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Development of Electronic Navigation Chart for ship navigation in HICT port, Hai Phong

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ABSTRACT

The ships navigation safety in the ports is always a matter of primary concern in the task of ensuring maritime safety. To do this, charts are an indispensable tool, especially electronic charts. Electronic charts have advanced features and the ability to connect with the peripheral sensors. One of the electronic charts management software is the ECDIS (the software has been official accepted by the IHO) which is a powerful tool for ships' navigation. In order to establish the electronic chart, we apply the IHO procedure and follow the international standards. The ECDIS software has been used to manage the electronic charts in our system. This article will present an overview of the electronic charts and build experimental electronic charts for the navigation into HICT port, Hai Phong city.

1. Introduction

The map is a familiar tool with seafarers. It plays a major role in the development of the maritime industry in the world. Analogue maps dating back to the fifteenth century were portrayed by mariners notes on transatlantic journeys to find new islands, continents, and so on. They have been produced by many countries around the world. However, analogue maps are designed to display the information needed for the user, edited for various users, and require users to have knowledge, skills, and experience to understand the data drawn on the chart. Thus, on the journey, seafarers always are working in the past, not present. Because to determine their position, they must follow these steps: identifying objects; drawing position on the chart; and checking the position, etc. For experienced people, it takes 60 seconds to perform this operation, equivalent to the distance the ship moves are ¼ nautical if it runs at 15 nautical miles/hour. Furthermore, the manipulation process can be confused.

As a result, electronic charts are emerging as one of the solutions to the limitations of using analog charts in the navigational work. Electronic

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maps provide navigators a "smart map" and navigational information that is displayed on the computer screen. In addition, electronic charts contain more details than analog maps for enhanced navigational safety and enable navigators to navigate the ships in the most convenient and secure manner.

In fact, electronic charts are widely used in many fields such as charts used as the base database on electronic map display system (combining Automatically Identification System - AIS, Global Positioning System - GPS, Radar,...) to select the display object, adjust the display ratio and display information in real time. Electronic charts are used for maritime management when combined with AIS, VTS, etc. to help manage and regulate maritime activities in the area. Electronic charts with AIS equipment are also used to manage the position and operation status of maritime signals with installed AIS to ensure maritime safety and security. Electronic charts are used in research and teaching institutions, agencies operating in the field of search and rescue, oil and gas exploration, environmental protection, marine planning, etc.

Vietnam, with its coastline stretching from the north to the south, has a system of coastal ports along the northern, central and southern coasts. Every day, thousands of vessels enter the navigable channels of coastal ports engaged in cargo and trade operations. The distribution of lanes for the movement of ships to ensure safe transportation is one of the issues of particular interest to the port authorities. Therefore, the construction of electronic charts for navigation of ships in Vietnam's seaports is a necessary and practical issue in the current period.

The construction of this electronic chart system is not only a practical means of navigating ships into the coastal ports but also contributes significantly to the formation of the technological process, specialized scientific materials for university and postgraduate teaching in the field of cartography, remote sensing and GIS as well as in the area of marine safety assurance in the current period.

2. A brief review of electronic chart

2.1. In the world

In the past few years, along with the strong development of technical means, information technology, and especially the services of the GNSS system, electronic charts have been and are being researched and developed. Many countries in the world such as the United Kingdom, Canada, USA, China, South Korea, etc., invest in the construction of marine charts for the safety of marine navigation. Canada has built a nationally-based navigation system capable of harnessing and supporting the needs of its crew in the available infrastructure (Daniel et al.). The chart was originally designed to integrate and navigate the sea, but increasingly with the help of electronic charting technology, it has been gradually integrated and enhanced for better maritime safety (Wendy, 2011; Christos and Pilikou, 2017; Ahmad et al., 2017). In this direction, many scientists around the world have focused on researching and articulating the architectural requirements of electronic charting systems in order to further improve the technology in electronics marine charts construction. (Axel et al., 2016). In addition, the IHO has organized workshops and set standards for electronic charts and digital map database to standardize the digital map system. However, the current reality of each nation, the construction of electronic charting systems for their own navigation purposes, is especially guiding access to coastal ports. As a result, electronic charts still exist in parallel with the two systems, and the first is the electronic chart system under the SOLAS Convention (International Convention for the Safety of Life at Sea), the second is the Non-SOLAS Informal Electronics chart system (Kwang, 2016).

There are currently two types of data that can be used on an electronic chart display system. The first is a raster navigation chart (RNC), which is a chart of paper that is projected to integrating peripherals on an ECDIS system, which allows easy location of the vessel characterized by familiar interface. However, this chart pattern is not acceptable for use in the SOLAS standard. Therefore, it to be used in areas where ENC maritime navigation is not available; The second is the electronic navigation chart (ENC). This is a chart format established from digital navigational data and is standardized for digital data conversion standards - S57 issued by IHO,

controlled by software and experienced producers, is displayed according to the IHO S52 standard.

2.2. In Vietnam

Over the years, in Vietnam, paper charts have been used extensively in navigating inland waterways. The use of paper charts in waterborne traffic activities are often used by sailors with personal knowledge and experience, so for each person in use there will be different views. The use of paper maps when navigating in waterways is limited because paper maps are provided in individual sheets. If traveling in wide ranges, multiple sheets must be used. The data will not be consistent due to inconsistent data measurement when charting (Tran Van Luong, 2017). The introduction of electronic charting (ENC) will help overcome these problems, and an electronic chart with the characteristics of a "smart map," will provide the user with sufficient information and accuracy. The texture is much higher than the traditional paper chart. Built on international standards issued by the International Hydrographic Organization (IHO), it incorporates marine terrain data, navigational channels, which contain descriptive and positioning characteristics, for Electronic map display software recognizes the characteristics of accurate geological depth and location and provides alerts if the route correction is required (Pham Quoc Suy, 2015, Tran Van Luong, 2017). Electronic Marines (ENCs), combined with peripheral devices, can help the operators to know the dangers of the ship's shipping lanes, which can generate warning signals when entering the area that danger or areas where the regulations are to be complied with. More importantly, the ENC can provide the necessary data for seafarers or other users on pollution-restricted area information, environmental protection, etc..

The establishment of electronic charts currently in Vietnam involves mainly digitizing the paper chart. This work is mainly provided by a number of agencies and units in the maritime field such as the 6th Navy Unit, the Northern Marine Safety Assurance Corporation, the Southern Marine Safety Assurance Corporation and University of Maritime Vietnam (Tieu Van Kinh, 2015). However, because the units have different characteristics, most of these units are set up in a separate process, independent products are not consistent, especially for the 6th Navi Unit is a unit of the People's Navy of Vietnam so most of the charters in general and electronic charts, in particular, are circulated internally and not released to the outside. Therefore, the research and development of electronic charting technology for navigating into navigable channels in Vietnam's coastal ports is a matter of urgency and high feasibility.

3. Study area and data

3.1. Study area

Experimental area for the construction of electronic charts was selected is the section outside the Hai Phong channel because of the geographical position is extremely favorable. Hai Phong area is the gateway to the sea of the northern provinces. It is the coastal shipping hub from Quang Ninh to Kien Giang; It is the focal point of the inland waterways to all the northern delta provinces. Moreover, there is also a developed seaport infrastructure, favorable road transport linking with the whole northern key economic region, and favorable position for tourism development. The sea economy has developed strongly over the years.

Hai Phong city area is the general port of the country, most typical of the northern region. The port system includes port areas on the Cam River; Dinh Vu port; Lach Huyen harbor area; Besides, there will also be a number of other specialized seaports serving the satellite role in Hai Phong port system such as the port of Bach Long Vi island district, the port of Nam Do Son, anchor piers, convey. These wharves have complementary function in general (Figure 1).

At present, Hai Phong seaport has 45 cargo wharfs with total length of over 11km. Lach Huyen harbor is capable of receiving ships of up to 50,000 DWT and 100,000 DWT for offloading;

Some ports in the Dinh Vu area are capable of receiving ships with a tonnage of up to 50,000 DWT. In addition, Hai Phong seaport also has three berths, Bach Dang, Lan Ha, and Ha Long are capable of receiving large tonnage vessels; two wharves for transshipment at Bach Dang and

Figure 1. Study area.

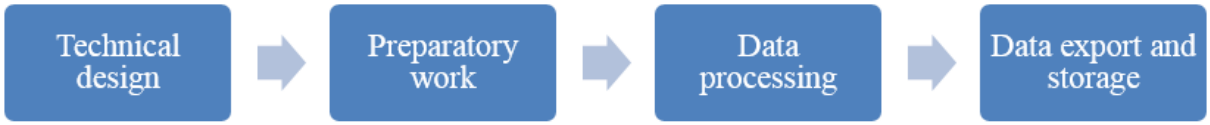

Figure 2. Process of establising of the electronic chart.

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The area has complex terrains with many small islands, reefs, and various marine signaling objects (lighthouse, lighthouse, trumpet, floating signal, virtual AIS ...). This will be an ideal area to experiment with building electronic charts.

3.2. Data

The data used to establish the electronic chart can be divided by Spatial and Non-Spatial data.

The spatial data included the depth of data from sonar surveys. It also includes the scanned and vectorized maritime charts based on IHO standards.

The non-spatial data includes lines, control signals, navigation facilities information,... Those data have been imported following of the IHO standards into databased.

4. Methodology

The establishing of the electronic chart for HICT has been done by several steps which will be described in the following flowchart (Figure 2).

Electronic charting has now been standardized and guided by IHO International Standard S65 (IHO, S63). However, to meet the practical requirements, on the basis of ensuring the suitability with the conditions of Vietnam, we have conducted the construction of experimental products according to the technological process (Figure 3). The process of building electronic charts we can use software such as Caris, DKart, SevenCs,... This is the group of software that can

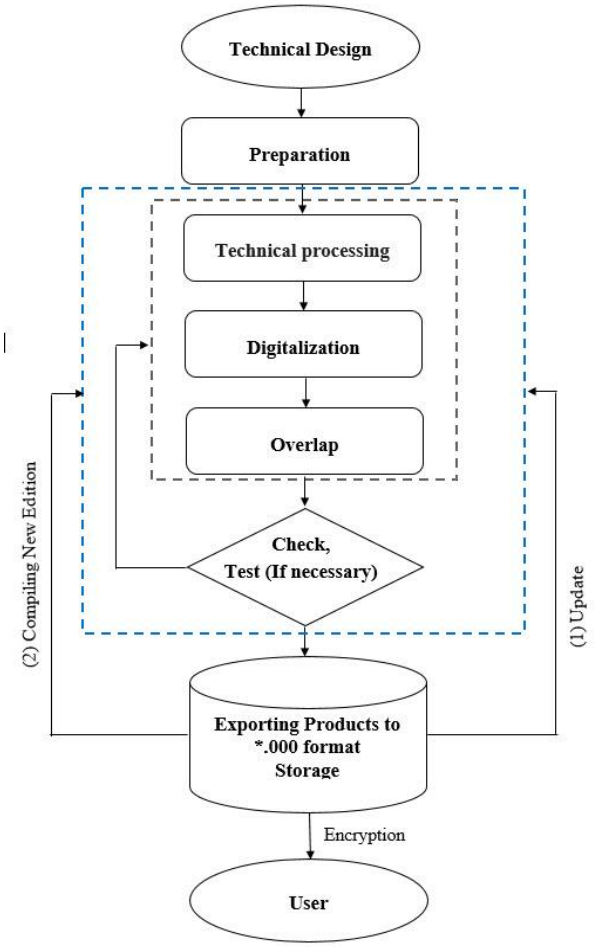

Figure 3. Procedure of building Electronic Navigation Charts.

produce and encode products to meet the requirements of IHO standards.

The process of building electronic charts is in accordance with the production code prescribed in IHO Standard S62 (IHO, 2014). In addition, we may also use the VN code (1510) registered by the Northern Maritime Safety Corporation or V1 code (1511) registered by the Southern Maritime Safety Corporation.

4.1. Technical design

On the basis of regulations on seaport waters; seaport development plan, the range of lanes, anchorage areas, pilot embarkation areas, etc. , we determined the name of the electronic map that should be built VN4HICT1. The construction range is limited to 20°35'20 "to 20°48'37" north latitude and 106°51'36" to 107°02'00" east longitude according to the WGS84 coordinate system.

The electronic chart was built based on the production code VN (1510) of the Northern Marine Safety Assurance Corporation and was established at Editorial Rate 1: 22000.

4.2. Preparatory work

Preparatory work includes the collection of data for the production of electronic charts. The data collected included: paper chart data from the Northern Maritime Safety Survey Enterprise, paper maps from the Vietnamese People's Navy, topographic map of the seabed, information on maritime signals, legal documents on maritime activities in the region, etc.

Preparation of software, equipment: To establish electronic charts for the experimental area, we used SevenCs software to digitize data according to IHO standard S57 (IHO, 2012); Dkart software checks the data and identifies errors that can be corrected in a timely manner, error-checking standards are complied with IHO S58 standard (IHO, 2014); Data encryption is done in accordance with S83 standard with code for Vietnam is 84 through software SevenCs (Kwang An, 2016). To test, we use the SevenCs Orca Master Chart Display System (ECDIS).

4.3. Data processing

The paper charts obtained from various agencies are classified, processed, and evaluated for quality as well as the need for navigational purposes. Scanning and image processing in SevenCs software is then carried out, and digital images must be digitally corrected according to the new requirements. After digitization, we obtained digital chart data and conducted reference checks on some other specialized software before being put into use as a database for electronic charts.

The selection of depth data for electronic charts is selected according to the priority criteria for selecting new data, near time measurements, larger measurement scale, and maritime signaling data need to check the attribute before updating to the electronic chart database. In the experimental process, we selected the depth data from the measured data of the multi-beam imaging device and then ran the DEM model to

check the bottom surface of the channel and then select the specific depth values to ensure that the navigation of electronic charts is accurate and safe (Figure 4).

With other pieces of chart, in order to be able to put data into use, it is necessary to go through the process of checking and correcting the errors. The process of checking digital chart data was conducted by two methods: first, visual inspection to detect inappropriate object editing errors; wrong object position such as signal on the right of the channel but placed at the left-hand side of the channel; and wrong type of the navigation signal. The second is software testing to detect logic errors in accordance with S58 standard IHO. After the inspection and repair process, we obtain complete chart data.

4.4. Data export and storage

Data is exported in standard *.000 and stored in the software system as described in section 4.2. When there are changes in the data, we perform the evaluation and implementation of data updates; the incremental update is respectively *.001, *.002,... When there are too many updates, we can conduct a review and production of a new edition based on the background data of the original.

5. Results of construction of electronic charts of navigation lane into Lach Huyen international port - Hai Phong city

After completion, the chart database will be integrated into SevenCs' ESCIS Orca Master software to display electronic charts. As a result, the VN4HICT1 (Figure 5, Figure 6) electronic maritime charters were obtained from the pilot area to the Lach Huyen International Container Port in Hai Phong for ship navigation, maritime navigation, search and rescue, and environmental protection (Figure7, Figure 8).

6. Conclusion

On the basis of a study of the IHO standards for the construction and management of electronic chart data, in conjunction with the existing charters available at a number of agencies in Vietnam, the process of establishing electronic charts for navigation of coastal navigable

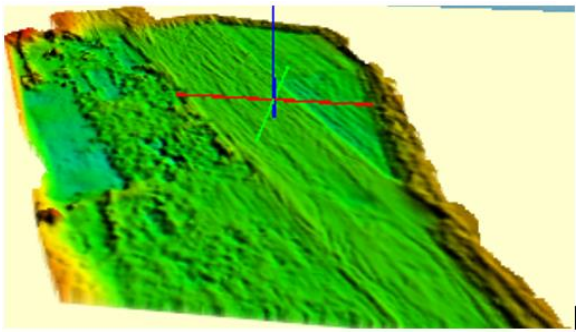

Figure 4. Modelling the depth of lane in HICT port.

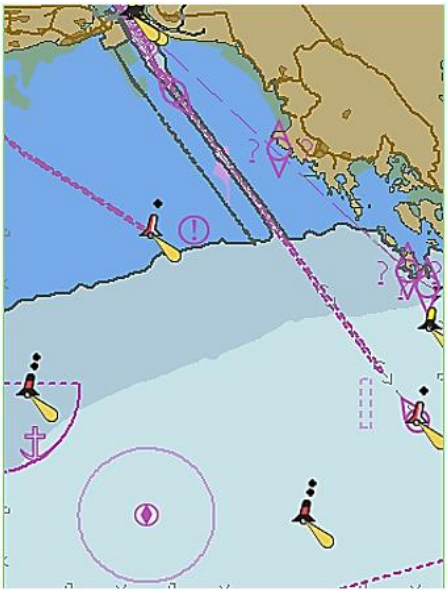

Figure 5. Electronic Navigation Chart-VN4HICT1.

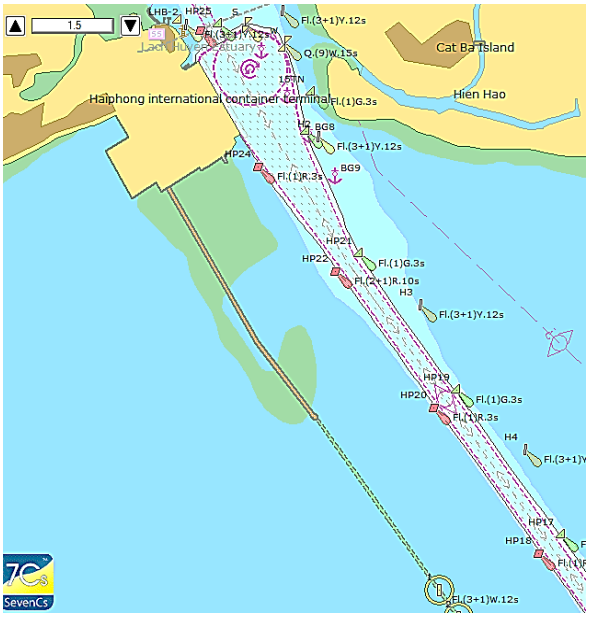

Figure 6. Electronic Navigation Chart of HICT port in Hai Phong.

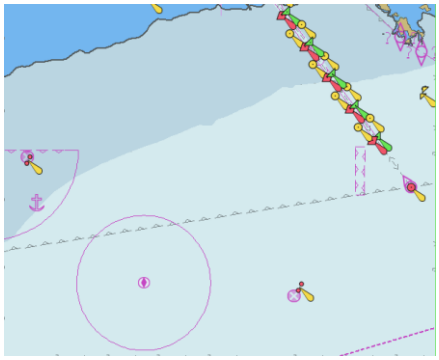

Figure 7. Electronic Navigation from the area to welcome the pilot to HICT port in Hai Phong.

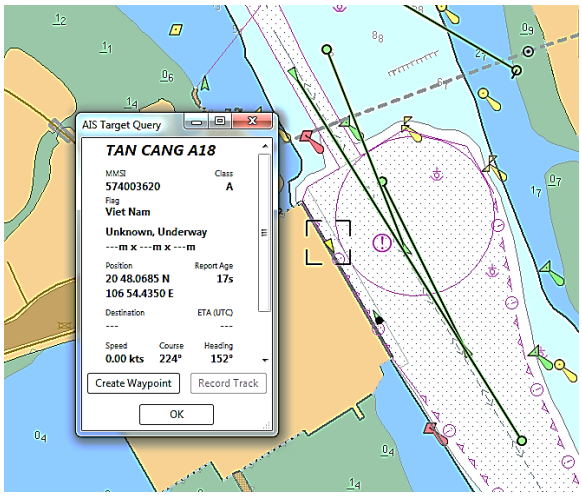

Figure 8. Query information of anchor position on ENC when connected to the AIS systemin HICT port.

channels in Vietnam has been developed. We have successfully built the electronic chart in accordance with the proposed process on the basis of the application of international standards, and at the same time use a number of standards the Northern Marine Safety Assurance Corporation has proposed for the electronic map in the port area of HICT, Hai Phong.

Experimental maps can be displayed on specialized software that has been adopted by IHO (ECDIS), which can search for depth information, flow charts, pilot pickup information, and system information. Maritime navigation, especially connected to the AIS system, facilitates navigation in order to ensure safety and order, thus facilitating traffic management in the navigation network is effective.

However, in the experimental area of the article we have only built a test piece of electronic charts for navigable channels into HICT port of Hai Phong city. With the technological process in place, we hope to build more electronic charts for other shoreline navigable channels to meet navigation needs and ensure maritime safety for incoming and outgoing vessels. This will create favorable conditions for the port management and management agency.

References

Ahmad, F. A. F., Mohd, S. A., Mohd, N. F., Noor, A. O., 2017. The Utilisation of Pisang Island as a Platform to Support the Current Safety and Security Needs of Marine Navigation in the Straits of Malacca. *International Journal of e-Navigation and Maritime Economy 7*. 11 - 18.

Axel, H., Andre, B., Martin, F., Sibylle, F., Jin, H. P., 2016. Requirements for e-Navigation Architectures. *International Journal of e-Navigation and Maritime Economy 5*. 1 - 20.

Christos, K., Maria, P., 2017. Nautical cartography competences and their effect to the realisation of a worldwide Electronic Navigational Charts database, the performance of ECDIS and the fulfilment of IMO chart carriage requirements. *Marine Policy 75*. 29 - 37.

Daniel, B., Jennifer, B., Lisa, V., 2016. Improving Canada's Marine Navigation System through e-Navigation. *International Journal of e-Navigation and Maritime Economy 4*. 23 - 30.

International Hydrographic Organization (IHO), 2000. Transfer Standard for Digital Hydrographic Data - S57.

International Hydrographic Organization (IHO), 2004. ENC Producer codes - S62.

International Hydrographic Organization (IHO), 2010. IHO data protecion scheme - S63.

International Hydrographic Organization (IHO), 2012. S65 - ENCs: Production, Maintenance and Distribution Guidance.

International Hydrographic Organization (IHO), 2014. Recommended validation checks - S58.

International Hydrographic Organization (IHO), 2014. Specification forChart Content and Display Aspects of ECDIS - S52.

Kwang An, 2016. E-navigation Services for Non-SOLAS Ships. *International Journal of e-*

Navigation and Maritime Economy 4. 13 - 22.

Pham Quoc Suy, 2015. The effectiveness of electronic charts in the work of ensuring maritime safety. Vietnam Maritime Safely Corporation - South.

Tieu Van Kinh, 2015. From Analog mapsto Electronic Navigation Charts. Transport Publishing House.

Tran Van Luong, 2017. Rulers of rating values and Scamin in Electronic NavigationChart editor. *Journal of Maritime's Science and Technology 52*. 58 - 62.

Wendy, Z., 2011. Electronic navigation charts could reduce disaster at sea. *New Scientist 212*(2835). 26.