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Navigation with ECDIS: Choosing the Proper Secondary Positioning Source

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ABSTRACT: The completion of ECDIS mandatory implementation period on-board SOLAS vessels requires certain operational, functional and educational gaping holes to be solved. It especially refers to positioning and its redundancy, which represents fundamental safety factor on-board navigating vessels. The proposed paper deals with primary and secondary positioning used in ECDIS system. Standard positioning methods are described, discussing possibilities of obtained positions' automatic and manual implementation in ECDIS, beside default methods. With the aim of emphasizing the need and importance of using secondary positioning source in ECDIS, positioning issue from the standpoint of end-users was elaborated, representing a practical feedback of elaborated topic. The survey was conducted in the form of international questionnaire placed among OOWs, ranging from apprentice officers to captains. The result answers and discussion regarding (non)usage of secondary positioning sources in ECDIS were analysed and presented. Answers and statements were elaborated focusing not only in usage of the secondary positioning system in ECDIS, but in navigation in general. The study revealed potential risks arising from the lack of knowledge and even negligence. The paper concludes with summary of findings related to discrepancies between theoretical background, good seamanship practice and real actions taken by OOWs. Further research activities are pointed out, together with planned practical actions in raising awareness regarding navigation with ECDIS.

1 INTRODUCTION

1st of July 2015 will be half of the period of mandatory Electronic Chart Display and Information System (ECDIS) implementation. This six-year implementation period appears as a long-term look-ahead; however, taking the enormous change and the need to adapt in consideration, it requires certain issues to be solved properly and, above all, timely. After the implementation ending date, there will be increasingly less time for solving or reviewing arising problems. It especially refers to positioning, which is by mandatory means incorporated in the ECDIS system, acting as an integrated part of it. Here, it is not about a traditional classification of maritime navigation in general and coastal navigation, but about a fact that reliable positioning and its redundancy represents fundamental safety factor on-board navigating vessels. Positioning methods depend on the nature of the type of navigation which takes place as well as available positioning means. Global Navigation Satellite Systems (GNSSs) are nowadays used as primary positioning sources in ECDIS. They provide most reliable and most accurate positions among others; however they are not immune to errors and failures. The safety of navigation requires a usage of secondary positioning source in ECDIS system as a trusty redundancy back-up in the case of potential primary positioning failure. Moreover, there appears a strong need for its verification by comparing obtained positions with other, independent methods and techniques. The proposed paper deals with positioning in ECDIS system and the usage of reliable secondary positioning source. Standard positioning methods are described along with their pros and cons, pointing out the possibility of obtained positions' implementation in ECDIS. Considering common navigational practice and theoretical background for good seamanship, the positioning issue from the standpoint of the end-users, i.e. navigational officers was elaborated. During the period of 2013-2015 a survey in the form of international questionnaire was placed among seafarers, ranging from apprentice officers to captains. The questionnaire contains questions related to experience with ECDIS, operation, personal opinion regarding justification of ECDIS system as a primary navigation mean, withdrawal of paper charts and other specific problems with which OOWs, as skilled end-users, are facing with. Questions and answers regarding ECDIS positioning were elaborated. The results and discussion regarding (non-) usage of secondary positioning in ECDIS were presented and analysed. Answers and statements were elaborated focusing not only in using the secondary positioning in ECDIS, but on navigation in general. In this way, a practical feedback was obtained, identifying potential risks arising from sequence of events in operational navigation. The main causal process here is transitional period of ECDIS implementation. The paper concludes with summary of findings and points out further research activities and practical actions needed, aiming at safer navigation and raising situational awareness.

2 POSITIONING

This chapter gives an insight into positioning methods used nowadays on board merchant vessels. A short overview of traditional methods is also presented, in order to emphasize the flow and the significance of transition period. It refers not only to positioning, but development of navigation tools, navigation conduction in general and its repercussions.

2.1 *General considerations*

Positioning can be classified in order of which type of navigation takes place: ocean going, coastal, navigation in port approaches and restricted waterways, and navigation in port areas and inland waterways (Bowditch 2002, IMO A 860(20) 1997, IMO MSC 915(22) 2001, Brčić et al. 2014). The navigation type determines (available and proper) positioning methods, positioning frequency and the required redundancy level. The most distinct difference appears between ocean and coastal navigation. In open-sea navigation, the officer of the watch (OOW) cannot rely on landmarks and shore stations which are providing lines of positions (LOPs) relative to marked objects (Nav 2013). Coastal navigation therefore provides number of reference objects from which LOPs are derived, but also represents greater risk for navigation (waterways, restricted passage routes, shallow waters …). In open sea, satellite positioning is the most common method, also often and regularly employed in other navigation segments.

2.2 *An short overview of positioning*

Depending on the type of positioning source and method used, position can be absolute (unambiguous) and relative (related to an object), employing different coordinate systems. On the one hand, traditional positioning methods developed over time in pace with technology and navigational equipment. On the other hand, the sole positioning methods remained the same, but the navigation tools changed. The positioning process remains the same. New navigation methods are developing, becoming more accurate, but also more susceptible at the same time.

Visual observations are the first and yet most reliable positioning and situational confirmation. On the open sea they are referring on other vessels in the first place, however in coastal navigation they are considered as the fundamental way for navigational situation interpretation and situational awareness. The observed, orienteering directions from objects are taking form of bearings, and the changing rate of objects size gives an perception of distance to the object. It determines two fundamental lines of position – the azimuth and the true distance (polar coordinate system LOPs). These two positioning tools are nowadays used in almost all methods and navigational devices, becoming more refined with navigational development.

Figure 1 presents a traditional positioning method based on the moment of appearance or disappearance of the object on the horizon (Kos et al. 2010). It seems unlikely that this method is still used; however it illustrates the human ingenuity one time before, when visual observations were sufficient to obtain a reliable position.

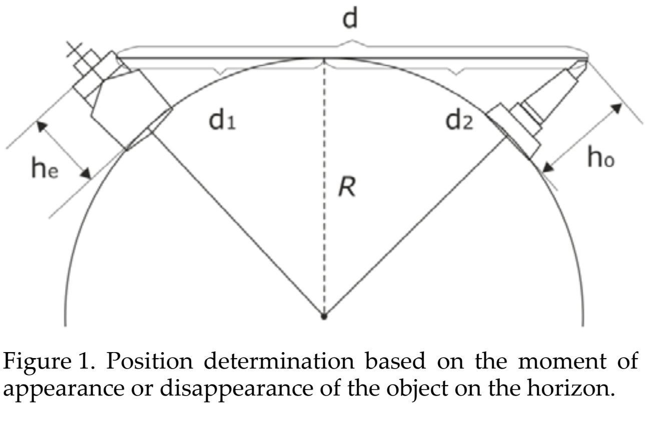

Figure 1. Position determination based on the moment of appearance or disappearance of the object on the horizon.

This ranging method is based on the calculation of the curvature of the Earth, Earth radius (R) and the usage of direction finder, e.g. magnetic compass (Kos et al. 2010):

$$d = d_1 + d_2 = k\sqrt{h_e} + k\sqrt{h_o} \quad (1)$$

where d = distance to object in (NM); h_e = height of the eye of the observer; h_o = height of the observed object; and k = constant calculated from the Earth's mean radius and distance conversion in nautical miles, $k = 1.9274$.

Since the sea horizon is greater than geometric, it can be stated that $k = 2$. This leads to final distance determination (Kos et al. 2010):

$$d \cong 2\left(\sqrt{h_e} + \sqrt{h_o}\right) \tag{2}$$

Although aged, described positioning method provides the navigator with azimuth (direction line) and distance (circle), the same lines of position on which contemporary coastal navigation relies on.

One of the first and sustained positioning methods is Dead Reckoning (DR). In this method, a known position is advanced on the basis of vessel's course and distance prevailed regarding vessel's speed. This method can be employed always, under condition that there is one known position, known course and known speed of the vessel. DR method developed from manual plotting on navigational charts to sophisticated methods embedded in navigational devices, by employing various differential and other algorithms. It can provide reasonable accuracy, however it becomes fairly inaccurate over time (Nav 2013). An Estimated Position (EP) can be viewed as DR upgrade, where outer effects on vessel's course and speed are taken into consideration (e.g. set and drift and other leeway effects), providing corrected Course Over Ground (COG) and Speed Over Ground (SOG) (Nav 2013, Bowditch 2002).

Celestial navigation positioning methods are not reliant on any electronic systems, and the position in due accuracy (≤1 NM) can be obtained by using the sextant, compass and nautical almanac solely. Lines of position (azimuth and distances again) are derived by known locations and movements of celestial bodies – stars, planets – which are acting as reference objects. Astronomical positioning methods are still valid check in open sea navigation. However, with the rise of new technologies and real-time positioning, there appears a possibility that these methods will slowly go into oblivion. The number of vessels where sextant is not anymore obliged increases, distancing celestial navigation methods from the common usage.

Radar represents an enhanced eye of the navigator, providing visibility in different parts of the frequency spectrum. Vessel's position can be obtained in several ways. LOPs from reference objects can be derived thus manually providing the position. In an automated way (Echo Reference - ER), the reliable object in vessel's vicinity can be used, providing vessel's continuous position relative to the object. Radar is autonomous device, meaning that it is not dependent on any other source except electricity. Even in the case of connected sources failure (e.g. heading and speed sources) it can be used with satisfying positional accuracy (e.g. in Relative Motion mode and Head Up oriented). Radar positioning is confined to coastal navigation, while in open sea remains a primary collision avoidance tool.

As for (and not only) ocean navigation, satellite positioning provides the navigator continuous service of positioning, navigation and velocity determination, as well as time standard service provision (Parkinson & Spilker, Jr. 1996, IS-GPS 2013). Among all GNSSs, the Global Positioning System (GPS) is most used, fully operable system. Satellite navigation is embedded in various systems which are based on its services. In relevant navigational equipment, such as Automatic Identification System (AIS) and ECDIS, GPS not only provides its services, but acts as an integrated part. With the development of multi-frequency satellite receivers (either employing several dedicated frequencies from one GNSS system, or employing various GNSS system's frequencies) and local and global differential services, satellite positioning services are reaching great levels of accuracy and reliability; however they are, as any other system, susceptible and vulnerable to effects of number of external causes (Chapter 5).

A number of supplementary positioning and situational methods can be used in order to obtain a position and interpret navigational situation. Some of them can be used as direct positioning means (e.g. Inertial Navigation Systems, or hyperbolic navigation systems where available) while other are used as complementary navigation tools (e.g. Echo Sounders).

This short positioning overview was given in order to present the choices and possibilities OOW can employ in order to obtain a position, but what is more important, to provide the OOW with supplementary positioning means in redundancy terms. Emphasizing the need for secondary positioning source, every position has to be double checked or multi checked. Moreover, theoretical knowledge of positional error and uncertainty areas is essential.

3 ECDIS

ECDIS system units can be divided in hardware and software components, uninterruptable power supply, official/updated databases (electronic charts) and required sensor ports for mandatory and additional navigation and aiding devices (IMO MSC 232(82) 2006, IMO A 817(19) 1995). These devices in ECDIS context act as a sensors, and they are not treated as standalone devices anymore. This is important fact. Once the regulated requirements are fulfilled (SOLAS 1974, IMO MSC 232(82), IMO A 817(19), IMO A 694(17), IMO MSC 191(79), IHO SP S-66 2010, IMO SN/Circ. 248), the system can be '…*accepted as complying with the up-to-date chart*'. This fact determines further way of understanding and conception of ECDIS as a primary navigation mean, but entails number of consequences.

3.1 *General review*

According to (IMO MSC. 232(82), IMO A. 817(19) 1995) performance standards, at least three mandatory devices should be connected in ECDIS;

positioning, heading and speed source. These sensors are needed for ECDIS to reach its full operability. Today, those are (most commonly): satellite navigation receiver (SNR) (ship's position fixing system, mainly GPS receiver), a gyro compass, and a speed and distance measuring device, although certain variations are possible. In case of two or more independent ECDIS systems on board vessels, at least one positioning system per ECDIS unit should be provided (IMO MSC 232(82) 2006). Independent ECDIS systems as a topic will not be elaborated further, but other means of positional redundancy inside sole system.

3.2 *Position determination and transfer*

The SNR GPS acts as an integrated part of the system. It is embedded in the ECDIS as well as in position interpretation on Electronic Navigational Charts (ENCs), which are produced in the same reference frame (MSC 232(82), NIMA 2000, IHO SP-66 2010), providing continuous display of vessel's position. In most of ECDIS equipment there are other dedicated sensor ports in order to connect other positioning sources; second SNR or other. Here, the most popular candidate is the Loran hyperbolic system. Although these systems were abandoned with the rise of satellite navigation, there are indications that improved Loran (*e-Loran/e-Chayka*) will take place increasingly. Several Loran chains are operating worldwide (NP 282 2014). The reasons of re-commissioning of hyperbolic systems are either positioning redundancy back-up as well as security reasons (Brčić et al. 2014). However, the Loran global network is far from fully operational.

Besides heading (HDG) and speed through water (STW) information, speed and distance measuring equipment (SDME) and gyro compass data inputs are enabling the DR automated position calculation in ECDIS. In addition with external sensors which are determining vessel's drift, leeway and steering errors (Bowditch 2002) an EP positioning method is enabled, improving the DR technique. DR/EP method is quite reliable over short periods, and they have to be corrected regularly. However, this implementation in ECDIS can be poor, depending on specific ECDIS manufacturer (Nav 2013, Norris 2010).

The position in ECDIS can be obtained and maintained relative to reference objects in the vessel's (restricted) vicinity, using the Echo Reference (ER) method. It can be employed by using the radar objects (overlaid on ENC), or by employing ECDIS radar functions – Radar Integrated Board (RIB) (Weintrit 2009). Although more reliable than EP/DR method, it suffers from several deficiencies: the possibility of selection of proper object is not always the case, and the time and the usage of reference object is limited on the vicinity to the specific object, i.e. vessel's movement. Moreover, there appears the possibility of skipping between objects.

Another possible positioning technique in ECDIS is a manual input of lines of positions (LOPs) from outer sources. It refers primarily on radar derived LOPs. Since entered manually, LOPs can be derived by all available navigational equipment means. Thus, any of methods providing desired lines of position can be used; however it is hardly ever the case.

3.3 *Display and plotting of positions on ENCs*

Current ECDIS systems are allowing for several possibilities of plotting positions on the ENC. Once predetermined, the positions are always present. SNR GPS derived positions are continuously displayed on chart. By using track options, they can also be presented as trajectories showing vessel's past movement. The same is possible with positions obtained with the secondary positioning, whatever the source. However, the secondary positioning source option has to be defined in the system and associated as the source which will provide the position and track. The system will alert the user in the case of positioning source error or unavailability. However, if the primary positioning source fails, and there is no secondary positioning source defined, the chart will freeze and it will become useless. Depending on the appearance of system's alarm, the time span between failure and OOW's awareness can be significant. Figure 2 presents an example of ENC primary and secondary position plots and corresponding tracks.

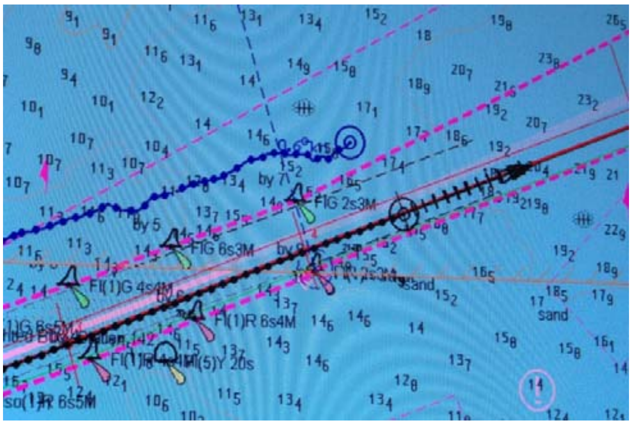

Figure 2. Own ship track display presented with Transas© Navi-Sailor 4000 ECDIS System on ENC chart. Black dotted (straight) lines represent vessel's position and past track from the primary positioning source, with the secondary positioning display marked in blue.

Position from outer source can be plotted manually in two ways: by using the manual option (depending on the ECDIS model and function availability), or by using predefined maps overlaid on ENC (additional layers). Usually, this function is often used to actuate the usually inactive raster chart to a certain degree, when ECDIS operates in Raster Chart Display System Mode (RCDS).

So far, four position types are possible to plot on ENCs. Each of positions has its own accuracy and uncertainty area and a level of reliability. That is why sole position is inadequate for safe navigation, and the positioning redundancy is essential. One has to always check and compare as many positions from various sources as available. Moreover, the navigator has to know the reliability and performance of each positioning source and the accuracy on which he can count on, as well as to choose proper positioning method depending on navigation type which is taking place.

To the date, positioning was defined clearly and proven methods have been employed over the years. However, with the rise of paperless ships, the navigation tools and, in a way, methods are changing, becoming automated, implying certain knowledge adopted. It is essential to ensure that all operational and functional issues have been clarified, understood and handled properly. At the half time of the transitional period from paper charts to digital cartography, the aim of this research was to receive a practical feedback about the ECDIS positioning topic. A survey has been conducted asking answers from truly engaged end-users – navigational officers, which are experiencing the transitional change.

4 THE SURVEY

The survey firstly emerged as questionnaire to seafarers which are attending the Merchant Navy Certification Courses at the Faculty of Maritime Studies in Rijeka, Croatia. The aim of the questionnaire was the assignment of attendees in ECDIS simulator working groups, depending on their experience and familiarization level. The questionnaire internationally spread on ECDIS Course attendees in order to choose the proper level of exercises, besides those regulated with the ECDIS Model Course (IMO MC 1.27 2010). New questions raised in the questionnaire, regarding not only pure ECDIS topic, but also general and specific navigational questions. The final result (so far) was the comprehensive survey, spread among international shipping companies, achieving concrete opinions from navigational officers on global basis. The survey yielded an international character, comprising the period of 2013/2015. The initial motivation developed and became a wish for the improvement – to gain an insight in current knowledge not only on the good seamanship behaviour, but the response of seamen on transition and its reflection on navigation officers.

4.1 *A questionnaire overview*

The questionnaire is entitled: *'ECDIS Survey Analyses: Experience, Handling and Opinion'*, or *ECDIS EHO*. Among total number of 24 questions, and besides general questions (years of experience, rank…), the following questions were elaborated:

1 Does your job description include working with ECDIS/ECS system?
2 In accordance with the SOLAS Convention and the ECDIS mandatory regulations, what is the current status on your vessel?
   – Possession of paper navigation charts solely;
   – Possession of one official ECDIS system and appropriate folio of paper charts;
   – Possession of two or more independent official ECDIS system, meeting the requirements for paperless vessels;
   – Other ________.
3 Is the ECDIS system used as the primary means of navigation on your vessel?
4 In the system, do you use the setting related to secondary positioning source? If YES, please state which one.

4.2 *The respondents*

The questionnaire was targeted to seafarers for whom the ECDIS term is not unfamiliar and the usage of ECDIS is expected. Thus, the profile of respondents comprises present and future navigation officers entirely. The Officers are affiliated to global shipping companies, sailing on vessels ranging from DP Offshore vessels, large cruisers to merchant navy vessels. The survey was completed by 123 participants: Captains (41), 1st Officers (30), 2nd Officers (24), 3rd Officers (5), Apprentice officers (5), Senior Dynamic Positioning (SDPO) Officers (2), staff captains (2) and undefined rankings (14).

Undefined rankings comprise all of the mentioned ranks including harbour pilots, port captains and port inspectors. The seamanship experience among respondents varies between 12 months and 41 years.

4.3 *Analyses and results*

Total number of 87 of respondents (71%) is forming a part of the navigational watch (Question No.1), or their work description encompasses ECDIS handling, respectively.

Answers regarding current ECDIS status onboard (Question No.2) are presented in Table 1.

Table 1. Summary of answers regarding current ECDIS status on board vessels

In accordance with the SOLAS Convention and the ECDIS mandatory regulations, what is the current status on your vessel?	
Status	No. of answers
Paper charts only	31
One ECDIS & ACF	44
Paperless requirements fulfilled	19
Other	29
TOTAL	123

In order to achieve answers from officers to whom the questionnaire was dedicated, the respondents which answered *a)* (possession of paper charts only) were eliminated from further analyses. Their answers will be discussed later.

The most common case (36%) was the possession of one official ECDIS system and one Appropriate Chart Folio (ACF) (*answer b*). As for option *c)*, where there was no requirement for mandatory carriage of paper charts, the answers can be further divided in two cases: *i)* Paper charts not required but present; and *ii)* Truly paperless vessels with two or more independent ECDISs. Looking at the time span of obtained and fulfilled questionnaires, the paperless scenario becomes more common as the time goes by and, as expected, paperless transition increasingly takes place on board vessels. The Figure 3 shows graphical presentation of noted scenarios regarding ECDIS and paper charts carriage requirements.

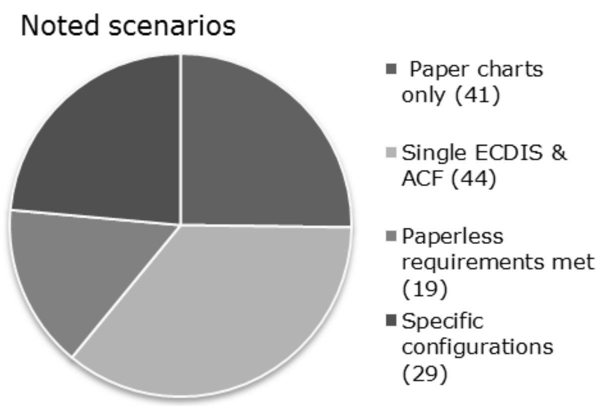

Figure 3. Noted scenarios regarding ECDIS status on board vessels.

The last possible answer (*option d*) refers to specific cases on board vessels, where various configurations were noted, mainly *ECDIS as a training system only* (*'not to be used for navigation'*); *ECS systems on board*; *RCDS system and ACF*, *unofficial ECDIS on board*, and *ECDIS and RCDS on board with and/or without ACF*.

Table 2. summarizes answers to Question 3.

Table 2. Summary of answers regarding ECDIS as a primary navigation mean

Is the ECDIS system used as the primary means of navigation on your vessel?	
Answer	No. of answers
Yes	21
No	71
TOTAL	92

This question determines further quantity of respondent numbers which will be additionally elaborated. The final question (Question No. 4):

In the ECDIS system, do you use the setting related to secondary positioning source? If YES, please state which one,

presents the backbone of the proposed research. Answers were considered implying that *i)* there is ECDIS system present on board (omitting case *a)* from Question No.2), *ii)* ECDIS is used as a primary navigational mean, and *iii)* there are several systems on board in case of paperless vessels.

The analysis excluded seamen not forming part of the navigational watch (apprentice officers, port captains and pilots), which resulted in total number of 84 answers. The conditional respondents' profile, now ECDIS operators solely, is presented in Table 3 and Figure 4, respectively.

Table 3. Profile of respondents as ECDIS operators

Rank	Number
Master	24
1st Officer	24
2nd Officer	23
3rd Officer	5
Staff Captain	2
SDPO	2
Undefined	4
TOTAL	84

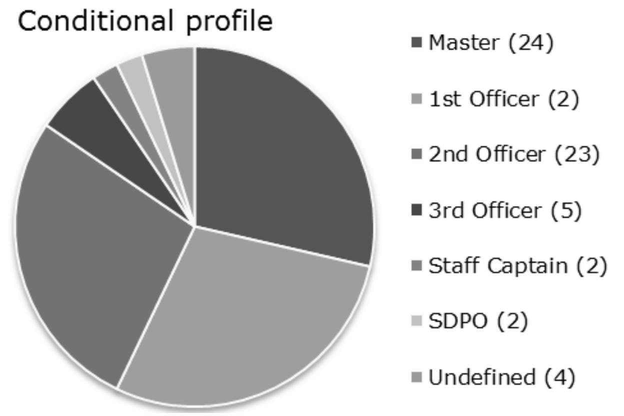

Figure 4. Profile of respondents as ECDIS operators.

Answers on Question 4 are summarized in Table 4.

Table 4. Summary of answers regarding SPS usage

In the system, do you use the setting related to secondary positioning source? If YES, please state which one.	
SPS usage	Answer
Yes	16
No	42
N/A	26
TOTAL	84

The share of specific answers (*Yes*, *No* and *Not Applicable*) is graphically illustrated on Figure 5.

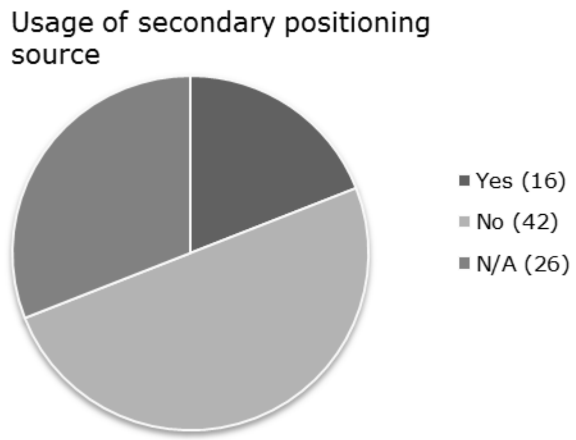

Figure 5. Answers regarding the usage of the secondary positioning source in ECDIS.

When asked which positioning source is used as a secondary (implying affirmative answer), respondents mostly (69%) answered GPS/DGPS system. The remaining percentage refers to Dead

Reckoning (19%), or the column remained blank. As for the N/A answer, it can be interpreted in several ways. One of the acceptable explanations is that either *i)* the respondents did not know the meaning of the question (even if SPS is used), or *ii)* they left the blank column instead of negative answer.

In cases where ECDIS appears as a primary navigation mean (19 in total), 7 respondents (37%) are using the SPS option, for 1 respondent (representing 5% of the total amount) the question is not applicable, and 11 respondents does not use any of the secondary positioning options in the system, making 58% of total respondent number.

5 DISCUSSION

In Chapter 2 (*Positioning*) and Chapter 3 (*ECDIS*), the tendency was to emphasize the importance of positioning redundancy in order to monitor the primary position of the vessel. Several ways and methods were presented. The possibilities of positioning in ECDIS system were also described. The aim of theoretical background overview was to emphasize the need and the possibilities of using proper, reliable positioning technique as a secondary positioning source in ECDIS system. Obtained (simultaneous) positions will never match perfectly, however one (OOW) should know the uncertainty area of each position method, as well as which factors are influencing the accuracy and reliability of derived position. Again, it is essential for the OOW to employ as far of the methods as he can (in due time). The core question was: what is the proper replacement for well-known and well-used GPS? The question was placed among the navigational officers as a part of the survey.

Considerable number of respondents (50%) does not use the secondary positioning at all. Moreover, it refers even to larger amount (58%) to respondents which are sailing on ECDIS approved vessels. As for SPS confirmative usage, it is frequently the satellite navigation receiver.

Here, drawing conclusions has to be made with caution. Seamen who are sailing on non-ECDIS vessels, or the system is not yet familiar on board, have a different approach and a different look at the stated problem. In a way, it can be considered as normal. Traditional methods are implying (simultaneous) combination of two or more independent systems for obtaining position, and the redundancy is covered in this way. However, with the rise of ECDIS mandatory implementation and paperless vessels, significant issues can occur. There appears the risk that the transition from paper charts and traditional navigation methods electronic navigation means will find the seamen unprepared. It specifically refers to officers which are not familiar with the system as their younger colleagues (Weintrit & Stawicky 2008, IMO MC 1.27 2010, Edmonds 2007).

A representative of GNSS family, the GPS system, is nowadays taken for granted. According to questionnaire results, respondents are using second GPS receiver as a positioning back-up, among those who are using SPS at all. It is quite logical that two SNR receivers will be used as primary and secondary positioning sources. However, whether it is about two or more GPS receivers, they are based on the same positioning technique, meaning that they are susceptible and vulnerable to common error causes. The same cause will degrade or disable all of the receivers.

There appears proportionality between the sophistication level of provided services and satellite navigation systems' sensitivity to external influences. It is particularly pronounced when navigational equipment (ECDIS, AIS, LRIT) relies and depends on the same basic technology. As for GPS, the error cause can be divided into a number of components, whose description would exceed the paper page limit. From the sea navigation context, the errors can be divided in three main categories: *i)* errors resulting by natural causes, *ii)* those which are a consequence of intentional interference and *iii)* system errors related to integration characteristics (e.g. Integrated Navigation System (INS) linkage failures) (Kos et al. 2013, Norris 2010, Parkinson & Spilker, Jr. 1996).

GPS is not an autonomous system. Its functionality and performance depends on number of outer factors on which navigator have no influence at all. At contrary, radar will serve its purpose even when no outer device is connected in it. That is why radar presents a basic navigational aid in coastal navigation, as well as in collision avoidance. In combination with ECDIS, radar overlay image acts as a reliable supplement on the ENC; however it is not yet recognized as such.

It is important to know and to be aware the existence of all these possible error sources, to mitigate them as much as possible, and if not possible, to find adequate (or any) replacement. At these ever-developing times, augmenting services are increasingly present in sea navigation as well (e.g. DGPS and SBAS services) (IMO MSC.114 (73) 2000). The International Maritime Organization has recognized the potential of other satellite navigation systems besides GPS (IMO MSC.379 (93) 2014, IMO MSC.233 (82) 2006, IMO MSC.915 (22) 2001, IMO MSC.113 (73) 2000, IMO A.860 (20) 1997), as well as the usage of combined satellite receivers onboard vessels (IMO MSC.115 (73) 2000). It leads to improvement of integrity and reliance, but also to complacency. It is important in this, still initial transitional stage, to *know* and to be aware of potential risks and dangers. And that is *the gist* of proposed research: to mitigate lack of knowledge with proper actions, and to ease in most efficient manner the forthcoming changes. As Dr. Andy Norris wrote in his book (Norris 2008): '*…in future integrated navigation systems, GPSs and gyro-compasses will be only black boxes hidden somewhere in the interior of the bridge*'. This statement says a lot, but also implies a lot. Satellite navigation systems became an inevitable part of navigational bridges. The navigator does not have to employ old, slow positioning methods, given that he has final, *perfect*, continuous position plot on the *chart screen*. Or does he?

The conducted survey initiated number of unwritten questions. Several issues were identified, and they can be summarized as follows:

– Non-usage of ECDIS secondary positioning source,
– Over-reliance on technology, and
– Issues arising from transition period.

Taking identified issues in consideration, an unwanted sequence of events can appear. Transitional issues (paper- to paperless) and improper usage of the ECDIS system (presented on the SPS example) can give rise to events and actions with unwanted manifestation. Lack of education and practice appears as a main reason for ignorance. Indifference appears as a continuation of ignorance, however here the problem has already seriously increased. In combination with human vanity and negligence, the sequence can lead to operational errors, development of unwanted events and finally to real accidents occurrence. The ever-present over-reliance on technology and operational systems only enhances this flow and weights the risks (Figure 6).

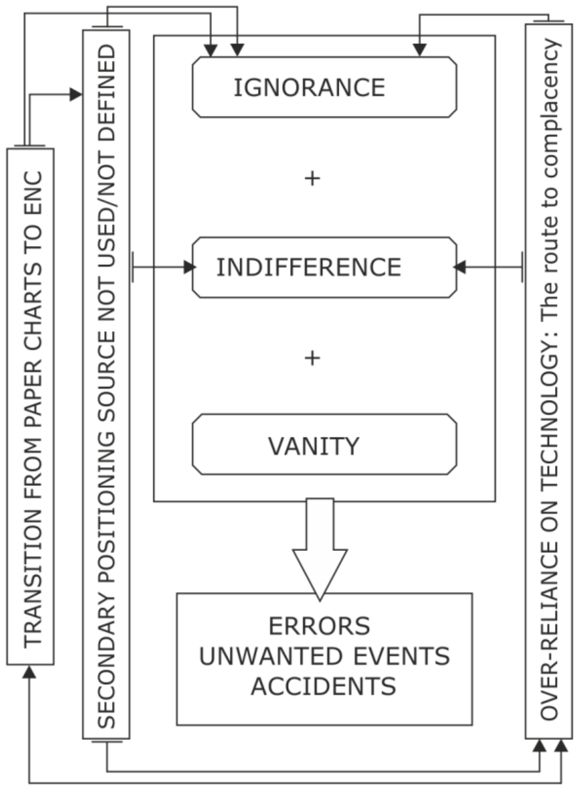

Figure 6. Sequence of unwanted events.

Several investigation and research reports (MAIB 2012, BSU 2011, BEMAER 2010, BSU 2009, MAIB 2009, NTSB 2007a, NTSB 2007b, Žuškin et al. 2013) demonstrated the share of ECDIS and its inappropriate usage in marine accidents, acting as a direct or indirect cause. The good seamanship and navigational practice may not be doubted; however it is the transition issue for what it counts for.

In order to prevent described events (the unwanted model – Figure 6), there appears a need for concrete actions. By proper handling of vertical components of the model (identified issues) horizontal chain of components can be mitigated to certain extent, and even eliminated. However, it requires fundamental and comprehensive actions to be taken, by engaging different levels of activities.

The activities should reflect on existing problems, developing problems and possible problems which can arise in the future, but which also can be predicted. In order to close this problem circle, several levels of activities have to be employed:

1 *Educational activities,* by teaching (regular classes), courses (STCW and other specifications) and discussions with seafarers, raising awareness on the basis of gained knowledge. In this way, the problems can be detected in their beginning;
2 *Practical activities,* supplement for education, taken by using available resources as navigational simulators, training vessels, etc.
3 *Research activities,* with the aim of preventing problems and maintaining this state. It is probably the hardest level. It comprises thorough research, monitoring, surveys among end-users, marine accident investigations and analyses, and other feedback methods, implying continuous bidirectional communication.

The final outcome will, of course, depend on individual person. However, in a proposed way the learning model achieve the required level of situational awareness, if looking at such delicate topic. The cornerstone of the model is proper education and its practical confirmation.

6 CONCLUSION

The proposed paper deals with usage on secondary positioning inside the ECDIS system, during the beginning of the second half on ECDIS mandatory implementation period. A survey was conducted aiming at insight gain in current situation on board vessels regarding positioning topic, but also navigation conducting in general. The answers from all navigational ranks were analysed and discussed. The findings indicated that the secondary positioning source is not used as it should be, what entails potential risks regarding safety of navigation. As the transition period passes, unsolved problems will only rise in their nature. Paper charts will not disappear, however the number of paperless ECDIS vessels will increase. It requires proper actions to be taken on different educational, practical and preventing levels, in general as well as in subtle means.

The ECDIS EHO survey does not end with this paper. The proposed research presents the basis for further work and described activities. As for the survey, it comprises all of them. The survey is not the research in whole: it acts as a part of it. The larger the future sample of respondents, the more the questionnaire is possible to extend, and to focus on arising problems, which in this way can be detected in their roots. The same applies to education, courses and discussions. This will determine further modification of the survey. Furthermore, different levels of problems can be identified: existing problems, those which are currently developing and problems which will appear in the (near) future.

The question remains: what is the proper secondary positioning source which has to be used in ECDIS system?

The key answer is the proper education and good seamanship. It is not anything new; however it requires thorough and complex actions to obtain it, as for any adoption to new concepts and situations. Aiming to reach a satisfying state of awareness, nothing is more effective than when a person realizes the gravity of the problem alone. And the proper path for recognizing it comes exclusively and only with one's knowledge. Not other's knowledge, but its own.

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