

Coastal Mapping and Marine Charts

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Overview

1. Introduction
2. The Roles and Objective of Hydrographic Service
3. Role of Indian Hydrographic Office
 - 3.1 Customer aspirations and needs
 - 3.2 Commitments
 - 3.3 Provision of Charts
4. The Hydrographic Data Base System at NHO
 - 4.1 Analogue Chart Data Base System
 - 4.2 Digital Chart Data Base System
5. Coastal mapping
 - 5.1 Coastal Charts Database
 - 5.2 Integration of Coastal Database with GIS
6. Conclusions

1. Introduction

The necessity to access the quantity of marine and coastal data to support a broad range of activities has been increasing in the hydrographic offices of the world. The digital data collected in multidisciplinary fields should have some commonality in a GIS based system and hence there is an ever increasing demand to integrate digital data collected in different domains. The improvements in geospatial technology demand now initiatives to link hydrographic, oceanographic and coastal databases to evolve and get linked with national spatial databases. The National Hydrographic Office (NHO), is all set to meet this digital technology revolution for combining a wide range of four dimensional oceanology and coastal data to create an environmental scenario adaptable to a wide range of uses based on Electronic Navigational Charts (ENC), which are part of the proven Electronic Chart Display and Information System (ECDIS), or marine GIS. NHO continues with its mission to make substantial contributions to national development and navigational safety under IHO/ IMO regulations. NHO interacts with various agencies at national/ international levels in all related fields of hydrography including *coastal zone management*, *environmental protection* and scientific quest at sea. India, as a leading maritime nation in the world, is constantly geared to meet the challenges of the future by expanding all facets of hydrography.

2. The Roles and Objective of Hydrographic Service

Hydrographic applications in marine coastal development and environmental preservation, is a growth area, the world over. According to an UN study, approximately 50% of the coastal states have no hydrographic capabilities. Another 25% have only limited capabilities. Only the

remaining 25%, including India, have adequate hydrographic capabilities. Therefore there is an immense scope among the hydrographic offices to conserve/ protect our coastal regions and develop and evolve spatial technologies for the less developed nations. The hydrographic offices of the world have the responsibility towards their maritime states to provide an essential service within the national transport infrastructure. Hydrographic services support safe and efficient navigation, foster national maritime development, help to safeguard life and property at sea, facilitate the protection of the marine environment and support the administration and sustainable development of the national maritime zones. A hydrographic office plays this multidisciplinary role. These important roles can be listed as follows:

- i) To collect, with systematic surveys at sea and along the coast, georeferenced data related to:
 - a) Coastal configuration, including man made infrastructure for maritime navigation (Aids to navigation and port configuration)
 - b) Depths of the seas in areas of national interest (including all potential hazards to navigation and other marine activities.
 - c) Sea bottom composition
 - d) Tides, currents
 - e) Physical properties of the water column
 - f) Gravity and magnetic observations at sea
- ii) To process the information collected in order to create organized databases capable of feeding the production of thematic maps, nautical charts and other types of documentation for the following most common uses:
 - a) Maritime navigation (and traffic control);
 - b) Naval operations;
 - c) Coastal management and defense;
 - d) Marine environment preservation;
 - e) Exploitation of marine resources and laying of submarine cables/ pipelines
 - f) Maritime boundaries definition (Law of the Sea implementation);
 - g) Scientific studies connected to the sea and near-shore zone.
- iii) To update the databases through re-survey when and where needed, gathering supplementary information from other maritime authorities.
- iv) To ensure the production, distribution and updating of charts and ENCs
- v) To ensure the timely dissemination of maritime safety information.

3. Role of Indian Hydrographic Office

Hydrographic services are controlled from Dehradun. The services include: -

- Planning of operations
- Issue of field directives to ships
- Examination, review and chart production (paper charts and ENC's)
- Printing navigational warning
- Archival of data
- Sale of products & services
- Custody of historical data

The Office maintains 350 charts and 15 publications covering the Indian waters and adjoining seas. Mariners are fully supported by round the year navigational warning services for NAVAREA VIII. The department is oriented to paper/ digital products & services and constantly strives to meet the present and future chart specifications for varied users.

Our corporate objective is to ensure total satisfaction of the customer needs for precise and accurate hydrographic and oceanographic products and services to the international & national agencies, duly updated by a reliable mechanism.

3.1 Customer aspirations and needs:

- Precise, accurate & detailed surveys for safety at sea, for offshore development work (ports and harbours), maritime routes, fishing, offshore exploration, coastal recreation.
- Updating service round the year.
- Availability of charts & publications in paper & digital formats(ENC)
- Technological updating.
- Affordable cost of the products and services.
- Assistance to R&D agencies for marine related projects.

3.2 Commitments: The naval hydrographic department (NHD) is committed to respond to national and international regulations/ conventions relating to the safety at sea and offshore development work by furnishing accurate and reliable hydrographic products and services. The Department can undertake surveys in the coastal/ inland waters and in the deep seas for the following purposes :-

- Navigational safety
- Oceanographic/ environmental parameters.
- Pipeline and cable route
- Geophysical and geotechnical
- EEZ/ continental shelf/ maritime boundary delineation with baselines.
- Pre and post dredging.

In addition, NHD offers its well-developed management

expertise in the form of contract surveys, establishment of hydrographic offices and training facilities for other agencies.

3.3 Provision of Charts: Ideally, every maritime state should be responsible for charting its maritime areas as well as for the distribution of the relevant nautical information. In fact, many states do not yet have the appropriate structures and organization required to handle this task. For historical reasons, some countries (notably: France, Portugal, Spain, UK and USA) have continued to play this role on behalf of the international community for territories, which are now independent. This means that they continue to maintain a portfolio of nautical documents, which are often the only reference available.

The main service provided by a hydrographic department is the national chart series. The department should therefore have access to a production facility. A production facility has a number of key features. These include facilities for:

- o compilation of new charts, including cartographers and computing equipment.
- o maintenance and updating of these charts on a fortnightly basis.
- o publication of charts in digital and analog form.
- o compiling and publishing supporting texts such as sailing directions, tide tables, etc.
- o distribution of information and products to users around the world

The National Chart Series of India is published by Indian hydrographic department which is divided into 3 groups:.

a) **Small Scale** charts are provided for passage planning and for navigation in out of sight of land. These charts are typically of a scale between 1:10 million and 1: 1 million.

b) **Medium Scale** charts are provided for making landfall and for passage along the coast. These charts are typically at a scale of 1:300,000 or 1:150,000.

c) **Large Scale** charts are provided for port approaches, ports, and other areas where navigation is constrained by land formations, navigational hazards, traffic density etc.

The number of charts in the national chart series will depend upon the length of the national coastline and the extent of the national EEZ. Often the national chart scheme will be linked to the international chart scheme of the region, compiled by member states within the International Hydrographic Organization. The purpose of the international chart scheme is to ensure that the needs of international shipping are met in an economical and efficient way by co-ordination of the chart schemes of neighboring regional nations.

4. The Hydrographic Data Base System at NHO

The hydrographic data in Indian waters has been

collected for centuries, which is contained in the analog database at NHO. NHO presently holds two types of databases :

4.1 Analogue Chart Data Base System:

- Results of local surveys from port trusts & other ports
- Oceanic soundings (GEBCO)
- Indian nautical charts and publications
- Foreign nautical charts and publications
- Survey of India topographical maps
Air-photographs & satellite imageries
- Geodetic control data
- Tidal stream & currents data (ocean dynamics)
- Publications such as sailing directions, light lists, list of radio signals, list of wrecks and shoals, etc.
- Reports from maritime agencies, port trusts etc.

4.2 Digital Chart Data Base System: The development of digital chart database System at NHO started with the installation of the Computer Plotting System at NHO in 1995. Initially a five year plan was proposed for the following:

- To create a digital chart database by digitization of paper charts/ compilations and production of vector files for paper chart generation
- Digital hydrographic database creation and further creation of ENCDB for ENC in DX 90 (IHO S-57) format for use in ECDIS.
- Customization of software package for symbology , line style and various limits, and attachment of feature tables for various object classes.

4.2.1 Development of Digital Chart Database: On successful completion of this five year plan and as the result of digitization NHO has created digital databases for the following:

- (i) Paper chart database (PCDB)
- (ii) Electronic Navigational Chart Database (ENCDB)
- (iii) Geographic Information System (GIS) as available on related sub-themes
- (iv) Digital sailing directions are planned to be linked with ENCDB as text file and picture file as per S.57 specifications.
- (v) WGS-84 positional digital database which is being created at NHO based on DGPS observations for giving information on Everest/ WGS 84 differences both in paper charts and ENC's.
- (vi) Digital database for base lines and other UNCLOS aspects is being created at NHO which is the certifying agency for bathymetric and seismic data and which is responsible for preparation of documentation for submitting India's claim to CLCS.

4.2.2 Futuristic Plans for Digital Chart Databases: At present, the important challenge for NHO in this post economic liberalization policy of the government of India is the spurt in offshore activities especially along the coastal belt. This trend is a welcome phenomenon in view of the importance of commerce and energy requirement of our country through oceans and the NHD is ever committed to provide navigational safety at sea. NHD is constantly being modernized to keep pace with the revised IMO/IHO procedures, standards and technology to make high content charts, including Electronic Navigational Charts and Integrating GIS technologies.

NHD during the next five years, plans to lay emphasis on the following:

- a) Updating and maintenance of digital database (PCDB & ENCDB)
- b) Digital reprinting (already commenced)
- c) Creation of digital database for general bathymetric charts of the oceans under IHO Data Center for digital bathymetry and GEBCO Digital Atlas (GDA) project of IHO.
- d) NHO being one of the 13 Data Centers under National Ocean Information system (NOIS) will collect bathymetric data under National Marine Data Center (NMDC)
- e) To work for real time tidal information database, which will play a key role in ENCDB
- f) Coastal zone management (CZM) digital database will be created at NHO as national agency for validation of HTL/ LTL for use in coastal zone regulation (CZR) plans of MOEF.
- g) Digital compilations
- h) Increase in human resource development
- i) Use state of the art equipments such as laser bathymetric system (LBS), multi beam echo sounders, mobile caravan etc.
- j) Integration of under-water systems (IUWS).
- k) Explore uses of digital photogrammetry and remote sensing for updating nautical charts.
- l) Integration of GIS technology for navigational charts
- m) Prepare and submit claim under UNCLOS on extended continental shelf of India.
- n) Print on demand

5. Coastal Mapping

The coast is a distinct, and extremely important, feature of the earth's surface. It marks the three-way boundary between the main environmental domains of our planet: land, sea and air. Carter (1988) defines the coast as '*that space in which terrestrial environments influence marine (or lacustrine) environments and vice versa*'. Although in

popular terminology, the term coastline is frequently used, in practice the coast has width and depth as well as length, so the term coastal zone is to be preferred.

The coastal zone also provides access to physical and other resources. For many countries of the world the oceans, and especially the continental margins, provide an important primary source of protein. Minerals and vital hydrocarbons also come from many of our coastal waters while we also use the off-shore zone as a convenient disposal ground for sewage and for domestic and industrial wastes, including toxic and/or radioactive materials. As well as attracting industry, the coastal fringes of our landmasses are also becoming increasingly sought after for leisure and tourism developments, both organized and informal. All of these activities may contribute significantly to regional, national and international economic performance (Bartlett, 1993).

A coastal state must declare and publish a catalogue of its coastal charts as it is the prime requisite of the maritime state for managing its marine coastal resources. The technological developments in the field of sub-sea explorations to gradually explore and utilize submarine resources have increased tremendously in the recent times. It is nothing new that new technologies enable new applications, which, in turn, open markets for new technologies. This has happened with hydrography as well. Satellite positioning, sophisticated high power computer technology and electronic communications have made hydrographic surveying and oceanographic data observations more efficient and hence there is a need to combine all these technologies and data into a seamless database for the purpose of extracting spatial and attribute information for efficient use in coastal zone management and finally into electronic charts.

The NHO of India has this national responsibility for mapping/ charting its coastal areas for the purpose of production of navigational charts. It is the only charting organization in India which is well equipped in coastal mapping techniques. The NHO, situated at Dehradun has a fleet of eight modern survey ships to carry out hydrographic surveys for coastal waters of India. Each survey ship collects bathymetric data using state-of-the-art equipments to collect this data for preparing the end products i.e. nautical chart. So far, only analog charts are available, but in view of international commitments by the Indian Hydrographic Office and being a signatory of International Hydrographic Office (IHO), which is fulfilling IMO/IHO/UNEP conventions of navigational safety services at sea it is obligatory to provide all the coastal charts in a digital format called ENC i.e. electronic navigational chart. The production of ENCs has started three years back and now it has reached to an advanced stage. So far 262 ENCs have been completed and the ENCDB is also nearing completion. Presently, only issues pertaining to encryption and marketing needs are to be resolved.

5.1 Coastal Charts Database: The acquisition of

hydrographic data for coastal mapping and creation of hydrographic databases are the primary requirements to provide safety in navigation. The hydrographic data for coasts is not only required for preparation of navigational chart and publications but it is also used by a variety of other specialist users. It is worth mentioning that in the past 20 years, most of the ports, harbours and their coastal approaches of India, have been re-surveyed to high standards using modern surveying equipments. The era of automation and digital cartography initially started since 1981 with acquisition of new ships, modern automated equipments, automated data logging & plotting system, automated cartographic & printing systems.

The NHO has always adopted the changing technology and India will soon be one of the first few hydrographic offices in the world to enter in the field of digital cartography with confidence at the start of 2003. In order to adapt to the wind of change, dynamics of technology and to meet expectations of new offshore marine ventures, developments of private ports, commercial imperatives, changing international scenario of hydrography and nautical cartography, the NHO is in the process of moving way ahead in field of creating digital database.

5.2 Integration of Coastal Database with GIS: NHO being a leading hydrographic service provider for the nation feels the need to evolve information technologies in the coastal mapping in a GIS system (COMGIS) by combining a wide variety of four-dimensional oceanographic and coastal data to create an environmental scenario adaptable to wide range of uses. The digital databases created at NHO are quite extensive and varied in nature. The need is to examine and analyze this temporal and spatial relationship within these GIS systems. Coastal area being a place of constant dynamics therefore requires special attention. NHO presently has a rich database of ENC's, but before we must develop a basic understanding of "What is an ENC?" Unfortunately, it is not necessarily based on what is defined in Section 2.2 of the IMO performance standards for ECDIS:

ENC means the database, standardized as to content; structure and format, issued for use with ECDIS on the authority of 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 (e.g., sailing directions) which may be considered necessary for safe navigation.

ENC Database uses S-57 as the International Hydrographic Organization Transfer Standard for digital hydrographic data. It consists of a feature dictionary, a data model, and an exchange format called DX-90. S-57 is an object-based data structure; its feature dictionary describes the geometry and attributes of all features that may appear on an electronic navigation chart (ENC).

In defining what is an ECDIS, Section 2.1 of the IMO performance standards states: electronic chart display and information system (ECDIS) means a navigation information system which, with adequate back-up arrangements, can be accepted as complying with the up-to-date chart requirement by regulation V/20 of the 1974 SOLAS convention, by displaying selected information from a system electronic navigational chart (SENC) with positional information from navigation sensors to assist the mariner in route planning and route monitoring, and by displaying additional navigation-related information if required.

ECDIS supports most of the GIS requirements including an ability to accept additional objects necessary for new objects, and handling of the temporal variability of the dynamic objects.

ECDIS, helps navigate the ship safely in all weather conditions .ENC is a replacement of conventional paper chart, which is used as a tool for navigation, which provides detailed input on depth, hazards and navigational aids within the area. This supported by visual and audio alarms of ECDIS provide the navigator on bridge sufficient means to navigate the vessel safely. The display is used to provide selective information either spatial or textual information to the navigator for safe passage. ENC is the database for GIS operations and ECDIS is the real time GIS application in marine environment.

Many marine GIS companies are developing intuitive and easy to use client interface, customizing solution for integrating GIS datasets using client wizards, template and code examples combining speed with flexibility. They are developments into spatial fusion mapping engine

which supports a variety of industry standard spatial data formats such as CARIS, Shapefiles, Oracle8i, MapInfo, S-57, and many more.

Spatial fusion engines provide the ability to integrate multiple sources of data into one seamless map view without the need for conversion. Powerful GIS functionality will be available to all users without the need for additional infrastructure. Furthermore these applications' scale-friendly pricing model allow one to grow without the need for a costly upgrade, allowing to easily add mapping to their web site.

6. Conclusion

New developments in ECDIS promise a quick progress of integration of various datasets. Integration of some oceanographic variables, like tides and currents is already possible in ECDIS and hence objects and attributes for meteorological and various oceanographic data are also possible to be merged.

As the hydrographic community all over the world generates multi-dimensional environmental data within a coastal and/or oceanic area there is significant requirement of developing a GIS based spatial and dynamic data system for resources planning and decision making for use in coastal zones and oceanographic applications. There has to be some actions influenced by present priorities and opportunities. Integration of these databases will provide the necessary flexibility to adapt to these future needs of coastal zone and oceanographic applications. This will provide scientists a new tool to advance and understand interaction of many temporally varying parameters within the oceans, in the coastal zone and on dry land.