GIS IN MARINE ENVRONMENT

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Abstract

We are all familiar with land-based maps and its application in GIS environment supported by Aerial photography and Satellite images. How GIS tools are used in Marine environment? As in the land based GIS application, Marine GIS application requires input in the form of a map of the water area. This sea map is more popularly known as Nautical Chart or Navigation Chart. On land we can move around the places without aid of map, but in the sea you cannot go from a place to another with out this navigational chart. In marine environment navigation chart is an instrument of navigation and a typical example of GIS application.

The navigation chart is compiled from field (Hydrographic) surveys conducted to measure depth of the water, and delineate various subsurface hazards for navigation. All coastal states have Hydrographic offices to acquire hydrographic data from regular surveys using specially designed ships for the conduct of surveys for publishing navigational charts and other publications.

The paper presents an overview of the current developments in marine GIS database creation with new technologies in vogue for data acquisition, position fixing and processing the data for production of Electronic navigation Chart (ENC) in International Hydrographic Organisation (IHO) standard for ENC database. ENC database is used in shipboard Electronic Chart Display and Information System (ECDIS), a real time GIS application in marine environment.

The primary objective of ENC and ECDIS is safe navigation. Other applications may be related to Naval operations or scientific research in ocean environment. In addition, the ports and harbours where the traffic is heavy, this facilitates vessel traffic management. In addition, coastal zone management, Recreational activities and development of ports are few of potential applications of ENC data.

Introduction

Since time immemorial, man's quest for exploring the new frontiers is in vogue. 78% of the planet Earth is covered by water and the secrets in the unknown depths of these waters has been constantly explored by the man to conquer new frontiers and also for economic benefit. In addition, the quest for controlling more areas on the planet earth by mighty nations is order of the day from old times. Sea routes from ages used to carry out the most significant exploration of new frontiers. Navigation is an integral part of this exploration as these sea explorers devised several ways of locating the new routes and mapped them for their safe return to their homeports. In the modern times the navigation chart presentation has evolved over a number of years with changing trends in the technology development in terms of symbology, textual features and printing. The data acquisition methods also took a leap with modern techniques for acquiring data more accurately from the field and this resulted in accumulation of voluminous data. Handling of this voluminous field data necessitated the use of computers. Consequent to the induction of digital techniques in various disciplines, nautical chart has also changed its face and turned to digital form.

Data Acquisition

In the conventional method of navigation at sea in earlier days was carried out using the known position of celestial objects and position of the Sun on the horizon. Long ropes measured depths in the sea with markers in ancient times. Later lead line replaced to gauge the depth. Over a period of time this has changed with advent of Echo sounder for measuring the depths of the water and sextant for measuring the angles of celestial objects. Latitude was determined using the reference of celestial objects at any point on the surface of the earth and longitude was determined using the time difference from the homeport. The invention of chronometer and subsequently introduction of electromagnetic methods for position fixing methods have

improved the positional accuracy at sea. However these methods have relatively accurate during the vessels are in the proximity of the coastal region.

The induction of Global Position System (GPS) has radically changed the geographical position determination over the last one and half decades. Most of the seas going vessels are now fitted with GPS receivers for position determination at sea. For more accurate position for surveying Differential GPS is used. In addition the depth measuring techniques also have rapidly changed with induction of precision depth recorder and multi beam echo sounders to map sea bottom surface more precisely and accurately.

In the present context of data acquisition, Automatic Data Logging Systems (ADLS) are in vogue, which has the ability to process voluminous field data in real or near real time for obtaining accurate field data.

Navigational Chart

A navigation chart is a map showing the depths of water, navigational aids, and hazards to navigation. In addition the chart contains administrative and regulatory information covering a port or approaches to a port or general navigation details for coastal navigation or oceanic areas. The charts are prepared on different scales for different purposes of navigation. The scales used in preparation of these navigational charts range from a very small scale of 1 to 10 Million, larger scales ranging from 500,000 to 10,000 or larger depending upon the area to be covered and their usage.

The data acquisition and chart production are governed by standards laid down by IHO and each producing agency has to comply with these specifications for a uniform international standard for presentation of details for safe navigation at sea. Navigational Chart is an instrument of navigation at sea and is mandatory to carry these charts by all sea going vessels. Carriage requirement of sea going vessels are stipulated by IMO for safe guarding the men and material at sea.

Hydrographic Offices compile the charts using hydrographic survey data, topographical data from land mapping agencies for the coastal land areas and navigational aids data such as light houses, beacons, landmarks and floating aids known as buoys. The hydrographic survey data contains mainly the information on depth of the water, submerged dangers such as rocks, wrecks (submerged and visible) and obstructions, which are not visible on the surface of the water.

The art of chart compilation largely depends upon the skills of the cartographer to present most important features for safe navigation and present them aesthetically without clustering the chart presentation. The navigator places implicit faith on the content of the chart for safe navigation. In addition to the hydrographic, topographic and navigational information on the chart, additional details for determining the orientation by presenting a compass rose; for calculating positions of places and distance between points a typical navigational chart border is shown for the specific scale of the chart are also shown on the chart. The navigator uses the chart for marking his course and constantly monitors the ship's voyage from a place to another place at sea.

Technology

The technological advances in the field of electronics, computers, communications and information technology in the past one and half decades paved the way for better navigation at sea providing safety to the men and material. World Trade is largely dependent on sea routes for moving the cargo from one place to another place. Ships of large size to carry bulk cargo/oil/chemicals are built. These very large vessels need safe passage while moving across the oceans and various sea routes.

Prior to introduction of electronic equipment and computers on board ship, the navigator on the bridge of the ship used conventional methods for navigation at sea as explained earlier. The induction of electro magnetic devices for position fixing, Echo sounders for depth measurements and other sophisticated devices such as gyro, radar and communication systems, improved the navigation at sea. The concept of Electronic Navigation Chart (ENC) was conceived few decades back but could not be brought to reality due to hardware limitations at that time. A whole new intelligent shipboard electronic navigation system was introduced with

the availability of Global Positioning System (GPS), supported by other radar navigation techniques, computer technology and digital chart.

Electronic Chart Display and Information System (ECDIS)

In the modern world the technological innovations have given boost to improve navigation method at sea. The display techniques and integration of various senor outputs paved the way for implementing digital techniques in the field of navigation at sea. This resulted in the concept of ECDIS use on shipboard computers and displays. ECDIS is a real time GIS application in marine environment for navigation. Electronic Navigation Chart **(**ENC) is database used in conjunction with other sensors used for navigation in ECDIS system.

ECDIS system concept gained popularity and several developed countries in close collaboration with the industry tested the efficacy of such system. North Sea Hydrographic Commission, Canadian Hydrographic Service, US Government Agencies in collaboration with Equipment Manufacturers and Shipping giants have conducted independently tests for the system in Europe, Canada and USA respectively. The outcome of such test bed was well documented revealing the need for standardization of various aspects of such system for induction in to the normal use.

ECDIS is a real time Geographic Information System (GIS) in marine environment that is capable of integrating different navigational positioning systems and ship sensors with the ENC. ECDIS provides more information, faster and more accurately than navigational methods used earlier. It displays ENC, which is legal equivalent of paper chart issued by hydrographic offices of the world and is likely to replace paper charts on all Safety Of Life At Sea (SOLAS) class vessels. Its automatic position tracking, safety features like various alarms, ability to set a safety contour and updating capability, relieve the navigator of many time consuming duties and allow him concentrate on the navigational and ship management decisions. The greatest advantage of ECDIS against the conventional paper chart is the dynamic display of temporally variable information essential for navigation, which is frequently not sourced, or controlled by the hydrographic offices.

Figure 1, shows various components of an ECDIS on board ship. The ECDIS consists of a colour display (with options for additional display units), ENC, SENC, Updates of ENC, inputs from Navigational sensors, Gyro, Compass, Echo Sounder, RADAR/ARPA and any other navigational data.

You may observe there is an ENC and SENC, the difference between these are as follows:

ENC is the data base produced by the official government agency and is validated and updated by the hydrographic offices.

SENC is the System Electronic Navigation Chart. It is the database resulting from the transformation of the ENC by the ECDIS for appropriate use, updates to the ENC by appropriate means and other data added by the mariner. It is the database actually accessed by ECDIS; and is equivalent to an up-to-date paper chart. The SENC may contain information from other source.

Even though an ECDIS cannot be considered as an Electronic Navigation System without ENC, it is the SENC that is derived from ENC, which is displayed.

IMO and IHO realized the importance of such system and set up committees to define the specifications and standards for such system and the data. The details of such standards and current status of ECDIS and ENC are discussed in the paper later.

ELECTRONIC NAVIGATION CHART (ENC)

ECDIS has emerged as a new navigation tool that can provide significant benefits to the navigation on the bridge in terms of safety and more precise navigation at sea. ENC database in ECDIS is not only a display of paper chart, but combines both spatial (geographic) and external information in to a readily useful operational tool. ECDIS is an automated decision aid capable of continuously determining the ship's position in relation to charted objects, aids to navigation and subsurface hazards. The most advanced form of electronic chart is the ECDIS. All other types of electronic charts can be considered as Electronic Chart Systems (ECS).

As per IHO definition of ENC, " Electronic Navigational Chart (ENC) means the database, standardized as to content, structure and format, issued for use with ECDIS on the authority of the Government authorized hydrographic offices. The ENC contains all the chart information necessary for safe navigation and may contain supplementary information in addition to that contained in the paper chart which may be considered necessary for safe navigation".

In addition, IMO Performance standards for ECDIS stipulate, " The chart information to be used in ECDIS should be latest edition of that originated by a government authorised hydrographic office" and conform to the IHO standard. The production flow of ENC in Hydrographic office is illustrated in figure 2.

STANDARDS

International Organisations such as International Maritime Organisation (IMO) and International Hydrographic Organisation (IHO), regulate, coordinate and oversee the standardization of equipment, personnel and data required for maritime community. These are essential to safe guard the interests of the maritime operations and protecting the marine environment from disasters at sea due to collision and accidents to the ships.

IHO STANDARD FOR ENC

IHO is an international body, which oversees the standards in hydrographic data acquisition, competency of the surveyors who collect the data, compilation of nautical chart and digital chart. IHO is a body comprising of all Hydrographic offices of coastal states. IHO constituted Committee On Electronic Chart (COE) to define the specifications for the content of ENC and what ECDIS should display. The sub committees of COE in consultation with several experts conducted several meetings. After these meetings and deliberations, the COE has prepared the following documents:

a) Transfer Standard for Digital Hydrographic Data (IHO S57)
b) Specifications for Chart Content and Display Aspects (IHO S52)

All the government agencies who are producing paper charts are to produce the digital data for use in ECDIS to conform to the IHO S –57 standard. All the manufacturers are to comply with the IHO S 52 Specifications for chart content and display aspects.

Several commercial agencies producing digital charts were not following any specific standard format while designing the ECDIS system. This naturally leads to inhibit inter platform transfer of the data. To overcome this problem, IHO stipulated the above standards for uniform data structure across the platforms. The format is independent of software and hardware used in creation of database.

IMO PERFORMANCE STANDARDS FOR ECDIS

IMO is an international body constituted by all coastal states to oversee the safety of life at sea and protect marine environment from pollution and prevention of oil spillage from oil tankers plying high seas. IMO has developed and adopted carriage requirements for certain ship borne navigational equipment and also performance standards for such equipment. Performance standards have also been developed for electronic navigational equipment for which there is at present no carriage requirements. IMO work on electronic charts

has resulted in resolution A.817 (19) on Performance Standards for ECDIS. For an electronic chart to be considered as an ECDIS, it must comply with the performance standards which specify the components, features and functions of a system, the primary purpose of which is to contribute to safe navigation, including functional requirements for back-up arrangements for ECDIS.

These performance Standards permit National Maritime Safety Administrations to consider ECDIS as the functional equivalent to the charts required by regulation V/20 of the 1974 SOLAS convention. IMO has specifically requested that the member governments have their National Hydrographic Offices produce ENCs and the associated updating service as soon as possible, and to ensure that the manufacturers conform to the performance standards when designing and producing ECDIS.

To comply with the IMO Performance Standards, ECDIS should have the following conditions adhered to in respect of SENC:

a) ECDIS should provide a means of ensuring that ENC and all updates to it have been correctly loaded in to SENC.
b) The chart information to be used in ECDIS should be the latest edition of information originated by Government authorised Hydrographic Office, and conform to IHO S57 standard.
c) The contents of the SENC should be adequate and up-to-date for the intended voyage, as required by regulation V/20 of the 1974 SOLAS Convention.
d) It should not be possible to alter the contents of the ENC.
e) Updates should be stored separately from ENC.

This means SENC is the component in ECDIS, which achieves SOLAS V/20 compliance in respect of nautical chart equivalence. It is also necessary that regular official updates are available to the mariner from the authorised Government agencies producing ENC.

In regard to ENC database, IMO Performance standards for ECDIS stipulate, " The chart information to be used in ECDIS should be latest edition of that originated by a government authorised hydrographic office" and conform to the IHO standard.

FUTURE

The ENC is likely to replace the paper chart in the current century, but initially in SOLAS class vessels and later in all ships over 300 Gross Tonnage. ECDIS, which can display the ENC, is a reality now. It has been accepted for navigational merits and also for ship management capability. It has the ability to show dynamically the time variable Marine Information Objects (MIO). Some of the ECDIS manufacturers have already providing tidal overlays for ECDIS. Other thematic overlays will also be provided to ECDIS to make it a multi dimensional, dynamic display of the real world and thus enhance the safety of navigation. Marine community has recognised the advantages of ECDIS and most of the modern ships have started using the system along with other sophisticated shipboard electronic systems. There are many types of navigational data available and all of which cannot be shown on a paper chart due to scale limitations and clutter of the details. The user can selectively overlay required information in ECDIS unlike a paper chart there by reducing cluttering of the display. The greatest advantage of ECDIS is its ability to provide the navigator is the safe navigation at sea in all weather conditions.

In addition to navigational use is the advantage of ECDIS, is its ability to be used as a Marine Geographic Information System (GIS) for non-navigational applications. Similarly, for military applications, the information can be overlaid for specific requirement. ECIDS and ENC database can be used for Vessel Traffic Management System (VTMS), Automatic Identification System (AIS) and in Oceanographic research applications as base database of the ocean environment by selective display of required layered information.

CONCLUSION

The thought provoking keynote address to the workshop on Electronic Chart in 1983 by Mr. Eaton has become reality at the end of this century after 16 years. The International agencies dealing with maritime operations have set the standards for the DATABASE and equipment to be used for safety of navigation.

All the organizations concerned with the maritime operations realized the importance of this new technology in providing safety of navigation at sea. The technological developments in the new millennium will pave the way for cost effective solutions in making this tool a common factor on the bridge of system. At present updating the ENC database on board ECDIS is still in formative stage. The induction of communication satellites to cater the needs of offshore vessels should provide cost effective solutions in updating the ENC database on board vessels in the near future. The E- Commerce concept prevailing in other areas will play significant role in marketing the ENC data to the users at sea and on shore. The Regional ENC (RENC) centers will be taking care of providing the facilities for updating and distributing ENC data sets produced by Hydrographic offices in the Region. The methodology for coordinating such activities is being worked out in close cooperation of the member Hydrographic offices and IHO.

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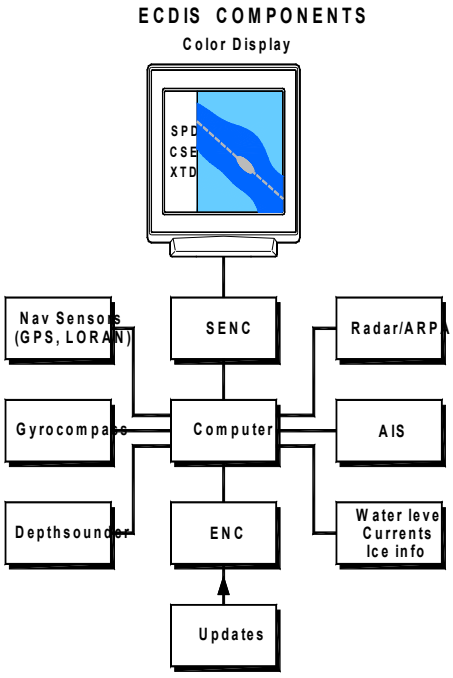

Figure 1: Components of ECDIS

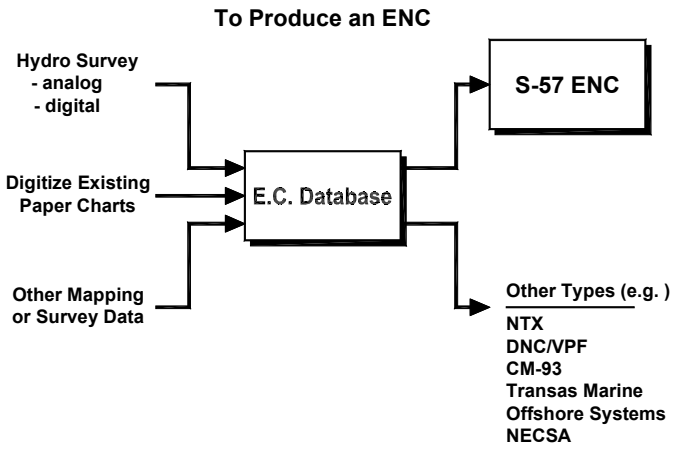

Figure 2: ENC Production Flow