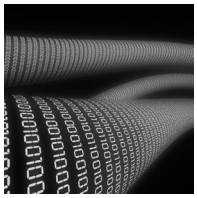

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Possibility of integration of navigational information on electronic chart

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ABSTRACT

This article presents the problem of proper use of navigational integrated equipment installed on modern vessels. Large number of electronic aids to navigation and even greater amount of information obtained make it possible to integrate and arrange these devices in a proper way. Such arrangement of all instruments make it possible to present all their data and information on the screen of electronic chart.
The dynamic development of information technology gave rise to electronic charts. The authors focused on the possibilities which are offered by electronic charts and presented the possibility of integrating individual instruments such as gyrocompass, log, echo sounder, GPS, ARPA and AIS and the information gathered from them with an electronic chart. This is a subject with further prospects and both all the companies producing the software as well as the ship-owners aim at the most efficient use of this device in order to improve the safety of navigation. This work also presents the mistakes which are made when electronic charts are used improperly. The further development of this system and the possibilities it can offer the future users are also presented here.

KEYWORDS: Electronic chart, ECDIS, navigational information, integration of equipment and navigational information, human error, integrated bridge

1. Introduction

Proper and accurate navigation in these days is based on the information obtained from various navigational aids. That is why the officers on the watch have to be able to make use of all of them at the same time. This skill is very important for safety of navigation. The development of navigational instruments installed on board the vessels improves the safety of navigation at sea. The instruments provide a lot of different information, but too much at the same time. Therefore there is need for selecting information that is necessary for the officer on the watch at a given moment. A navigator must know exactly what is needed and useful at any time to make the right decisions to navigate the vessel safely. Too much information given by all the instruments may result in mistakes during decision making. Such mistakes may be caused by limits of some navigational equipment, improper interpretation of the data (human error) or by the fact that they are not updated. The more information we have, the more possibilities of making mistakes arise. The development of information technology makes integration of some equipment used on navigational bridge possible, which facilitates the work of officers on the watch. An important feature of integrated navigation system is the possibility to collect information about vessels' traffic in a given area and send such information directly to VTS centre or to the ship owner. Some

Fig. 1. Integrated navigational bridge
Source: [own work]

attempts have been undertaken to create vessels without crew with the use of IT. One of such vessels is a yacht which is equipped with different types of devices of remote and intelligent steering. It can sail unmanned. At the present stage of technology development all the devices can be combined into one coherent unit.

2. Possibility of integration of navigational equipment

The increasing number of navigational devices and restrictions of human perception forced the producers to create such equipment which enables the watch officer to read on one screen also the data from other screens. There is tendency to improve the systems in such a way that the most important information regarding safe navigation can be found in one unit. This can be achieved by integration with other devices. Initially, radars where integrated with other equipment. Combining radar with the GPS receiver and gyrocompass enable the officer to read ship's own course on a radar screen and update own positions and positions of echoes detected by radar. Positions of other echoes were found basing of our positions obtained from GPS signal. The signal from gyrocompass made it possible to illustrate the course of our vessel. The data regarding the ship's own speed was obtained by integrating radar with ship's log. An additional device, ARPA, making it possible to trace radar echoes was created with such data. By combining data from these three devices ARPA provides automatic tracing of a given radar echo, as well as, defining the parameters of it's movement, such as speed and relative course. It has always been a very useful device during anti-collisions maneouvers. On the radar screen the officer can see not only the objects detected by the radar but also courses, relative courses of other vessels. Thanks to these functions the officer of the watch on the bridge is able to see the situation clearly and make prompt decisions and actions to avoid collisions. Another important aspect, from the point of view of the navigating officer, was the integration of gyrocompass and magnetic compass in the bridge control panel. This innovation made it possible to steer the vessel automatically and was especially useful in unrestricted areas.

Next step was creating integrated navigational bridge. The basic assumption was to collect all the necessary information for safe navigation in one place, so as the navigating officer has easy access to all data at any time.

The development of technology introduces more and more modern and sophisticated navigational aids, such as AIS (Automatic Identification System) and ECDIS (Electronics Chart Display). Even these systems have some restrictions. The basic problem faced while using AIS is reliability of the data obtained with this device. The operator has to compare the data from AIS with the data from radar and on such basis has to decide whether the received information is true or not. Primarily the system of electronic charts was meant to be an auxiliary device. However, at present it replaced standard paper charts once it follows some requirements. The producers focused on integrating different navigational devices with ECDIS. This work presents the possibility of integrating electronic charts with different navigational devices.

3. The possibility of presenting navigational information in ECDIS

The system of electronic charts ECDIS was mainly created to replace paper charts. Thanks to this system a navigator is able to concentrate more on observation of current situation rather than on marking positions and plotting the course or planning the sea passage on a paper chart. Electronic chart has the possibility to register data regarding positions, course alternations, and changes in speed etc. automatically, at regular intervals set by the operator. The development of these systems led to new solutions which help officers of watch to assess the situation of a vessel in a given moment in a better way. Integrations of electronic chart system with such navigational devices as RADAR and ARPA, AIS, log, GPS, autopilot, gyrocompass or magnetic compass, echosounder, wind sensor, VDR made the process possible. In this way a system was created where all the information indispensable for officer on watch is presented on one screen of electronic chart. Thanks to this system the officer can assess the situation properly and is able to navigate safely.

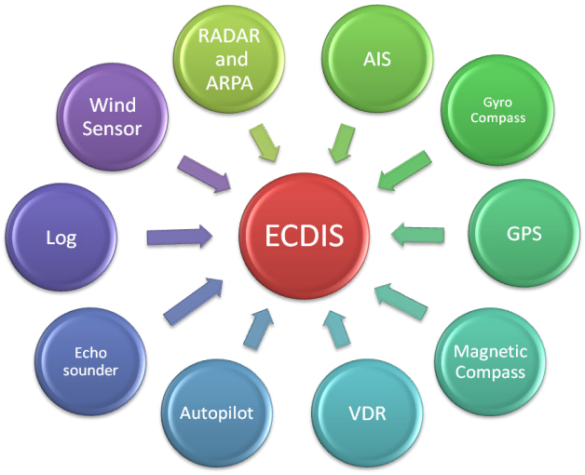

Fig. 2. Integrated devices displayed on the ECDIS screen Source: [own work]

Integrating GPS or other equipment defining the present position of the vessel with ECDIS makes it possible to display present position of the vessel on electronic chart screen. The officer can see what the distance of the vessel from dangers to navigation is and is able to take proper action to avoid collisions. Additionally, these positions can be registered automatically in ECDIS database at regular intervals. Position of our vessel is especially important with reference to safety of navigation. Another important feature of the system is the possibility to implement our vessel's contour. We can give our particulars (length, breadth and height), as well as, our present draft. In this way our position is presented on the electronic chart more accurately. In order to improve the accuracy of the displayed position we can insert data regarding the location of the antenna of the positioning system installed on board the vessel. This helps to define the ship's position on the electronic chart very accurately.

ECDIS presents the officer a lot of information which can be used to define proper and safe route of the vessel. One of the most necessary items of information is the depth of the area. Thanks to these data the officer can mark the limits of safe navigation. The chart also provides data regarding dangers to navigation, as well as, sea and land marks. These data are clearly shown on the screen and a click on the object offers additional information which is not present in case of paper chart. For example, the additional information about seamark may give light characteristics, the shape, top mark etc.

When carrying out navigation on bridge using electronic chart, we get the same data as on paper chart but in a far better way, i.e. more clearly and with present position of our vessel. This process is automatic. The user has possibility to insert own symbols on a chart which facilitates navigation. While we sail on the same route, it is possible to implement such points as pilot embarkation or the place we drop anchor, as we know them from previous experience. An electronic chart with such points marked on it helps navigator to define such points easily and plot the course towards them in coastal navigation. Electronic chart has two automatic functions marking contours of sea area, safe for navigation. This area is made out on the basis of parameters introduced by the watch officer. The function (safe depth) makes it possible to mark the depths which are unsafe for our vessel clearly once we insert the data regarding our ship's draft. Another similar function is "safe contour". This function shows us sea area which is unsafe for our vessel when taking into account draft. The operator can also set the alarm which is activated when critical values are either exceeded or approached. Thanks to this alarm the officer will be immediately alerted about leaving the route by acoustic and visual signal. In this way this device is more effective while warning against danger. The operator can also incorporate echo sounder to electronic chart. In such a case, apart from the depth presented on the chart, we also have the depth of the area displayed on the screen based on indications of the echo sounder. The officer can compare the readings from the device to those data from an electronic chart.

It is very important to integrate electronic chart system with gyrocompass, with log indicating speed over water and with anemometer. Thanks to these data the system can calculate the direction and speed of true wind. Consequently, this can define the parameters of leeway of our vessel. Another important feature of this system is the possibility to define current which has influence on our vessel. Special software calculates the ship's course and speed over ground using information from GPS or other positioning system. We can define the drift of our vessel accurately by comparing these values with ship's course and speed over water. These data are indispensable during ship's passage through narrow channels, restricted areas or while entering the port. It makes it possible to adjust the course quickly and efficiently in order to pass a given sea area. It is very important that electronic chart can display speed vectors of ship's course over water and over ground. This graphic representation is very useful because the navigator can state if he altered the ship's true course properly. This vector shows if the ship's course over ground is safe or leading towards danger.

It is extremely useful to overlay radar picture on the chart in order to define and identify given seamarks or landmarks. This function makes it possible to overlay object detected with the help of radar on the electronic chart. Thanks to it is possible to identify points which can be used to define with radar ship's position quickly. Such coverage offers new possibilities of detecting dangers and advances the time of assessing present ship's situation

which, further, is extremely important for the safety of navigation. The most modern radars and electronic charts provide the possibility of far reaching integration of these two devices. In the most modern versions of electronic charts there is remote control of such radar settings as tuning, sea and rain clutter and gain. In modern equipment there is possibility to control options or other navigational aids from one function (electronic chart) and to display information on one screen. This helps the officer on navigational watch to assess present situation easily.

Electronic chart, ECDIS, can also be very useful to make collision avoiding decisions or during these manoeuvres. Thanks to integrating this device with radar fitted with system of automatic tracing of echoes ARPA, we can display echoes on an electronic chart which were activated on radar screen with their vectors of movement and relative or true speed. This situation is very useful for officers as they can observe parameters of movements of other vessels on one screen and also restrictions of a given sea area presented on a chart such as: depths or dangers to navigation. All this helps to plan safe collision avoiding manoeuvre in which all elements of potential threats to ship's safe navigation are taken into considerations. Another device which is also extremely helpful during collision preventing manoeuvres is the system of automatic identification of ships AIS. The data from this device can also be displayed on the screen of our electronic chart. Apart from graphic representation of a given vessel in a given position we can also see vector of its movement and speed. We can also get more detailed data regarding a particular vessel. Pointing at an object displayed thanks to AIS data we can obtain additional information such as: MMSI number of a given vessel, name, call sign, type of vessel, navigational status, present position, course and speed, CPA and TCPA, port of destination, ETA, vessels dimensions, type of cargo carried, number of crew members and other data. Thanks to such information we get all data regarding a vessel which may be on a collision course, which is dangerous for us. There is one more situation which is new and has not been observed before. The operator can compare the data received from ARPA with those from AIS and state if the data transmitted by means of AIS are true or false. We can also easily identify the name of the vessel which is traced with ARPA. Integration of such information on an electronic chart helps us to assess information in a very good way and makes the contact with potentially dangerous vessels possible.

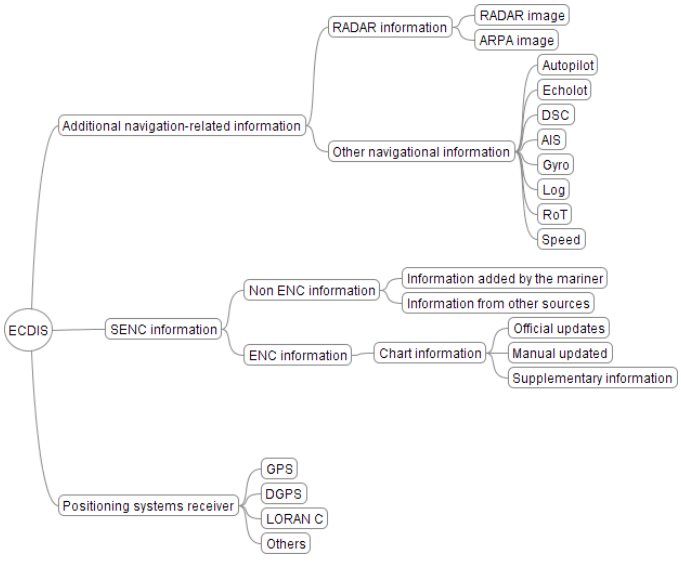

Fig. 3. Devices and navigational information integrated with ECDIS
Source: [3]

The development of electronic charts and technology was meant to provide the most of possible information to the navigators and to make the operation of some instruments easy, as well as, to reduce time needed and to increase the quality of work and to limit the number of errors caused by human factor. Passage planning on electronic chart is an easy and nice task. Here we have a number of functions at our disposal which make our job easy. What is most important we do not have to look for a set of charts for a voyage and to copy courses form one chart onto another. We can insert our points on the electronic chart and the whole route is drawn automatically. In a form of a table all the following points of changing course and the course we should steer to reach a given point are presented. Parameters regarding maneuverability of our vessel can also be inserted into the system. This is a very useful function because with such information the system will show us the point where we should start the manoeuvre to alter course. In order to be on the planned route after the change of course, the system in an automatic way gives us distances between given points of changes and also makes it possible to calculate the time needed for the whole voyage, different speeds of our vessel are also taken into consideration. When we finish voyage planning and when we insert data about vessel's draft and the required under keel clearance, the system in an automatic way checks the planned route. It is done by checking if our route is not crossing shallow waters, prohibited area dangerous for navigation. Combining an electronic chart with an autopilot is very useful when we have already had our voyage route planned. The autopilot's parameters can be set in this way that the vessel will follow the track appointed on a chart. At that moment the navigator's role is only to control if the autopilot is steering the given course.

Modern systems of electronic charts make use of other helpful tools, which up till now have been accessible only in books or by means of specialized programs. Nowadays, from the electronic chart, we can obtain information about ports which contain the following:

- data regarding services rendered in a given port,
- addresses and telephone contacts of port authorities,

- VHF channels used in communication with pilots,
- information necessary in reporting systems (all the data it should contain, when, to whom and on which channel must it be sent),
- other information, the navigator thinks is necessary.

We also have access to data regarding tides, tidal streams and sea currents. It is extremely important information when port approaching, as we know what conditions may be expected there. Some systems of electronic charts were fitted with special software to receive weather information. In this way we can get information about present weather conditions in a given area. We can obtain the following data regarding:

- fog, mist,
- heights and directions of wind wave, swell,
- precipitation: rain, snow, hail etc.,
- storms, cyclones,
- other weather phenomena.

Additionally, we have also access to a function person over board (MOB) which makes it possible to mark the position where the person fell over board and to monitor this position constantly. It is a very useful function during search and rescue operation as we can see the marked position and in this way we can define the search and rescue area easier and faster.

However, there are also some disadvantages and restrictions in this system. ECDIS can be a very useful tool enabling safe navigation but when used improperly it can result in collision of our vessel.

4. Errors observed while using electronic charts

The most frequent mistake made by the user of ECDIS is the choice of improper scale of the electronic chart. The electronic chart follows the rule: the larger scale the more details can be seen, the smaller scale the fewer details can be observed. It is extremely important because when we use small scale chart of a given sea area we cannot see some information regarding isolated navigational dangers; they are not displayed. That is why navigators who base only on electronic chart should be careful as a lot of cases of running aground were noted which were caused by choosing by the officer improper chart scale where some important details were missing. The best solution is to add echo sounder and observation of its readings to the system as they can warn us against danger.

Another frequent error observed while using electronic chart is the function of automatic change in defining position. When the signal disappears from the basic system of defining position such as GPS, the program switches to another system automatically. This system it is usually dead reckoning set by the producer. The operator has the possibility to change the other source of defining position or he can turn off the automatic switch of positions. In case of switching to dead reckoning our position will still be displayed but it will be defined on the basis of the last marked course and speed. The navigator can see position of the vessel on the screen of the chart, however, this position is not the true position of own vessel. It is a frequent cause of collisions. Officer should carry out constant observation not only of the chart but also pay attention to readings and indications and alarms shown on a panel being an integral part of electronic chart system.

An operator of electronic chart system has to draw attention to appropriate tuning of radar because improper radar display will cause shifting of positions and the information shown on a chart will be illegible. Proper attention should also be put on echoes traced by ARPA. All equipment has its restrictions. Sometimes it happens that ARPA loses the traced object or the target will be proceeding very close to a buoy or other object and ARPA will automatically start tracing the fixed object. If we do not monitor that situation constantly it may happen that our collision avoiding manoeuvre will be done in relation to a fixed buoy and not to a vessel which is on a collision course.

The navigating officers should also be aware of errors generated by automatic identification of a ship and displayed on a screen of electronic chart. These errors from AIS can be generated twofold: by our equipment, and by improper data sent from other vessel's equipment. That is why the officers should always compare the data form ARPA with the data from AIS and basing on such information they can state if AIS gives true or false information. The possibility to overlay the picture from ARPA and from AIS onto the screen of electronic chart makes the process easier. All this makes it possible to identify vessel and check information about a given vessel. According to international regulations we cannot take into consideration the data obtained from AIS during collision avoiding manoeuvres because such information can be false. It should be stressed that some information must be inserted to AIS manually by the operator and if it is not done, the device will also transmit false data.

The most important problem is the operators' level of knowledge of electronic charts. All electronic chart users should be aware of restrictions imposed by this device, as well as, by other instruments integrated with it. Such knowledge will allow avoiding a number of errors and making safe navigation possible. The development of technology will enable getting rid of some errors and restrictions of some devices in the future.

5. The future of ECDIS, the integrated system of electronic charts

Nowadays, the international organisations are working out the requirements regarding the system of electronic charts. This system is to be made compulsory equipment on vessels by 2012. However, the requirements imposed by the organisation are not easy to be met. This system not only must be fitted with an additional source of power supply but also must have a backup device ready to be used at any time. The conditions for updating these charts must also be possible. The updating must be possible in any conditions and there are three ways of updating, i.e. via internet, via satellite and from a CD record. The last mentioned method is not taken into consideration because it is least convenient, as it may result in delays and long breaks in updating when the vessel is at sea or in the sea area where there is no possibility to deliver the post from the shore. The development of information technology will soon make installation of the system on vessels and its constant progress possible.

Modern electronic charts and fast net connection with land will enable monitoring the situation on a given vessel all the time. Thanks to it the picture of all situations can be sent further on land or to the ships owner or to VTS centre. The ship owner will be able to control the position of the vessel at any time and will be able to see the same information which is at the disposal of officer on watch in real time. Additionally, thanks to the installation of visual system the development of unmanned vessels may be possible in the future. Such vessels would be controlled from land basing on the information sent directly from this vessel. This visual system would facilitate the work of port pilots as they would not have to embark the vessel each time. They would manage the traffic from a certain place on land having at their disposal visual system and indications of all ship's instruments.

The development of electronic chart system and integrating it with the systems used for example in the ports or VTS centres will make sending current information regarding the sea area a vessel is entering possible. Such centres could send updated charts of port approaches or send corrections regarding e.g. work or surveys carried out etc, and such information would automatically be inserted on electronic charts. At present electronic charts and their integration with other devices is for many companies priority and everybody wants to invest in this field of maritime technology.

6. Conclusions

The development of electronic chart systems is inevitable because despite present restrictions, the advantages following its usage are enormous. It causes that navigation is not only easier and safer but this system also shortens the time the officer needs to make decision regarding collision avoiding manoeuvre. However, each operator should be aware of restrictions of this system and should not over rely on the picture displayed on the chart. The officer should be familiarized with the alarms generated by the system, readings from other devices accessible at the level of an electronic chart and, first of all, should keep a sharp lookout. At present, an investigation is being carried out in Maritime Chamber regarding collision connected with the use of electronic chart. The officer on watch relied only on the indications of the chart to that extent that he had no reading from echo sounder; such negligence resulted in running aground.

It is also possible to switch automatically from one system defining position to the other without the operator's interference. Dead reckoning is usually the other system to find the ship's position. In this connection it is very important to train the staff operating this system in a proper way and to acknowledge this training with international certificates. The operators should know how to use the system of electronic charts and should be aware of errors generated by the system and the ways to avoid some of them. Integration of this system with other vessel's devices will make it possible to display lots of different information on a screen of one monitor. The task of the officer is to define which of these data are needed at a given moment and to decide to switch off those which are not necessary in appropriate options of the programme. One should be aware that too much information leads to misinterpretation. The proper selection of the data obtained with this device is one of the most important skills the operator of the system should gain.

In the future, thanks to visual transmission via satellites, the navigating officer will be supported by people on land. This refers also to collision situation where OOW would be able to contact appropriate shore based unit which on the basis of the data received from the integrated system of electronic charts and on the basis of visual signals sent by satellite will advise the navigator the best collision avoiding manoeuvre. Thanks to this solution navigation will become much safer and the number of accidents which create a great threat both for people and natural environment will be decreased.

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