

**SVEUČILIŠTE U SPLITU
POMORSKI FAKULTET U SPLITU**

ILGIN OZGUL

ECDIS ERRORS

SEMINAR WORK

SPLIT, June 2021.

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STUDIJ: ELECTRONIC NAVIGATION II

ECDIS ERRORS

SEMINAR WORK

MENTOR:

dr. sc. Lea Vojković

STUDENT:

Ilgin Ozgul

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ABSTRACT

In this study, ECDIS, components of ECDIS, and ECDIS errors are investigated. According to investigated researches, ECDIS errors are related to three articles: Human errors, operation errors, and equipment errors. Human errors are the reason for most accidents. Since equipment errors are not related to officer directly, it is crucial to know how to act in case of ECDIS failure. One of the most effective ways is to have a checklist. Also, the education of officers is essential because the information contained in ECDIS is increasing day by day, and it is becoming a more complex system. However, it is a life-saving system if used correctly.

Keywords: ECDIS, electronic chart errors

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1. INTRODUCTION

Considering that 90% of world trade is carrying by sea, we see that the safe navigation of ships plays an essential role in the continuation of the international trade chain. The "safe navigation" of a ship includes the safe navigation of the ship, the marine environment, and the ship's crew during the voyage. The components required for safe navigation range from the construction phase of the ship to the type of cargo transported. However, the most important of these components is the voyage planning of the ship. Voyage planning includes the route to be followed by the ship, traffic density, supplies, weather forecasts, and all other information needed during the voyage. The essential step in voyage planning is to create a route. The route of the ship directly affects the safety of the ship along with all the needs.

Ships have long been required to carry nautical charts and nautical publications to plan and display the ship's route for the intended voyage and plot and monitor positions to provide a safe voyage. Officers should check ship's position during the voyage and regularly check the points it has previously determined on the route, and be sure of the ship's position. In addition, it is essential to know the coastal structure, lands, depths, obstructions, transit routes, prohibited areas, and more on the ship's route and plan the route accordingly. It takes a chart to draw the route, and these nautical charts have been drawn for centuries to papers. In the last 30 years, these charts, which have been produced for centuries, have been transferred to electronic data or recreated as electronic data to show it on display. It aimed to reduce the officers' workload and increase the safety of navigation by updating the maps without errors using the digital environment.

There are several ways to show electronic charts on display. Today, ECDIS (Electronic Chart Display and Information System) is the most common system in electronic chart systems. Besides the display systems, there are other types of charts: vector and raster charts. But we will not investigate these terms in this study. Besides the ECDIS, which shows vector data, RCDS (Raster Chart Display System) displays raster; dual fuel systems show both vector and raster charts. And where a system does not conform to either ECDIS or RCDS performance standards, it is classified as an ECS (Electronic Chart System) system.

IMO (International Maritime Organization) says the undeniable safety benefits of navigating with ECDIS were recognized through Formal Safety Assessments submitted to the Organization and experience gained by the voluntary use of ECDIS for many years (International Maritime Organization). Today, ECDIS has reached a high usage percentage. The amended SOLAS regulation V/19 requires all newly built passenger ships of 500 gross tonnage and upwards, as well as newly built cargo ships of 3,000 gross tonnage and upwards engaged on international voyages to be fitted with ECDIS. For existing ships, the phase-in introduction of fitting requirements is being introduced for all ships of certain size engaged on international voyages (International Maritime Organization). Figure 1 shows an example of ENC using ECDIS.

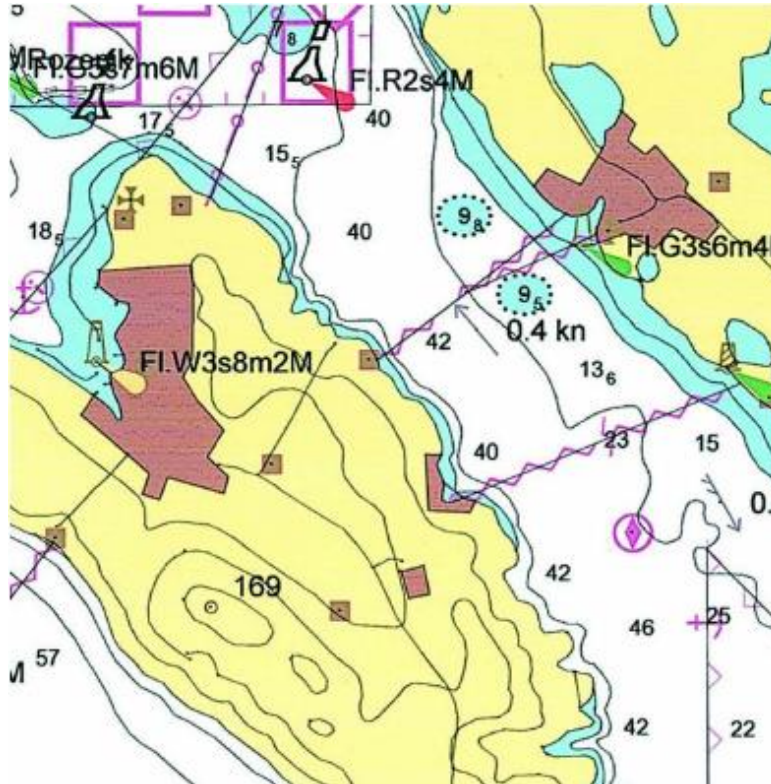


Figure 1. Example of ENC (Electronical Navigational Chart). *Source: Croatian ENC Production Process - a new approach.*

During ECDIS using, it is possible to encounter some errors due to both human errors and machine errors. These faults can occur during an ocean voyage or a narrow channel passage. As continuous and accurate monitoring of the ship's route is an essential part of safe navigation, an OOW needs to understand the causes of these errors and learn how to react. To find and eliminate the source of errors, firstly, we need to understand the components of the ECDIS and the sources it uses. An ECDIS device is shown in Figure 2.



Figure 2. ECDIS device. *Source: American Nautical Services.*

2. COMPONENTS OF ECDIS

ECDIS displays information from ENC that has at least the same reliability and availability as conventional paper charts. The official ENC is a vector-based digital file that contains marine features suitable for marine navigation. It is based on the International Hydrographic Organization (IHO) S-57 standard. (The Error Chain in Using Electronic Chart Display and Information Systems, 2008). ECDIS integrates GPS/DGPS, RADAR, AIS, NAVTEX, Autopilot, Echo-sounder, compass, and ENC. ECDIS components are shown in Figure 3.

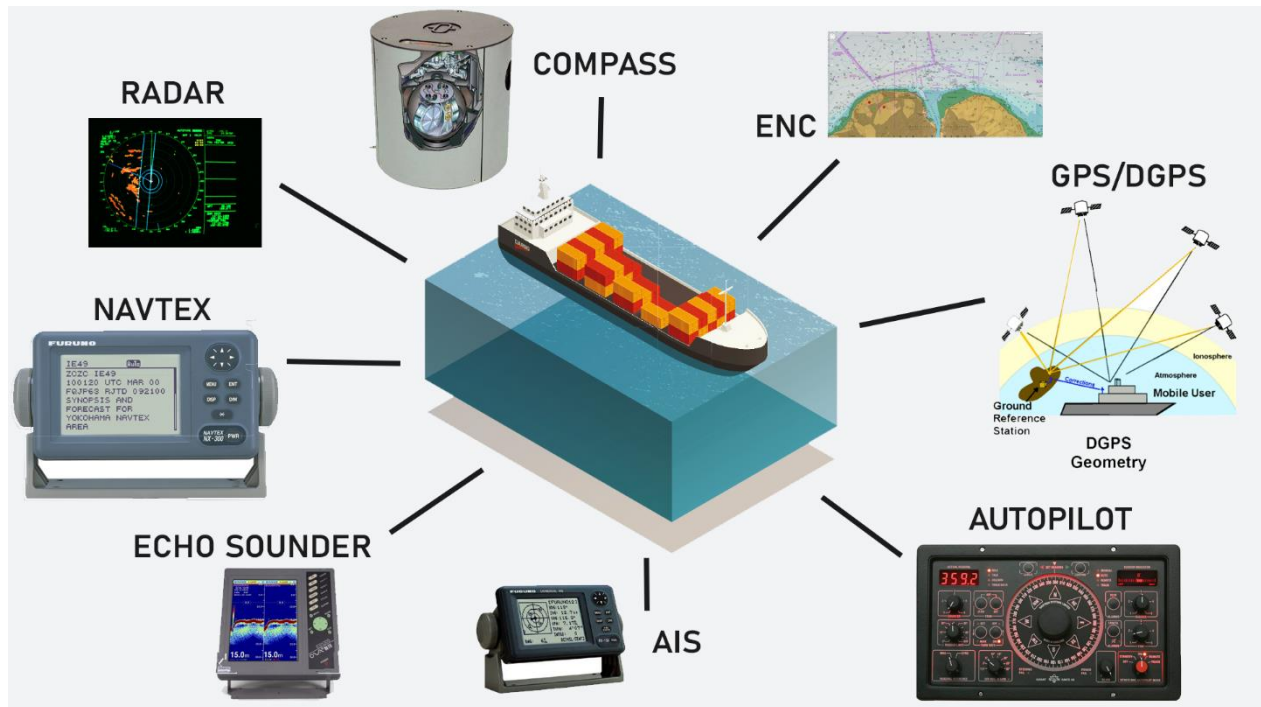


Figure 3. Components on an ECDIS system. *Source: Author.*

The next step is to examine which system provides what information to ECDIS. Thus, we will be able to understand better the errors caused by externally connected devices.

2.1. RADAR (Radio Detection and Ranging)

RADAR works by transmitting a beam of radiofrequency energy from a RADAR antenna. The transmitted energy is reflected from any objects in the path of the beam. Usually, the same antenna then receives the reflected signal. A RADAR processor then amplifies and optimizes the received information to allow a clean display of RADAR targets.

RADARs operate on X-Band (at a frequency of 9 GHz); and S-band (at a frequency of 3 GHz) with benefits in fog and rain.

RADAR does not rely on ‘cooperating’ targets. It can detect passive, non-transmitting landmasses, and large floating objects such as vessels, buoys, or icebergs. RADAR operates independently of satellite-based navigation systems (GNSS) and less vulnerable to natural or accidental signal interference, though not entirely immune for malicious disruption (Royal Institute of Navigation).

It is possible to show the screen image of our radar on the ECDIS device. Using it in this way provides the watch officer with many advantages. For instance, if we cannot update a navigation aid removed from use or taken into use, it will prevent safe navigation in our ECDIS device. If echoes on the radar screen are used with ECDIS, safe navigation is always ensured. The information that cannot be received by the AIS (Automatic Identification System) is also detected via RADAR. Information received via RADAR:

- Distance,
- Bearing,
- Course,
- Speed,
- CPA (The Closest Point of Approach) and TCPA (Time to Closest Point at Approach).

A RADAR overlay on the ECDIS is shown in Figure 4.

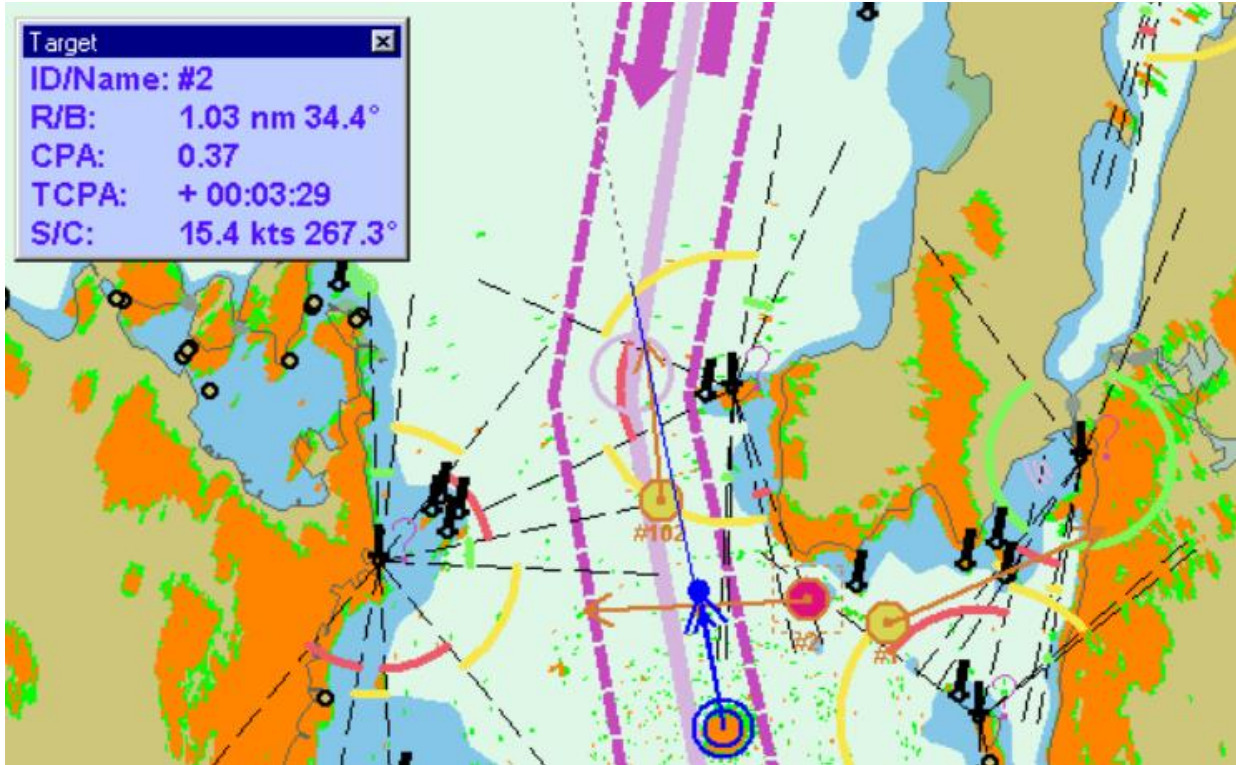


Figure 4. RADAR overlay on ECDIS. *Source: T.C. Milli Eğitim Bakanlığı.*

2.2. AIS (Automatic Identification System)

Automatic Identification System (AIS) is a shipborne transponder system capable of broadcasting continuously, using the VHF marine band, information about the ship. With AIS, ships can track the status of the target ships, the cargo they carry, etc., can see information; can integrate this information with ECDIS and, as a result, take the necessary action much faster. Three types of data are transmitted: Static, Voyage Related and Dynamic (Royal Institute of Navigation):

1. Static Data:
 - MMSI (Maritime Mobile Services Identity) identifying code,
 - Vessel name,
 - Registered Call Sign,
 - The type of vessel/cargo,
 - The length, beam, and ‘reference point for reported position.’
2. Voyage Related Data:
 - Draught,
 - Destination,
 - Estimated time of arrival,
 - Hazardous cargo type,
 - A number of persons onboard.
3. Dynamic Data:
 - Latitude/longitude, using the WGS 84 datum (GNSS reliant),
 - Time (in UTC) of the position fix (GNSS reliant),
 - COG (Course Over Ground) derived from ‘immediate past’ GNSS positions (GNSS reliant),
 - SOG (Speed Over Ground) (GNSS reliant),
 - Heading,
 - Rate of turn,
 - Navigational status, e.g., “At anchor,” “Not under command,” etc.

Some features of AIS work with GNSS (Global Navigation Satellite System). Global Navigation Satellite System (GNSS) refers to a constellation of satellites providing signals from space that transmit positioning and timing data to GNSS receivers. The receivers then use this data to determine location.

By definition, GNSS provides global coverage. Examples of GNSS include Europe’s Galileo, the USA’s NAVSTAR Global Positioning System (GPS), Russia’s Global’naya Navigatsionnaya Sputnikovaya Sistema (GLONASS) and China’s BeiDou Navigation Satellite System (European Union Agency for the Space Programme).

Such broadcast information would be capable of reception by other AIS-equipped ships and by shore sites such as Vessel Traffic System (VTS) stations within broadcast range. Data received by a ship or shore station could be relayed to an ECS, and AIS targets could be displayed, with GPS or DGPS accuracy, with a velocity vector indicating speed and heading. By ‘clicking’ on a target, other information such as ship identification data, etc. could be displayed (Tetley & Calcutt). AIS information on the ECDIS is shown in Figure 5.

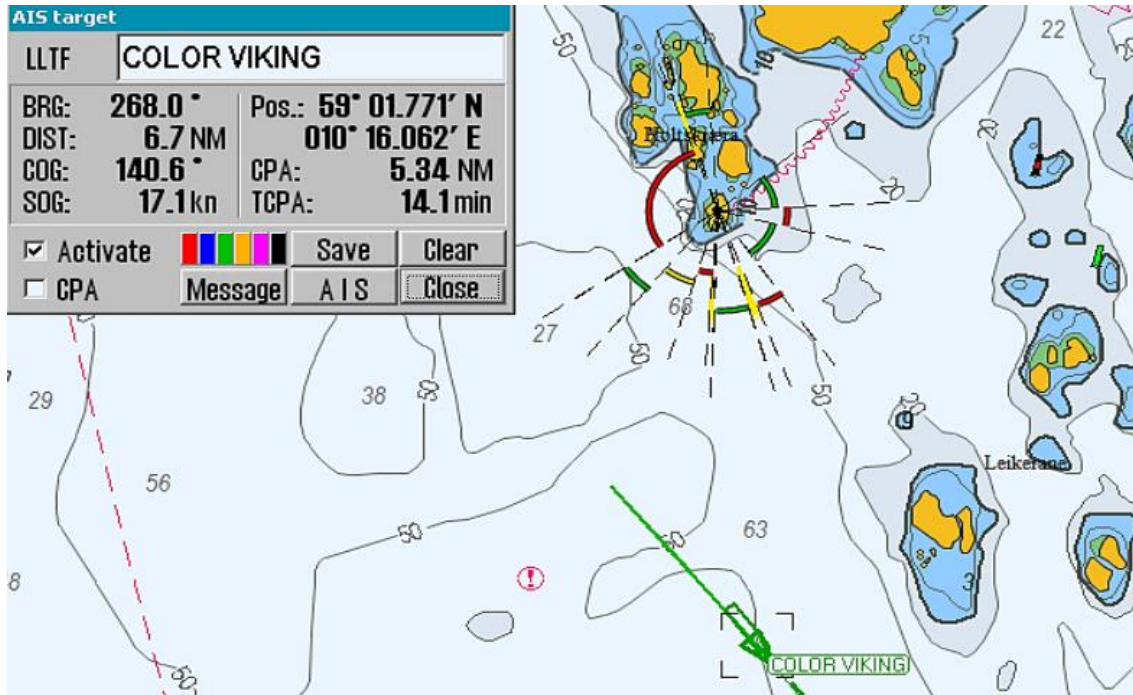


Figure 5. Target ship's AIS information on the ECDIS display. *Source: T.C. Milli Eğitim Bakanlığı.*

The regulation requires AIS to be fitted aboard all ships of 300 gross tonnages and upwards engaged on international voyages, cargo ships of 500 gross tonnages and upwards not engaged on international voyages, and all passenger ships irrespective of size. The requirement became effective for all ships by 31 December 2004. Ships fitted with AIS shall maintain AIS in operation at all times except where international agreements, rules, or standards provide for the protection of navigational information (International Maritime Organization).

2.3. NAVTEX (Navigational Telex)

NAVTEX is a method of transmitting navigational warnings and weather forecasts from designed coast radio stations. All English-language transmissions are made on 518 kHz, and each station is allocated several time “slots” during the day when it is permitted to transmit. These are normally emitted at four-hour intervals. Except for the gale warnings and search and rescue messages which can be transmitted at any time. Reception of NAVTEX is limited to an area of a 200-300-mile radius around each transmitting station, although considerably greater ranges are possible at night. (Wartsila). With the NAVTEX connection of the ECDIS device, it is possible to see the incoming messages on the screen. NAVTEX messages on the ECDIS are shown in Figure 6.

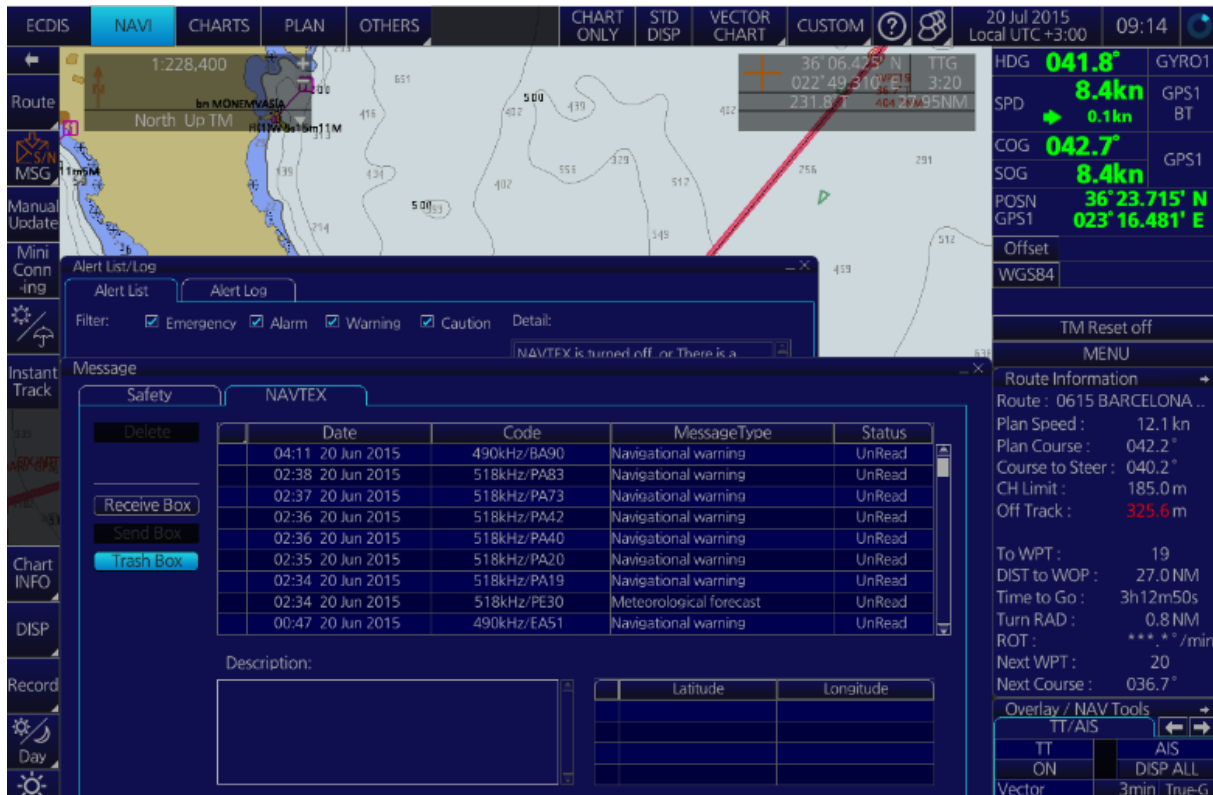


Figure 6. NAVTEX messages on ECDIS display. Source: T.C. Milli Eğitim Bakanlığı.

2.4. COMPASS

The compass, which can be considered the first of the navigational aid devices, is a navigational device that still maintains its validity. The compass, which is used to determine the ship's direction, is settled on the ships as magnetic and electronic (gyrocompass). Unlike the magnetic compass, the gyrocompass is not affected by variation and deviation, and works with a much lower error. Information read from these compasses can be displayed simultaneously on the ECDIS display. HDG (Heading) information derived from gyro compass is shown in Figure 7.

2.5. ECHO SOUNDER AND SPEED LOG

The purpose of the Echo Sounder is to provide instantaneous depth information to the ship while sailing. In this way, the current depth can be followed continuously. It is a device that needs attention, especially when navigating in shallow waters. Although depth information is written on the ECDIS, the depths may change due to natural or man-made reasons. Observing these changes in real-time is crucial to avoiding grounding. The data from the Echo sounder is shown simultaneously on the ECDIS screen.

Speed logs, also known as ship logs, chip logs, or common logs, measure the speed of a vessel. The speed is determined with reference to water flowing by the hull (water reference speed) or to the seabed (ground reference speed). Such equipment is referred to as a log due to the obsolete practice of using wood logs for detecting how fast a ship is moving (Engineering 360).

There are also devices with a combination of echo sounder and speed log. In addition, it should be noted that speed information is obtained with both speed log/echo sounder and GPS. LOG (speed) and DGPS information derived from speed log and GPS are shown in Figure 7.

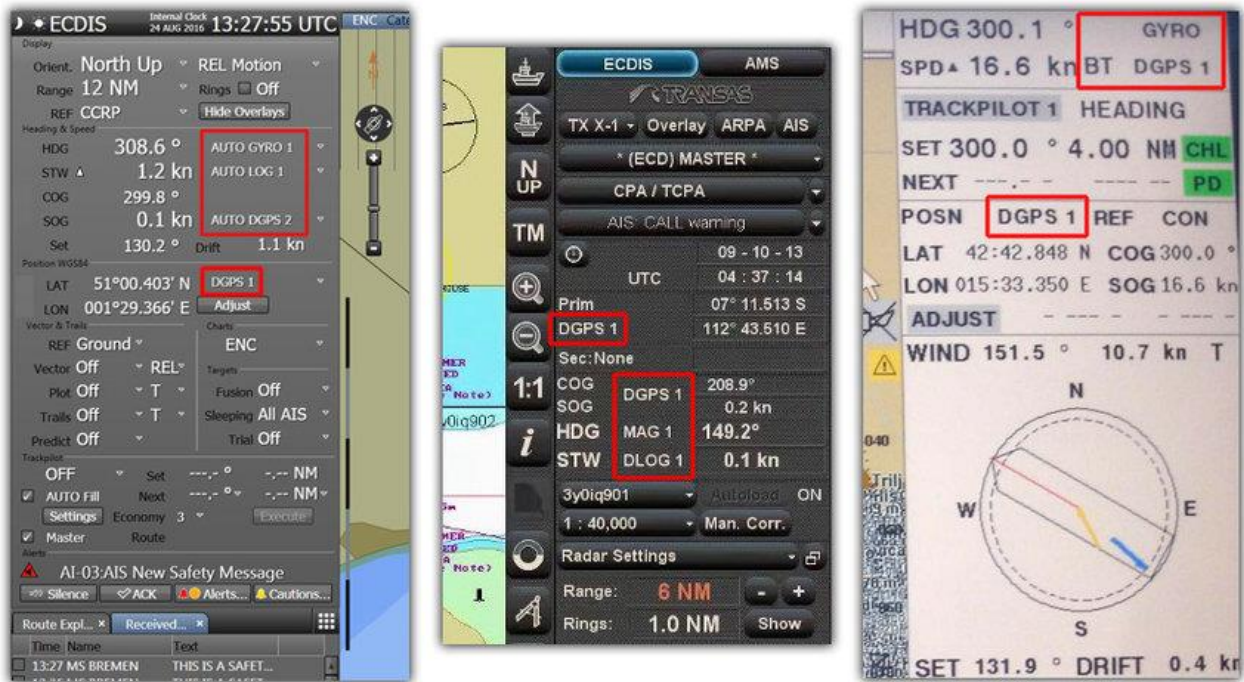


Figure 7. HDG (Cyro), LOG (Speed Log) and position (DGPS) information on ECDIS. *Source: ECDIS: Implementation of Annual Performance Test (APT) - A Reliability-Centered Maintenance (RCM) Adaption*

2.6. GPS/DGPS (Global Positioning System)

It is crucial in marine navigation for the ship's officer to know the vessel's position while in the open sea and congested harbors and waterways. While at sea, accurate position, speed, and heading are needed to ensure the vessel reaches its destination in the safest, most economical, and timely fashion that conditions will permit. The need for accurate position information becomes even more critical as the vessel departs from or arrives in port (U.S. National Coordination Office for Space-Based Positioning, Navigation, and Timing.). GPS is a satellite-enabled locating system that allows users to determine their location, regardless of topography, weather, or time of day, anywhere on the globe, provided the GPS receiver is not physically obstructed. GPS receivers utilize a minimum of three of the 24 network satellites to triangulate a user's location. In the case of marine equipment, this is converted into a two-dimensional display overlaid on electronic charts provided within the equipment (Queensland Government).

2.7. ENC (Electronic Navigational Charts)

ENCs are the designated charts for the ECDIS system, and they possess a single universal data format. Such charts use vector data based on the IHO Special Publication S-57, edition 3, IHO

Transfer Standard for Digital Hydrographic Data. Some of the major points which identify the unique property of these charts are as follows:

- They are issued by or on the authority of a government-authorized hydrographic office.
- Items on the chart must be attribute-coded and must be able to be interrogated to provide information.
- The data is delivered in cells to provide seamless data for the task at hand. The cell structure changes according to the data set used.
- All chart data is referenced to a global geodetic datum, WGS-84, which GPS uses.

Electronic Nautical Chart data is shown as a first layer on the ECDIS screen. All other information, such as RADAR, is superimposed on the ENC data as an additional layer.

2.8. AUTOPILOT

Autopilot is the use of an automatic system to control the rudder on the vessel. The use of autopilot can reduce fuel consumption by smoothing out the large-angle rudder movements used to hold a steady course. Efficient and adaptive autopilot operations allow minor deviations to the course-line but will use fewer and smaller angle rudder movements to maintain the course-line. This decreases the rudder movement and consequently reduces fuel consumption (GloMEEP). Auto-Pilot is synchronized with the Gyro Compass to steer manually input courses, with reference to the gyro heading. Modern Auto-Pilot systems can be synchronized with the Electronic Chart system (ECDIS) enabling to follow the courses laid out in the Voyage plan (MarineInSight, 2021).

3. ECDIS ERRORS

In this part of the study, errors that may occur in the ECDIS system are examined by using the study *The Error Chain in Using Electronic Chart Display and Information Systems* written by Jie Wang and Xian-Zhong Hu.

One of the most significant risks in using ECDIS is an over-reliance on the information provided by ECDIS, e.g., mariners become increasingly dependent on ECDIS for route planning and transit monitoring in congested waters, etc. It is necessary to accept that the ECDIS device is also a man-made machine and is not faultless. ECDIS is not a system that collects information from its sensors but a system in which information from connected devices is displayed in layers collectively. Therefore, an error in any device connected to the ECDIS ecosystem can change the values we see on the ECDIS screen. If we make decisions based on ECDIS only, it can lead us to an accident.

According to mentioned study above, ECDIS-relative errors are divided into three categories: Human errors, equipment errors, and operation/management errors.

3.1. HUMAN ERRORS

Human error is a critical feature of all aspects of ship or system operation. Studies have shown that in accordance with IMO reports, 90% of marine casualties worldwide are caused by human error. Many of them are attributed to a lack of situation awareness of the bridge team, and modern

technological aids have reached their limit. Moreover, with the growing number of screens, displays, systems on the bridge, and the resulting information overload, the responsibility of officers on the bridge to achieve and maintain situation awareness has become ever more complex. The human error can be listed as follows (without environmental conditions):

- Lack of knowledge, skills, and experiences about ECDIS: Since ECDIS is not only an electronic version of a paper chart but a more comprehensive navigation and information system, complete mastery of its resources and knowledge of the system limitations is of crucial importance for safe navigation. Studies of maritime accidents, which mention the improper use of ECDIS as one of the causes, show that, although the system itself is not entirely free of defects, officers make critical mistakes with their misuse of ECDIS. The most important among them are mistakes related to the system of safety and alarm settings. Results of the survey confirm the findings in the reports of investigation agencies, which is not entirely surprising since the transition from paper navigational aids to an electronic system with its multiple aspects poses a challenge to active seamen who have used paper charts throughout their active career (Human Errors in ECDIS Related Accidents , 2017).
- Poor management practice: Not examining errors, not doing error tests: A watch officer must know how to use ECDIS and how to act when faced with an ECDIS error. ECDIS performance tests are required to be performed at specific periods. The checks are designed to make mariners aware of any deficiencies with their system. In addition, a checklist should be created for the measures to be taken in case of any error. An example of a checklist is given in the following sections of the study. A sample of the performance test checklist is given in Figure 8.

Test/Checks on board	
<p>Note – Mark Yes for success; No for failure; or N/A for interfaces that are not fitted or functionality that is not in use.</p>	
<p>1. Pre-existing conditions</p>	
Confirm that the ECDIS equipment is not in an obvious failure condition prior to commencement of the test	<input type="checkbox"/> Yes <input type="checkbox"/> No
<p>2. Availability of documentation</p>	
Confirm that the following documentation related to the ECDIS is available for inspection:	
Type Approval certificate (or similar evidence of compliance)	<input type="checkbox"/> Available <input type="checkbox"/> Not available
Equipment manual (in printed or electronic form)	<input type="checkbox"/> Available <input type="checkbox"/> Not available
Approved installation drawings	<input type="checkbox"/> Available <input type="checkbox"/> Not available
<p>3. Power supply</p>	
Confirm that the ECDIS has adequate power supply arrangements in place as defined by IMO and Flag State requirements (reference should be made to approved installation drawings if available)	<input type="checkbox"/> Yes <input type="checkbox"/> No
If an Uninterrupted Power Supply (UPS) device is installed, confirm that the device is in operational condition	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A
If an Uninterrupted Power Supply (UPS) device is installed, confirm that the battery is not expired and record the battery expiration date	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A Expiration date: _____
If an Uninterrupted Power Supply (UPS) device is installed, confirm that its failure alarm is functioning properly	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> N/A

Figure 8. Sample of ECDIS performance checklist. *Source: CIRM Guideline GL-001*

3.2. EQUIPMENT ERRORS

System-related errors represent the vast majority of errors other than human errors. An error in any of the devices transmitting information to ECDIS mentioned in the previous section will directly affect ECDIS. Therefore, it is necessary to provide continuous control of the devices connected to ECDIS. In addition, the following errors represent specific errors that occur in ECDIS:

- Different geodetic coordinate systems:** The choice of the correct datum on the GPS or DGPS receiver illustrates the need for training. As ECDIS is dependent on GPS or DGPS signal, the choice of chart datum greatly influences the system's accuracy. Roughly speaking, the datum is a mathematical model adapted to parts of or the whole geoids where a coordinate system is used to present the position (longitude, latitude, and height). There are several datum; however, ED-50 and WGS84 are the most widely known. So, errors and misunderstandings may arise when using electronic charts. For example, the 'electronic seaway along the Norwegian coast from the Hydrographic Survey of Norway uses the WGS84 datum, while corresponding paper charts have three different datum: NGO, ED50,

and WGS84. The discrepancy between the WGS84 and ED50 datum can be up to 100 meters, and as much as 400 to 500 meters in the case of Norwegian-grid charts compared to WGS84. It may lead to severe problems in narrow waters. It should be noted that ECDIS is designed to give an alarm if the position transmitter and ECDIS use a different datum. The difference between Earth, spheres, and WGS84 datum is shown in Figure 9.

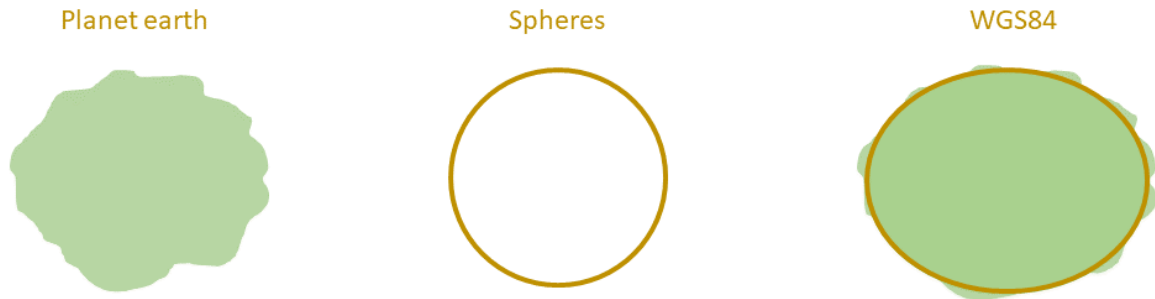


Figure 9. Difference between Earth, spheres, and WGS84 datum. *Source: Eyndt, 2018.*

- **Inaccurate input from the electronic position fixing system:** GPS or DGPS is mainly error sources of position fixing system. Especially on larger vessels, the relative position of the GPS antenna aboard the ship can also be a potential source of error when viewing the vessel icon in an ECDIS.
- **ENCs and raster chart:** Being the lack of ENCs worldwide, IMO has agreed that ECDIS can be operated in RCDS mode. So, when ECDIS displays in raster chart mode, it has limited ability to provide danger warnings to the mariner. This is since raster data has little inherent intelligence.
- **Chart errors and outdated data:** However, the adequacy with which that source data reflects today's real-world conditions, particularly depths and underwater features, is an entirely separate issue. For instance, over 50 percent of the depth information found on National Oceanic Atmospheric Administration charts is based on hydrographic surveys conducted before 1940, and the manual application of survey data of varying scales to the fixed chart scale was also a source of error that often introduced biases.
- **Design errors:** Poor instrument ergonomics is a primary error in this category. Because the ECDIS is a man-machine system used for safe navigation, it should be designed to consider the fact that the operating ability of ship operators tends to be affected by their mental workload under pressure from navigation environment, such as fitted position of ECDIS in bridge, safety alarms system.
- **Hardware and software failure:** Loss of power and “PC hardware and system failure” will lead to a breakdown of the system; depending on the different navigation environments, hardware and software failure will directly cause an accident or make errors during or after restart the system. Delay in updating or mis-updating ENCs in ECDIS also will cause an error.

3.3. OPERATION ERRORS

Failure to follow standard operating procedures and lack of model-specific training, overlooking, or ignoring individual fallibility in operation will be potential errors leading to accidents. And the interpretation of different modes of vector stabilization, over scale of the display, the safety values and display categories, etc., will also be an error in operation, such as track control system. The other operation errors can be list as follow:

- Position monitoring inaccurate or not frequent enough.
- Positions are not checked by another method or person.
- Inadequate passage planning.
- Features/functions/alarms not used or misused.
- Inaccurate data input – automatic or manual.
- Not adequately set up and inappropriate mode selected.
- No operations manual or operations manual not easily understood.

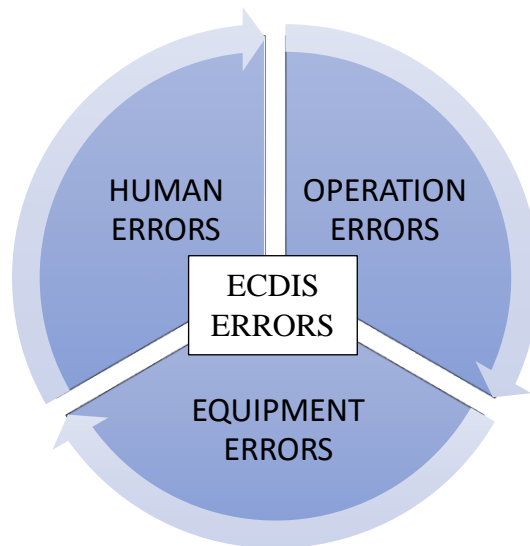


Figure 10. Human errors, operation errors, and equipment errors cause ECDIS errors.

4. WHAT TO DO TO PREVENT ERRORS

There are measures we can take to prevent ECDIS errors or measures we can do after they happen. The accidents can be avoided when appropriate action is taken to break errors.

4.1 HUMAN ERRORS

According to the Standard Technical Certification for Watchkeeping (STCW) Code, Section A-VIII/2, Rules 25 and 36, all navigators shall have sufficient training and knowledge of all systems installed onboard. Another training requirement for ECDIS can also be found in regulations I/14 Paragraph 1.4 and table A-II/1. Because many navigators do not have the required knowledge of ECDIS or ECS and are not aware of the legislation of ECDIS in force or the shortcomings and

limitations of ECDIS. So, mariners shall have the necessary training and skills when operating ships, which have installed ECDIS or ECS (The Error Chain in Using Electronic Chart Display and Information Systems, 2008).

In substance, STCW training has a crucial place in preventing all human-related errors on board. Concern with errors found in using ECDIS, the content of training should address but not only limited with:

- The limitations of ECDIS as a navigational tool.
- The potential risk of improper functioning of the system.
- System limitations, including those of its sensors.
- Hydrographic data inaccuracy.
- Limitations of vector and raster electronic charts.

4.2. EQUIPMENT ERRORS

Training of officers is the top priority in detecting and preventing equipment malfunctions. Every officer should know not to be wholly connected to ECDIS and to act when necessary. Performing the items listed below will prevent most ECDIS-related errors.

4.2.1. CROSS-CHECKING

Checking the own ship's position by using the other independent position fixing systems is vital. As many grounds incidents concern with ship's position, an emphasis should be placed on the need to keep a proper look-out and to perform periodical checking, especially of the ship's position, by ECDIS-independent methods. Also, the correct values of safety data; and the own ship's safety contour; safety depth (safety water) should be taken (The Error Chain in Using Electronic Chart Display and Information Systems, 2008).

4.2.2. COMPARISON OF ECDIS AND RADAR INFORMATION

Radar data representation on an electronic chart is real-time; moreover, the ECDIS, when integrated with an Automatic Radar Plotting Aid (ARPA), would be able to provide a comparison of the RADAR image and the electronic chart to anti-grounding and anti-collision, also present audio or visual alarms. Likewise, the anti-grounding and anti-collision features are essential in areas with either heavy vessel traffic, restricted visibility, or confined waters (The Error Chain in Using Electronic Chart Display and Information Systems, 2008).

4.2.3. FOLLOW THE CHECKLISTS

In the situation of a breakdown, following the previously prepared and written breakdown procedure will significantly assist the officer under stress. Example of the ECDIS Failure Checklist given in Figure 11.

BRIDGE CHECK LIST			
ECDIS Failure			
A.	Description	Personnel responsible	Completed
1.	If a single unit failure, use the second system, inform the Master and Navigator and instigate defect rectification.	OOW/Master/ Navigator	
2.	In the event of a power failure and both systems revert to UPS supply, consider a controlled shut down of one and inform the Master and Navigator.	OOW/Master/ Navigator	
3.	In a timely manner to coincide with the expiry of the UPS on the first system, restart the second.	OOW	
4.	On restoration following a power failure or uncontrolled shut down of the system, confirm that there are power supplies to each system.	OOW	
5.	Check ECDIS check- off cards to ensure that settings are correct, in particular:	OOW	
	• Anti-grounding cone.	OOW	
	• Safety depth.	OOW	
	• Safety contour.	OOW	
	• Velocity vector.	OOW	
	• Units.	OOW	
	• Chart priority.	OOW	
	• Chart auto load.	OOW	
6.	Check that the Primary and Secondary position sources are selected and working correctly.	OOW	
7.	Confirm that the heading source is selected and working correctly.	OOW	
8.	Confirm that RIO is operating correctly.	OOW	
9.	Check current position.	OOW	
10.	Verify that own vessel shape is correct and that the ship is aligned to ship's head.	OOW	
11.	Conduct Alarm self-test.	OOW	
B.	Other		

Figure 11. ECDIS Failure Checklist. *Source: SQEMARINE.*

4.2.4. AUXILIARY ECDIS FUNCTIONS

Secondary sources can be switched in case of RADAR failure, NAVTEX failure, or even compass failure. But sometimes, switching to the secondary source does not solve the problem in case of GPS error that occurs independently of the ship. According to the report published by the USA in 2018, the loss of the GPS signal in areas such as Egypt, the Suez Canal, around Cyprus, and even the Black Sea has been reported by many ships. Loss of GPS signal is a critical situation and should be dealt with immediately. If the secondary GPS receiver is also not working, the Dead Reckoning mode of the ECDIS should be used. ECDIS can calculate the approximate position of the ship and show position information since the current position of the ship, its speed over ground (SOG), and its course over ground (COG) are known. It can be a lifesaver if applied within seconds in channel passing, shallow waters, and heavy traffic areas where the position on the map should not be lost (ilginozgul.academy, 2021). ECDIS sensor settings are given in Figure 12.



Figure 12. ECDIS sensor settings. *Source: YouTube – Capt. Tymur*

4.3. OPERATION ERRORS

Since new advanced equipment has been introduced on board and vessel speed as well as size is being increased, advanced methods of operation are developed. The correct implementation of procedures becomes vital for the safe operation of the vessel. The checklist is very useful to improve standard operating procedures. Also, shipboard training is to enable deck officer to follow the standard procedures and be familiar with operation on ECDIS (The Error Chain in Using Electronic Chart Display and Information Systems, 2008).

Many error situations can be clear if the necessary checklists are created and the personnel is familiar with these checklists.

5. CASE STUDY

According to Human Errors in ECDIS Related Accidents study, the results of investigation on 'ECDIS assisted accidents' undoubtedly show that of all ECDIS associated errors that deck officers committed in these accidents, the most common ones are related to the incorrect setting of voyage safety parameters, ignorance of alarm systems and their adjustment, and the lack of checks and route corrections. Knowledge of the limitations of the equipment and detection of misrepresentation of information is essential for the safe use of ECDIS. Improving the accuracy of navigation by ECDIS will have a significant effect on avoiding grounding. But due to losing of situational awareness and misunderstanding the system, grounding cases will still occur (The Error Chain in Using Electronic Chart Display and Information Systems, 2008).

1. A vessel was scheduled for a laden voyage from South America to Northern Europe. The paper charts had recently been replaced by a dual ECDIS system – in preparation for the coming IMO ECDIS requirement. The chief officer started to place the different waypoints. The charts used had a scale of 1:100,000. The Chief Officer visually checked each leg of the plan to ensure they were clear of any hazards. In doing so, he noticed that several of the course lines were indicated in RED. The Chief Officer had identified a similar RED indication last time; he believed it was because the water depth in the English Channel was below 30 meters in several places but still sufficient for their ship. He accepted the “RED condition” because the vessel had followed the same route for the last three years, although previously on paper charts as official chart source. The default settings for safety contours were identified as 30 meters and were used throughout the voyage. Fifteen days after departing the loading port in South America, the vessel entered the English Channel from the south. During the watch, the 2nd officer adjusted one of the waypoints in order to avoid a close quarter. He visually checked the new leg and did not see any unsafe passing distances on the leg. However, he was not aware that the turning point in the previous waypoint was adjusted automatically by the system. Shortly afterward, the Master, who was in his cabin, felt a change in the vessel’s vibrations. He called the Chief Officer and instructed him to check the depth of water. The Chief Officer looked at the ECDIS display and reported to the Master that there was no cause for concern. The Chief Officer, following the intended course line – on a route that had been ground checked – believed that there were no dangers present at the moment. The vibrations increased, and the vessel began to slow down. The Chief Officer realized that something was wrong and put the propeller pitch to zero. He then changed the ECDIS display to a 1:50,000 scale and saw that the charted water depth was less than the vessel’s draught. He realized that the vessel was aground on a charted sandbank – now visible in the 1:50,000 scale ENC, but not on the 1:100 000 scale. However, the chart was “cluttered” by the wrong settings related to safety contours and depths and did not present the danger very clearly (Gard AS).

In this case, two errors appear: operational error and human error. Insufficient planning and inadequate control of the passage plan is an operational error. It is human error that the limits of the ECDIS device are not known to the officer and therefore sailing at the wrong scale.

2. A loaded dry cargo ship ran aground on Haisborough Sand off the east coast of England. The vessel quickly refloated without assistance and continued passage to Grimsby, River Humber, where she arrived the following morning. There were no injuries or damage to the vessel, and there was no pollution. The ship grounded 29 minutes after the OOW had adjusted course to follow an amended passage plan shown on the vessel's ECDIS. The route was hastily revised to ensure arrival at high water. This route took the vessel across Haisborough Sand, where the charted depth of water was considerably less than the vessel's draught.

Similar to the previous case, there are two errors: operational error and human error. The deck officers had not been trained in using ECDIS, and no procedures on the system's use

were included in the vessel's SMS (Safety Management System). They were, therefore, ignorant of many of the system requirements and features, operating the system in a very basic and inherently dangerous manner (The Nautical Institute, 2009).

3. On 9 July, 2018, the LPG tanker Pazifik ran aground on a shoal between the islands of Komodo and Banta. The ship was loaded with 18,000t of ammonia. Since only the forepeak and ballast tanks were damaged, no cargo escaped. After the incident, the vessel sailed to a shipyard in Singapore under its own steam escorted by a tug that had arrived in the meantime. During the vessel's repair, about 50m of the double bottom was renewed, and the rudder was repaired. The latter was damaged when the ship refloated from the rocks during a minor collision with the tug. The investigators found the ship to be in good condition and sufficiently manned with a qualified crew. Work hours and rest periods were adhered to, and no human error was detected. Culminating in the PAZIFIC running aground, this accident is due to the not fully engineered ECDIS, which is approved as a primary means of navigation and displaces other important sources of information, such as sailing directions, without the establishment of a consistent replacement for them. The Master and the second officer did not consider the plotted isolated danger, which is near the place of grounding, a threat to safe passage when they planned the passage. The information in the explanatory note about this isolated danger in the ECDIS/ENC did not cause the crew to conclude that it would pose a hazard to them or their ship. The Master and the second officer stated that the lack of depth information for the isolated danger or area surrounding it prompted the assumption that the water depth corresponded to the surrounding area. There was no appropriate designation around the isolated danger, nor was there any highlighting by a safety contour or the like for lack of depth contours. This accident would probably not have happened with paper charts, as more accurate surveys are available, and given their very nature, unsound surveys result in more distance being kept from shoals (Federal Bureau of Maritime Casualty Investigation, 2020).

In this case, one error appears: equipment error. There was no problem with the crew and operation, but the ENC used during the voyage was insufficient. To prevent equipment problems, cross-checking should be applied during the voyage. In this case, if the location and route had been checked, an accident would not happen. Since it is not mandatory to have paper charts if the ship has two independent ECDIS, it is not possible in every situation. No matter how careful and preventive measures are taken, an accident can be inevitable. At this stage, the action taken after the accident is of vital importance. Therefore, the precautions to be taken after the accident are as important as the precautions to prevent the accident.

6. CONCLUSION

Since recognizing the advantages of ECDIS for navigation by IMO in 2009 and the amendments entered into force on 1 January 2011 (International Maritime Organization), the use of ECDIS quickly became widespread. As the technology progressed and the quality and the quantity of the devices on the bridge increased, it became more and more difficult for the officer to control all the devices and control all the parameters. The widespread use of ECDIS at such a time has greatly reduced the workload of officers significantly because many parameters can be read from a single screen through ECDIS. However, ECDIS has made watchkeeping and voyage planning easier caused officers to become highly dependent on ECDIS. This dependence made the officers more vulnerable to dangerous situations on the ship.

Along with dependence on ECDIS, officers and captains accustomed to paper maps are also a problem. While over-dependence is an operational error, misuse of ECDIS by seafarers accustomed to paper charts is a human error. Failure of ECDIS and misdirection of the officer were investigated as equipment error which is less common than human error and operational error.

ECDIS is not just the electronic equivalent of a paper chart, and it is a much more complex system with dozens of connected sensors and devices on board. Therefore, it is vital to provide the needful training on the use of ECDIS. This is the first and most crucial step in preventing human-related ECDIS errors. Training is also an essential step in preventing operational errors. After training, the owner/agency should provide required checklists, test guidelines, up-to-date charts, and all the documents that the officer will need to the ship. Accidents can be prevented, or damage can be minimized in the situation of an accident, as an officer with operational competence and guidelines to refer to when needed will know how to act even during the equipment error.

ECDIS is one of the basis devices of the bridge that reduces the officer's workload with its advantages when used correctly. However, officers should keep in mind that the ECDIS is not a completely reliable device with its sensors but a display that shows data collected from other bridge devices and ENC charts.

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