Advent of Electronic Navigational Chart for National Development and Navigational Safety

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Abstract

The safety of navigation at sea was of great concern to navigators and cartographers since ages. The rapid technological revolution, particularly in the field of digital technology stressed the requirement to produce ENC in the form of Electronic Nautical Chart database (ENCDB). ENC's are the vector charts containing all chart information necessary for safe navigation which are prepared as per IHO Publication S-57 and S-52 under the guidelines of International Maritime Organisation (IMO), and which are equivalent to the existing paper charts as per Safety of life at Sea (SOLAS) Convention. ENC's produced by authorized hydrographic offices are the legal and valid input to Electronic Chart Display and Information Systems (ECDIS).

ECDIS is an intelligent and dynamic navigational information system designed to increase safety and efficiency of navigation which can be accepted as complying with up-to-date navigational chart. The system provides for selectively displaying the various navigational details and information and it provides audio video alarms while approaching dangers. It gives facility to mariners for setting up safety depth contour depending on the draft of the vessel. The safety depth contour will be highlighted on the display and alarm will be provided while crossing this contour.

In context of the above it is felt necessary to find out ways and means to create ENCDB for exclusive economic zone area in north Indian ocean to meet our national maritime requirement and international commitment for production of ENC's as per IHO specification. Security of our data set and requirement of preparing updates, new editions from the latest hydrographic surveys are addressed.

Overview

1. Introduction

The National Hydrographic Office (NHO) at Dehra Dun is the only national authority for the production of navigational charts and publications for our area of responsibility. The recent developments in the field of digital technology and automated cartography and navigation has contributed considerably to make the navigation easier and safer.

India was committed to International Hydrographic Organisation (IHO) and Maritime agencies to produce Electronic Navigational Charts to enable economic sustenance by shipping. Being the leading hydrographic nation in the region, we are committed to provide Electronic Navigational Charts, covering our area of jurisdiction, which at present is well covered by 311 paper charts on various scales. At present NHO has produced 262 ENCs on different scales for various purposes as per IHO specification S-57 Edn. 3.1

The ENCs produced by various hydrographic offices are the primary input to Electronic Chart Display and Information System (ECDIS). ECDIS is an intelligent and dynamic navigational information system designed to increase the safety and efficiency of maritime navigation. The system integrates the chart and navigational information along with the dynamic information available onboard and displays various navigational details along with the dynamic display of the vessel.

2. ENC Production

ENCs are digital data sets, standardized as to content, structure and format, issued for use with ECDIS on the authority of government authorised hydrographic offices and contain intelligent digital vector data produced as per standards and specifications laid down in IHO Publications S-57 and S-52. The ENC contains all the chart information necessary for safe navigation and contain supplementary information in addition to that contained in the paper chart (e.g. sailing directions) which is considered essential for safe navigation.

The production of ENCs is a complex and tedious process requiring considerable time and specific hardware, software and manpower. NHO has produced ENCs from compilations and paper charts after updating these with latest data. The horizontal datum for the paper charts is Everest and for ENCs, it is WGS-84. The department has conducted special surveys to meet the above requirement. In order to accelerate the production of ENCs, NHO as a one time measure has offloaded the

task of digitization of navigational charts, compilation and overlays to a competent private firm. The data sets submitted by the firm are properly validated by NHO using manual and automated means before the final ENCs are made. The ENCs produced at NHO are subjected to sea trials and feedbacks are quite encouraging. Our ENCs have been graded "good" by PRIMAR after validating a few of our ENCs.

The various stages of ENC production from published chart/compilation/film positive using CARIS S/W are as follows :

2.1 Conversion from Analog data to Raster Image: Finally examined new compilation or a corrected film positive of a published paper chart is scanned through a scanner having 400 dpi resolution to get a raster image in Tiff format.

2.2 Digitization: Digitization of various features of the chart as per cartographic requirement is a time taking task. Before digitization is done, a LLDG header file containing title, reference ellipsoid, geographical coordinates, central meridian, scale of the chart, projection etc., are defined. Raster Tiff file is then converted to CARIS Tiff. Then the CARIS Tiff file is cleaned and registered with LLDG header file. The digitization in CARIS environment is feature based. The cleaned raster data stored in a CARIS editor displays the scanned image as a backdrop to the graphic window, after clicking on any line segment, the line will automatically be converted from raster to vector format. The standard editing commands in CARIS editor can be used to capture other features like text, symbols, spot heights and soundings as per IHO standard.

2.3 Creation of Topology: The word 'topology' describes the geometrical relationships between features in a digital chart. In CARIS, graphical features are grouped together by their user numbers. When considering topological relationships, the feature to be processed is assigned a new CARIS user number. CARIS file may contain several layers of related information which are grouped together by a common user number. Topology is built layer by layer, first, identifying the user number of the features (lines) to process, and then convert them into topological areas.

2.4 Metadata: The metadata is a group of special object classes which contains information about other objects. All features represents the attributes common to the whole ENC cell or part of the cell at compilation scale. Depth units are some of the object classes which belong to the whole ENC cell. These object classes are centroid features created by taking the whole chart as an area feature and transfer the centroid information to the area boundary. The maximum use of meta object is to be made to reduce the attribution on individual objects and maximum use of data set subfield is to be made to reduce attribution on meta objects.

2.5 Data Quality Assurance : Inspite of the various checks done at different levels of data capture, the data quality is required to be ensured. The inconsistencies including missing mandatory attributes indicated by the translator and those observed during the examination of CARIS proof are removed. Any corrections found during the validation of ENC using international validation software are incorporated before the final conversion.

3. IHO S-57 Transfer Standard for Digital Hydrographic Data

The IHO Special Publication S-57 – Transfer standard for Digital Hydrographic Data (usually called S-57) is the technical specification for data standards to be used with ECDIS. As with most technical specifications, it goes through constant revision and is currently on version 3.1 which is based on an object data model. This specification defines the standard for exchange of analog data in digital form for use by hydrographic offices. The IHO S-57 transfer standard for digital hydrographic data was prepared by IHO's Committee on Hydrographic Requirement for Information System (CHRIS). Its earlier version was known as DX-90 till 1992. All the ENC producing countries have to follow S-57 specification for production of ENC data.

The CARIS hydrographic object manager is a software package within the CARIS suite which creates an S-57 object model, using a CARIS file that contains point, line and polygon data. The result of the conversion is an S-57 object model. Editing, if any, can be performed in S-57 object model.

Once the ENC is created in accordance with the S-57 specification, it is to be transferred to a physical standard as the data structure created can not be ported to other systems on its own. It is then encapsulated using ISO 8211 standard. This standard provides a file based mechanism for the transfer of data from one computer to another, independent of model and operating system. It is independent of the medium used for such transfer. Further, it permits the transfer of data and also the description of how that data is organised. This is also part of S-57 specification, the process of converting the ENC data, into a free format, is also handled by the software used for generating ENC data set. The specification serves as a guide for uniformity of products by various H.O.s and enables quality check and assurance of ENCs and their updates.

4. Product Specification of S-57

Production of ENC data must be in accordance with rules defined in the Product Specification of S-57 and must be encoded using rules described in object and attribute catalogue. The main points are as follows:

a. A cell is a geographical area containing ENC data and it must be rectangular

b. Navigational purpose of the cell must be defined such as overview, general, coastal, approach, harbour and berthing.

c. An ENC cell can not have inset (it will be created as a separate cell).

d. An ENC of same navigational purpose may overlap but not duplicate data in the overlap area (even if multiple producers are involved).

e. Objects on the border of adjoining cell must remain only in one cell.

f. The geographic extent of the cell must be chosen by the ENC producer nation to ensure that the data file must not contain more than 5 Megabytes of data and cell size must not be too small.

g. Topology must be in chain mode.

h. Horizontal datum must be WGS-84

i. Projection is not used.

j. Units to be used are :
Position : Lat. and Long. in decimal degrees
Depth – in metres
Height – in metres
Positional accuracy – in metres
Distance – in nautical miles

k. Feature objects id's must be unique world wide except where it crosses cells or usages.

l. Feature object id's must not be re-used even after deletion of object.

m. Mandatory, prohibited and optional geo, meta and collection objects to be followed as per specification.

n. Cartographic objects like area, line, Csymb, Comps & text are prohibited.

o. No user defined object classes, attributes or attribute values are to be used.

p. The relationship between objects are made using master and slave concept, and using collection objects, such as light over tower

q. Feature objects must belong to one of two groups :

All the feature objects of a chart can be classified in to four categories to enable efficient exchange of non-locational description of real world entities – *Metadata* is a feature object which contains information about other objects, *Cartographic_Objects* are feature objects which contain information about the cartographic presentation of real world entities (including text) this object is prohibited to be used in S-57 Edn. 3.1. *Geodata* is a feature object which carries the descriptive characteristic of a real world entity *Collection* – object which describes the relationship between other objects.

Group 1 – Skin of Earth

Group 2 – All feature objects which are not in Group 1 are in Group 2.

5. Updating ENC Data set

All ENC producer nations should ensure that subsequent updates are forwarded to end users time to time and end user should also ensure that all the updates are incorporated into the System Electronic Navigational Chart in the correct order without deletion; the file extension and a number of sub field in the "data set identification" (DSID) field should be used in proper manner as follows:

5.1 File Extension – Each new data set, new edition or re-issue must have a "000" extension. In case of update cell file, the extension is the number of update, ranging from "001" to "999". The number "001" is the first update after creation of a new dataset or new edition, but not after the re-issue. All the updates are to be incorporated in to SENC created from the original ENC data set. This ENC data are to be updated regularly through notices to mariners.

5.2 Edition Number – As and when a new ENC is created, the edition number 1 is assigned to it; it will be 2 in next new edition. Edition number will remain same for a re-issue.

5.3 Update Number - The new ENC data set must be assigned update number 0. The first update cell associated with this new data set must have update number 1. The update number must increase by 1 for each consecutive update, until a new edition is released. The new edition will again have update number 0. A re-issue of a data set will have the update number of the last update applied to the data set. In update cell file, the file extension will be same as the update number.

6. Electronic Chart Display and Information System (ECDIS)

ECDIS is an intelligent dynamic navigational system designed to improve the safety and efficiency of navigation. ECDIS integrates various navigational information including the chart information, positional information, derived through the sensors and equipments onboard, to provide display of various navigational details, comprising dynamic display of the vessel. The system also provides audio-visual alarms while approaching danger or malfunctioning of equipments.

The various information provided by the system are made available to the users through the displays; there are three categories of displays available on the display of an ECDIS:

Display base: The display base is always available on navigator's display which can not be removed. It contains coast line, contours, safety contours, isolated shoals, beacons, buoys, land area etc.; which are all required for route monitoring.

Standard display: Standard display does not contain enough details for safe navigation. It contains land area, safety contour, buoys, lights, coast line and built up area etc.; which details are required for route planning.

Display on request: Display on request provides various

detailed navigational information available in the SENC on query.

7. World Wide ENC database & Regional ENC Coordinating Centres

To facilitate the dissemination of ENC and their updates to mariners through out the world, one committee of IHO working group on the World Wide ENC data base (WEND) has produced a model for a distribution network. It proposes a number of Regional ENC Coordinating Centres (RENC) which will establish a cordial working relation with various hydrographic office's of the region and collect the digital data and their updates. RENC will then be responsible for storing and distribution of ENC data and their updates to the end users. RENCs should have the infrastructure to produce new ENC, validate using IHO approved software to manage complete data sets and distribute ENCs and their updates to mariners.

Norwegian Hydrographic Service (NHS) and United Kingdom Hydrographic Office (UKHO) have established two regional ENC Coordinating Centres (RENC) to meet the future requirements of all Cooperating Hydrographic Offices (CHO's); both the organisations are non profit making, operate on well established and proven technological infrastructure already used by PRIMAR. The main aim of these RENCs are to give member nations more control on their ENCs by focussing on flexible validation services and release updated data set to the end user through value added re-sellers.

8. Data Management

NHO is considering all aspects of future requirements of data management starting from collection of data, authentication of sources, production of ENCs as per IHO specification S-57 Edn. 3.1 and adhering to the product specification, management of data, release of ENC updates, re-issue of new editions; verification of data with regard to the correctness and accuracy, validation of ENC data sets, and finally ensuring a one-to-one correspondence between the paper chart and ENC data set.

9. Security of ENC data

The requirement of good and robust security system to ensure that the data delivered is not inadvertently tampered or maliciously changed. Such an occurrence would not only pose threat to safety of life at sea, but would undermine the official nature of the data. Any good security system should be based on international standard which will support the following issues to meet the H.O's requirements :-

1) Authentication – Digital signature
2) Selective Access – Key management
3) Piracy Protection – Compression & Encryption

The above security system should ensure that the delivered ENC data is official. The digital certificate consisting of a unique identification of H.O. based on public key. It contains the public key of the HO. The digital certificate is always included with all ENC data provided by the HO for both CD and online services. This digital certificate is used by ECDIS systems to obtain and verify HO public key. The use of the digital signature will allow the ECDIS to confirm that the data being loaded did originate from its stated source and has not been tampered with during transit. If the security modules in the ECDIS system detects that the data has been altered (i.e. the digital signature check fails), it will not decrypt the data and data could not be loaded.

Each ENC is encrypted using a cell key which is unique to itself. The cell key is supplied to the user in an encrypted form and serves as a cell remote or license for a period of one year. During this period the updates and new editions if any would be available free. After expiry of the above period user is required to renew the license for obtaining updates and new editions. On expiry of the license, the mariners will be granted a grace period after which mariners may not be able to get the updates. However, in view of the safety of the vessel, access to the ENC held will be available. The ECDIS must have this cell permit to decrypt the cell.

10. Marketing and Distribution

The complicated but important aspect of ENC is marketing and distribution of ENC data set to end user. To ensure an effective service, the distributor needs to advertise the ENC service in various journals and magazines. The service needs to make the ENCs widely available to the users. This may require local/ regional sales offices. Another method is through the use of distributors and agents. These distributors and agents need to be authorized and trained in the use of ENC service to ensure consistency of service through out the world. All the ENC cells of same navigational purpose should be produced on a single CD-ROM for easy distribution and access.

11. Conclusion

To meet the national and international obligation to produce ENCs of our area of responsibility, NHO being the leading hydrographic nation in the region, took this task of digitization and production of ENCs on priority and has produced 262 ENCs on different scales and for different purposes as per IHO specification S-57 Edn. 3.1, which is a valid input for ECDIS.

The ECDIS is the latest innovation which caters for increased safety and efficiency of navigation, in the interest of the country's development and for the benefit of marine community. NHO has provided complete ENC coverage for our waters. It is high time for the mariners to introduce ECDIS and exploit it effectively and efficiently. It should be the endeavor of the marine community to use reliable updated and authentic data provided by the national hydrographic offices and discourage use of pirated or inaccurate data.