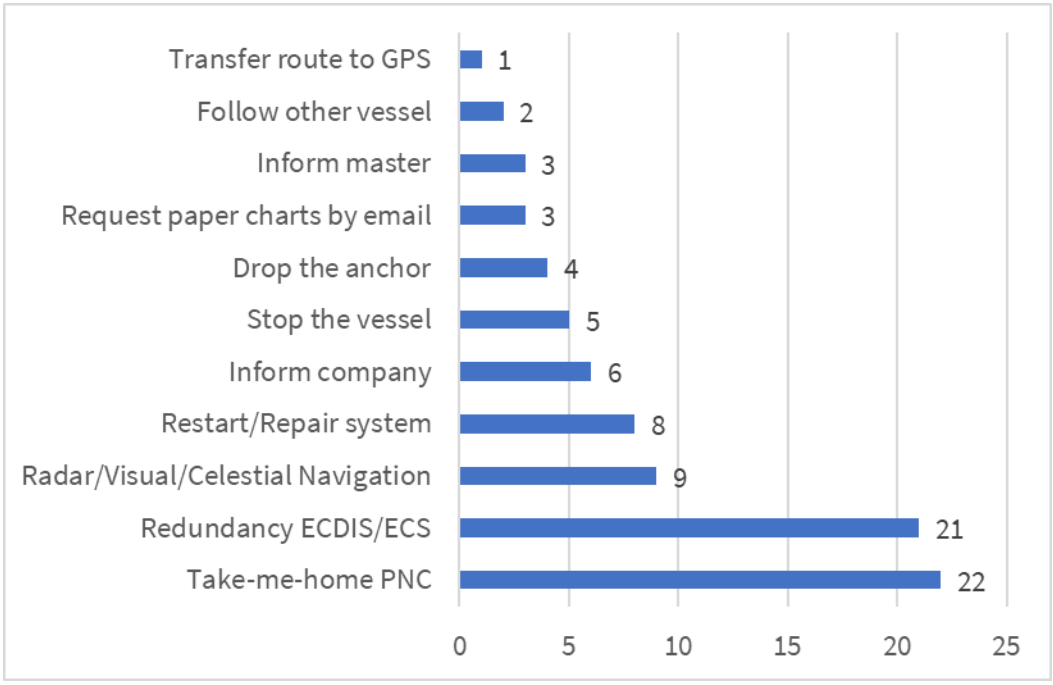

Figure 3: Distribution of answers on first part of Q1

There are two major groups of answers: usage of take-me-home paper charts answered by 22 respondents, and redundancy ECDIS/ECS by 21 respondents. Radar, visual or celestial navigation as a response is answered by 9 participants and 8 respondents would try to repair or restart of ECDIS. Other actions as informing the company, stopping the vessel, dropping the

anchor are considered by minor part of respondents. Only one person would transfer route waypoints to GPS, and nobody considered slowing down the vessel to a safe speed and raising engine status to stand-by.

Additionally, as some type of ships are subject to stricter control by internal and external parties, possible difference between participant subgroups is analysed according to ships type. Target group respondents were grouped into statistically significant subgroups: Tankers (39 %), Cruise ships (29 %) and Other (32 %) (Figure 4).

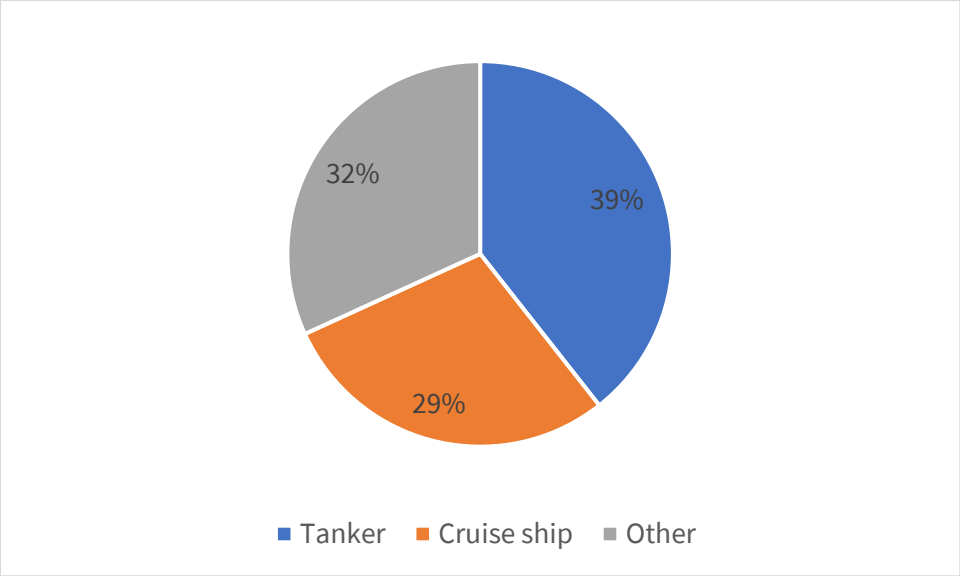

Figure 4: Target group respondents clustered by type of vessel

Only result of the four main answers, which summarizes together equal to more than 70 % of all answers, are analysed further. Distribution of answers to *Q1* among subgroups is shown on figure 5. Usage of redundancy ECDIS/ECS is the lowest in *Other* vessel group, while it is almost equal in *Tanker* and *Cruise ships* group. Usage of Gohome PNC is highest in Other vessel group.

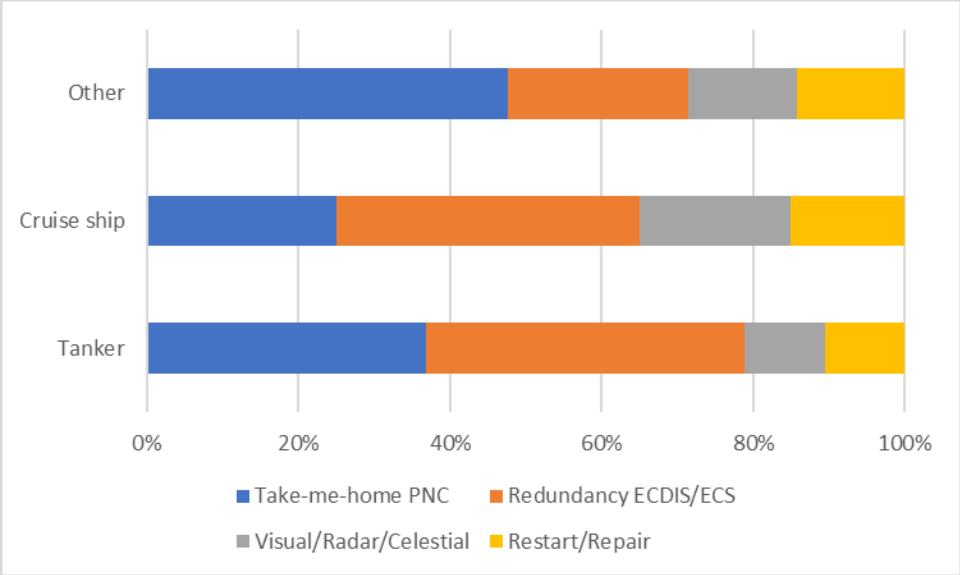

Figure 5: Distribution of answers of subgroups by type of vessel

For the analysis of the second part of question, answers of the 66 participants that responded to first part of Q1 were used. As remaining 49 respondents of target group gave no answer to first part of question, they were not further considered. Results of answers to second part of a question are shown in figure 6.

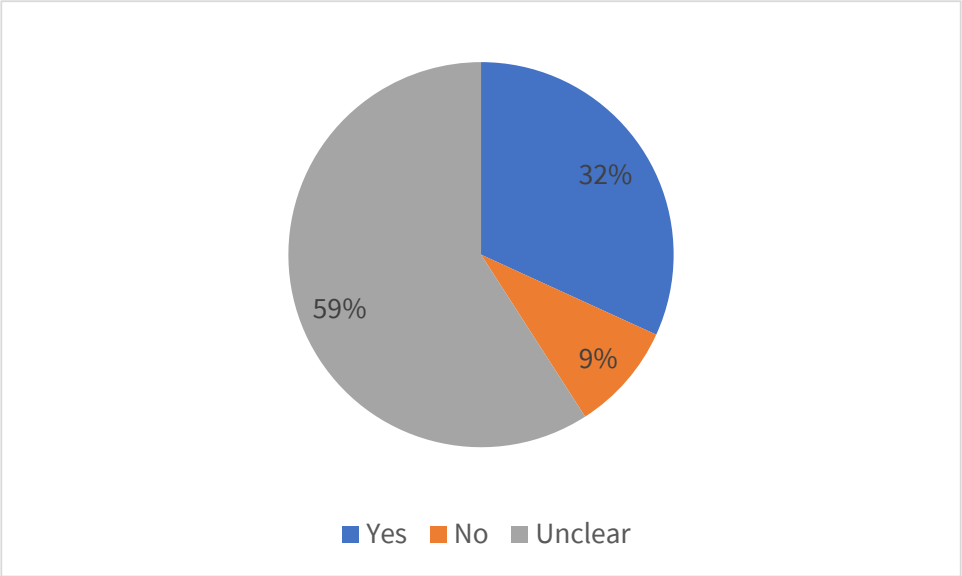

Figure 6: Result of answers on a second part of Q1

Only 32 % of respondents clearly confirmed that their companies have guidelines in case of ECDIS failure, and 9 % of respondents reported not to have a guideline. A remarkably high percentage of respondents (59 %) did not provide exact confirmation to the second part of the question. A fair share of unclear answers may be in fact confirmation of no procedure in case of ECDIS failure.

5. DISCUSSION

Generally speaking, the shipping industry is not well prepared to adequately respond to emergency arising from total ECDIS failure. On the first part of the question regarding respondents' action in case of technical failure of ECDIS system, more than 42% of respondents failed to provide any or at least any meaningful answer. Considering ECDIS as vital and central navigational aid in modern shipping, before mentioned survey participants are presenting potential problems for the safety of navigation. What is behind such a result? The percentage is too high to consider subjective reasons, so it is to assume system error. Is it failure of company to establish a procedure, failure of training and educational facilities, or both?

Another group of respondents that provided their response to hypothetical failure, mostly answered by two typical solutions: use take-me-home paper chart or redundancy ECDIS/ECS. Only eight respondents would try to restart or repair units, while nobody considered slowing down the vessel. Dropping anchor is solution for four respondents, even during time of ECDIS failure there is no chart to show if area is safe for anchoring, or what is the depth. Similarly, using celestial navigation with no chart available is not a valid option.

Response to failure at sea, normally includes set of actions, which are defined by procedure. Procedures itself are based on risk assessment that includes all kind of measures to safeguard navigational safety. Answers of respondents are just partial solution to complex situation, which must include several well-defined actions of navigator. Response should include most of answers that respondents provided.

Disagreements between groups was analysed by division of initial group to subgroups based on ship's type. The category take-me-home paper chart is the least represented on cruise vessel, and mostly on other vessels type. This is expected, as passenger ships usually have multiple ECDIS workstations, and invest more in navigational safety.
In analyse of second part of the question, only 66 respondents that answer on first part of question were considered, other 49 persons that gave no answer to first part were not included. It is logically to assume that they have no procedures as they didn't provide any clear answer to first part. Unfortunately, answers on first part of question forebode results of second part with regards to procedures on board. Only 32 % of respondents clearly answered to have procedures in case of ECDIS failure on board. Other participant did not answer or have no procedure on board.
Having result of second part of question available, it is plausible to conclude that responses on first part of question are mostly instinctive solutions to the perils of the sea, with no procedure and no training.
Finally, result of survey among navigators are confirmed by survey of industry practice conducted on four shipping companies. Only one of analysed companies has comprehensive guidance for navigators. It was interesting to find that one major shipping companies found redundancy as justification for not having ECDIS failure guidance. On modern ship redundancy is a standard, but additional steering gear for instance doesn't mean that ships are not required to train for emergency steering.
Three major findings could be presented:

- Significant number of respondents are not able to respond to ECDIS failure at sea,
- Procedures for ECDIS failure are not available to majority of navigators,
- Industry has no clear guidelines for ECDIS failure response.

While industry does not provide clear guidelines and procedure it is not possible to expect better results from navigational officers. ECDIS system is implemented globally probably faster than any other navigational aid in history and has changed radically navigator's environment and routines. This was not completely followed by proper procedures and there is still space for improvement of navigational safety.

6. CONCLUSION

The proposed paper deals with response to ECDIS failure by active navigators sailing on paperless ships. The term paperless describe vessels which ECDIS system redundancy is achieved by a second independent ECDIS workstation. For the purpose of survey, target group of respondents is selected. Only answers of respondent that are active navigators and have been sailing on paperless ship are considered for analysis. General conclusion of the survey is that navigators are not adequately trained and guided for ECDIS failure situation. Notable number of respondents could not provide any answer on question targeting their reaction to ECDIS failure at sea. Among respondents that answered first part of question, majority of them would use take-me-home charts or additional redundancy ECS/ECDIS. None of respondents provided full set of action to be taken in case of failure.
Such a result is somehow expected considering that other part of question reveals that procedures for this emergency are not well established. Most of respondent do not have procedures in case of ECDIS failure on board. Obviously, some shipping companies are reliant that technology will not fail them. However, it is obligation of shipping company under ISM to have emergency procedure on board the vessel.

Furthermore, analysis of four shipping companies confirms that procedures are still to be implemented on many ships worldwide. Without proper procedure based on detailed and ship specific risk assessment, there cannot be adequate response of navigators, this is what history of navigation has taught us so far. Future research should focus on defining factors that should be considered for comprehensive ECDIS failure procedure. This could assist the shipping industry in effort to propose suitable framework for shipboard ECDIS failure procedures.

ACKNOWLEDGMENTS
This study represents the continuation of the ECDIS EHO project and research. The authors are grateful to all the navigational ranks, officers of the navigational watch, and other ECDIS stakeholders for their time and willingness to complete the surveys, and participate in discussions. The authors believe that their responses and opinions have an immense significance for the appropriateness of the research deliverables.

REFERENCES

1. Brčić, D.; Žuškin, S. Towards Paperless Vessels: A Master's Perspective. *J. Marit. Transp. Sci*. **2018**, 55, 183–199. https://doi.org/10.18048/2018.00.12
2. Brčić, D.; Žuškin, S.; Valčić, S.; Frančić, V. Implementation of the ECDIS system: An OOW perspective as an integral part of educational improvement. In Proceedings of the 19th IAMU AGA Conference (IAMU 19), Barcelona, Spain, 17–19 August 2018; Grifoll, M., Martínez de Osés, F.X., Castells, M., Martin, A., Eds.; Universitat Politecnica de Catalunia/International Center for Numerical Methods in Engineering: Barcelona, Spain, 2018; pp. 121-128
3. Brčić, D.; Žuškin, S.; Valčić, S.; Rudan, I. ECDIS Transitional Period Completion: Analyses, Observations and Findings. *WMU J. Marit. Aff*. **2019**, 18 (2), 359–377. https://doi.org/10.1007/s13437-019-00173-z.
4. Car, M.; Brčić, D.; Žuškin, S.; Svilicic, B. The Navigator's Aspect of PNC before and after ECDIS Implementation: Facts and Potential Implications towards Navigation Safety Improvement. *J. Mar. Sci. Eng.* **2020**, 8 (11), 1–14. https://doi.org/10.3390/jmse8110842.
5. International Maritime Organization. International Convention for the Safety of Life at Sea (SOLAS) 1974, with amendments. IMO: London, UK, 2014.
6. International Maritime Organization. Resolution MSC.1/Circ.1503/Rev.1, *ECDIS—Guidance for Good Practice*; IMO: London, UK, 2017.
7. International Maritime Organization. Resolution MSC.232(82), *Adoption of the revised performance standards for Electronic Chart Display and Information Systems (ECDIS);* IMO: London, UK, 2006.
8. International Hydrographic Organization. *IHO Publication S-66e 1.0, Facts about Electronic Charts and Carriage Requirements*, 1.0.0 ed.; IHO: Monaco, 2017.
9. Sviličić, B.; Kristić, M.; Žuškin, S.; Brčić, D. Paperless Ship Navigation: Cyber Security Weaknesses. *J. Transp. Secur.* **2020**, *13* (3–4), 203–214. https://doi.org/10.1007/s12198-020-00222-2.
10. Sumić, D.; Peraković, D.; Jurčević, M. Contribution to ECDIS Reliability Using Markov Model. *Trans. Marit. Sci.* **2014**, *3* (2), 149–157. https://doi.org/10.7225/toms.v03.n02.006.

11. Blokus, A.; Dziula, P. Reliability Analysis of Different Configurations of Master and Back-Up Systems Used in Maritime Navigation. *J. Mar. Sci. Eng*. **2020**, 8, 34. https://doi.org/10.3390/jmse8010034
12. Baltic and International Maritime Council (BIMCO). The Guidelines on Cyber Security Onboard Ships -Version 4. Available online: https://www.bimco.org/about-us-and-our-members/publications/the- guidelines -on-cyber- security-onboard-ships (accessed on 23 January 2021).
13. International Hydrographic Organization. ENCWG 2-7.4B, *AUS Port State Control Issues regarding ECDIS and ENC (AMSA-AHS);* IHO: Monaco, 2017.
14. Sviličić, B.; Kamahara, J.; Rooks, M.; Yano, Y. Maritime cyber risk management: an experimental ship assessment. *J. Navig*. **2019**, 72:1108–1120. https://doi.org/10.1017/S0373463318001157
15. Sviličić, B.; Kamahara, J.; Ćelić, J.; Bolmsten, J. Assessing ship cyber risks: a framework and case study of ECDIS security. *WMU J. Marit. Aff*. **2019**, 18, 509–520. https://doi.org/10.1007/s13437-019-00183-x
16. Sviličić, B.; Rudan, I.; Frančić, V.; Doričić, M. Shipboard ECDIS cybersecurity: third-party component threats. *Pomorstvo, Sci. J. Mar. Res.* **2019**, 33, 176–180. https://doi.org/10.31217/p.33.2.7.
17. International Maritime Organization. Resolution A.741 (18), *International management code for the safe operation of vessels and for pollution prevention (International safety management (ISM) code)*; IMO: London, UK,1993.
18. United Kingdom Hydrographic Office. *Admiralty Guide to ECDIS Implementation, policy and procedures – NP232*, 3rd ed.; UKHO: London, UK, 2019; pp. 22.
19. International Chamber of Shipping. *Bridge Procedures Guide*, 5th ed.; Marisec Publications: London, UK, 2016; pp.101.

Assistant Professor, Srđan Žuškin, PhD - Curriculum Vitae

Srđan Žuškin, PhD is employed as an Assistant Professor at Department of Nautical Sciences Faculty of Maritime Studies Rijeka, University of Rijeka, where he is teaching courses related to the Concepts and Capabilities of the Navigation Information Systems, Ship Design and Construction, Ship Stability and Container Transportation Technology.

So far, he has been a member/researcher of several professional, national, and international scientific projects and also project founded by European Commission under the Seventh Framework Programme - FP7 and Interreg projects. Currently, he is a researcher on several scientific projects; ECDIS EHO, Research into the Correlation of Maritime-transport Elements in Marine Traffic and Environment for Satellite Positioning, Cyber Security of Maritime ICT-Based Systems and MarItime and MultimOdal Sustainable pAssenger transport solutions and services (MIMOSA). His competences, relevant for the scientific project activities, include optimization methods and various navigation simulations, particularly in the fields of marine navigation using decision support information systems raising navigation safety and environment protection.

Srđan Žuškin, PhD has significant experience and organization skills in maritime professional teaching according to the STCW convention and tailor-made courses for Navigation and Shiphandling for different stakeholders and shipowner companies. Author of various scientific papers concerning Electronic Chart Display and Information System (ECDIS) with other decision support information systems in function of safer navigation in corporation with Maritime Education and Training (MET).

Srđan Žuškin, PhD is Head of Navigation Simulators, Member of the Croatian Chamber of Transport Engineers - The Department of Maritime Transport and Inland Waterway Engineers, International Association of Maritime Universities – IAMU, member of the Royal Institute of Navigation (RIN) and President of the ALUMNI Club - Faculty of Maritime Studies Rijeka.