

# Convergence of Hydrographic Information in Nautical Charts

G. S. Vatsa, U. K. Singh, C. M. Doss and M. P. Gupta

National Hydrographic Office, Post Box-75, Dehra Dun

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## Abstract

Nautical chart provides the safe route to ships in seawater. The chart represents the bathymetric topography and facilitates with other navigational aids. So, role of nautical chart for navigation is like a torch at night. It has, therefore, become mandatory for producing authority to be precise and accurate about all information incorporated during the preparation of the nautical chart. The types of information included are results of various local and regional surveys, geodetic information like projection, scale and reference datum, which characterize nautical charts, nature of seabed, and tidal information. Nautical charts also contain navigational aids of visual, audible and radar type. It has shallow water line information like danger zone, inter-tidal region and coastline. Integrating all information in a defined limited space of the chart needs self-descriptive symbols and legend with a high order of accuracy. Information derived time to time from allied publications from various authorities are also used to update the chart.

In this paper, a description of all the data/ textual information from hydrographic data, geographical, topographical and allied sources used during compilation of chart is given. Further, object-wise important elements and processes of topographic and hydrographic details have been shown and finally convergence of these information for preparation of nautical chart is described. At last, the accuracy of these objects has been calculated at the largest scale of nautical charts.

## Overview

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4. Requirements of topographic & hydrographic information
5. Accuracy of nautical objects
6. Results and discussion
7. Conclusions
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## 1. Introduction

Most hydrographic offices have an obligation to provide nautical charts that cover their national waters to such an extent, and on such scale, as to permit safe navigation for all classes of vessels (IHO, 2000). Nautical chart is a legal document which contains the official description for permitted safe routes against hazards, which may be encountered. Thus nautical chart is a navigational tool.

Therefore legality of the chart is very important. It means that the government of a country, which produces the official navigational chart, is responsible for its contents and its up to date maintenance. Nautical cartography is the art and science of charting of the seas which broadly deals with the oceanic parameters relating to navigation in particular, and their spatial distribution and quantification, in general. National Hydrographic Office (NHO), Dehradun, produces nearly 325 nautical charts of national and international categories (Srinivasan, K.R. et al., 2000).

National charts are usually large-scale publications showing the detailed configuration of offshore seabed. In this respect, hydrographic offices have a de facto responsibility for their national waters. Such information about the shape of the seabed is required by a variety of users other than navigators: construction engineers for offshore developments, dredging contractors, oceanographers, coastal zone managers etc. The combined effect of these requirements (navigational & information source) caused India to cover national waters in great details by producing small and large-scale nautical charts. So producing nautical charts involves integration of information in a balanced and harmonious way needs great efforts and experiences.

## 2. Hydrographic information

Hydrographic information used in producing a nautical chart includes all nautical and topographical information that lies within the coastal area. The hydrographic information in Indian water has been collected for centuries contained in analog database and now-a-days in digital database of NHO (Sharma, S.P., 1999). The database used in preparation of charts and its all publications consist principally the following types of source information.

**2.1 Results of Hydrographic Survey:** The essence of hydrographic survey is depth values, coastlines, tidal information and low water line features. This information accompanied with ocean dynamics viz. tides, tidal streams and currents. Information like sailing direction and anchorage area is also derived from hydrographic surveys. So, hydrographic surveys provide all types of information, which promulgated through various publications time to time from NHO and international hydrographic offices.

**2.2 Results of Local Survey:** These results promulgated periodically from port trusts and marine port survey organisations. These contain information of offshore

developments, ocean dynamics and changes in the navigation aids.

**2.3 Oceanic Soundings:** Oceanic sounding of various oceans recorded through out the world on GEBCO sheet. The GEBCO sheet has oceanic data on scale of 1: 1M (at Mid-latitude 30°) on Mercator projection. The sources of data are World's Oceanic Catalogue, passages soundings from ships and Standard Navigational Charts from different hydrographic offices. At present, India is preparing 19 GEBCO sheets (Thomas, M.K., 1998).

**2.4 Nautical Charts/ Publications:** Each edition of nautical charts is maintained in the NHO's repository in order to show the state of the chart before and after publication of a new edition. Nautical charts pertaining to north Indian ocean from S. Africa to Singapore published by a number of countries are also maintained in repository. The allied publications like information regarding notices to mariners, list of lights, radio stations, wrecks & shoal and sailing directions are obtained from Indian and foreign agencies, which are used invariably in preparing pertinent nautical charts of the nation.

**2.5 Coastal Information:** Topographic information of coastal area that lie in a chart are usually taken from large scale Survey of India (SOI) topographic map & grey prints. The up-to-date coastal coverage map on various scales published by SOI is maintained in NHO's repository. Geodetic data contained in G.T. pamphlets are also maintained in repository. For areas where S.O.I. maps are not available, they are taken from foreign maps. Air photographs and satellite imageries are used often where latest information is not available or where area is inaccessible.

**2.6 Tidal Data:** The tidal data is recorded at the time of the survey in surveyed area. It helps in obtaining information about chart datum, mean sea level, and time vs. height graph of tides. This helps in transferring sounding depth from sea level to chart datum. The predicted tide table and tidal information at major ports/ coastal benchmarks are published by SOI.

### 3. Elements of compilation procedure

Preparation of nautical chart on a specified scale involves incorporation of numerous hydrographic as well as topographic information, in a balanced and harmonious composition. A fair drawing of compilation is prepared on mylar sheet indicating all details, which are to be appearing on the finished chart. The major steps involved in the process are;

**3.1 Projection & Graticule:** It forms a rigid framework controlling all the hydrographic and topographic details. It specifies the grid network in reference to the projected area. Transverse Mercator projection is used for charts of scale larger than 1:50,000 and Mercator projection is used for scales smaller than 1:50,000. Meridians and parallels are placed between 10-20 cm apart at equal interval, preferably at integral multiples of interval (IHO,

2000).

**3.2 Scale:** It is the ratio of unit length on map to the unit length on earth. Nautical charts are prepared on different scales to meet the specific requirements of mariners while navigating across ocean/ sea/ channel or while berthing alongside the jetty. Taking into these considerations, nautical charts are classified according to their scale as follows:

Small Scale Charts:

Planning Chart (1: 10 M, INT Chart Series)  
Ocean Chart (1:3.5 M, INT Chart Series)

Medium Scale Chart:

Coast Approach Chart (1:1.5 M)  
Coasting Chart (150,000 & 300,000)

Larger Scale Chart:

Approach Chart (1:37,000-100,000)  
Anchorage Chart (1:25,000-35,000)  
Harbour Chart (1:6,000-20,000)

**3.3 Extraction of Hydrographic Information:** Full depiction of details is naturally the cartographer's aim. But it is impossible because symbolization of all features is partly determined by the scale and partly by the conventions of charting practice. Moreover, requirement of chart users and efficiency of cartographer is also an important aspect. Depiction of details determined by the scale of chart and requirement of the navigator. But aim, in general, is not to omit anything, which are essentials for safe navigation. Hydrographic information include contour lines (0, 2, 5, 10, 20, 30, 50, 100, 200, 500, 1000 m etc.), sounding values at chart datum, low water line features (buoy, beacon, conspicuous and submerged rock, coral reef, breakers) and coast-line features (jetty, beacon, civil facility, signal station, mangrove, river, road etc).

**3.4 Transfer of Hydrographic Information:** The hydrographic and topographic information are transferred from source materials mentioned above. Details of these information are transferred from source materials to the compilation drawing trace either by "squaring-down" or by "photographic" methods. In squaring-down method, transfer of objects from original to compilation is done by drawing smaller sub-squares to achieve the desired precision. Whereas in photographic method, hydrographic and topographic originals are reduced or enlarged as closely as practicable to the compilation scale. Selected details are traced directly from the photocopy from reduced or enlarged film. For major jobs, photography is the most controlled and economical means of reducing/ enlarging details.

**3.5 Limit, Size & Datum:** While considering the limit of a chart, there are following points which should be considered.

- a) Sufficient land area should be included so that conspicuous landmarks and object for fixing the ship's positions are available on the charts.

- b) Sufficient sea room to clear shoal area to ensure safe navigation.
- c) Overlays with adjacent sheets should be so arranged that at least one fixed object like light/ beacon etc. is common in both charts.

The preferred size of neatline of the chart is 98´63 cm, which may be maximum upto 106´65 cm for E-W charts. For N-S charts, the preferred size is 63´98 cm and maximum is 68´106 cm. All national series charts produced by NHO are prepared in Everest spheroid. In these charts, a shift difference between Everest & WGS'84 is also provided. The vertical datum in these charts for hydrographic depth is chart datum and is MHHW/ MHWS for coastal features.

#### 4. Requirements of topographic & hydrographic information

The hydrographic and topographic information are equally important for navigation. It includes information of topography, inhabitation, public amenities, geodetic control points and conspicuous objects viz. light house, beacon etc. Hydrographic information includes coastline, berthing place, buoy, wreck, anchorage etc. The topographic details are extracted from SOI toposheets on required scale, whereas hydrographic details, in general, are extracted from hydrographic surveys by NHO and foreign agencies. Information is also taken from hydrographic survey if that is latest to SOI toposheet. Table-1 shows the various topographic and hydrographic objects with their authority and requirements.

#### 5. Accuracy of nautical objects

It is the prime motto of NHO to depict its analog and discrete hydrographic and topographic information with high degree of accuracy and precise in position. Since object size in all types of charts are uniform whereas scale varies, positional accuracy defers. Though, NHO maintains high degree of precision in recording process and placing the contents, the scale causes different precision at different scales. In Table-3 below, certain objects were taken to study their positional accuracy at the scale of 1: 10,000.

#### 6. Results & discussion

The accuracy of the objects has been calculated on the scale of 1:10,000. The objects in nautical charts have certain symbols with definite size. Some are point features and some are area features. These symbols are tried to be placed at the given geographic coordinate, which occupy some space at the specified position. Thus area covered by a symbol makes confusion of the geographic coordinate. Symbols of some features are placed according to a dot or positional circle in the symbol, viz. an eye of an anchor is the place of its geographic coordinate. These precise placing still has

some area covers and it may be considered as the accuracy of the symbol placing. In Table-3 below, the accuracy of some objects is nearly 100 sq. m or more. These are symbols, which have bigger positional size and represent an area rather than a point. Other remaining symbols whose accuracy is less than 80 sq. m are point features, which are placed according to the given point position in the symbol.

#### 7. Conclusion

In spite of all the hurdles in placing numerous data/ symbols in the limited space of a chart, the NHO is providing accuracy of certain objects within 3m-20m on the earth surface.

Integration of all hydrographic and topographic information from various sources is required during the preparation of a nautical chart. Convergence of this information within specified accuracy in the limited space of a chart needs expertise and experience in compilation techniques.

The NHD, a central authority of Indian nautical chart production and whose products and services are ISO 9002 certified, is thus committed to respond to national and international conventions relating to the safety at sea and offshore development works by furnishing accurate and reliable hydrographic navigational products and services.

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







**Table-1: Topographic & Hydrographic details**

<b>Object</b>	<b>Authority</b>	<b>Requirements</b>
<b>Topographic</b>		
Geodetic Control Point	SOI, NHO	To fix and link geodetic interconnectivity between the topographic and hydrographic objects. Also used as geographic reference point for hydrographic survey.
Coastline	NHO, SOI	To serve as demarcation line between land and seawater. It coincides with High Water Line. Depiction of coastline varies with nature of coastline.
Tower/ Light House	NHO	To facilitate navigator in fixing position of vessels in day/ night. Characteristic of tower/ lighthouse varies with type of information it does provide.
Public Amenities	SOI, NHO	To know the facilities available to vessel at coast. This help in making decision for berthing or not.
Inhabitation	SOI, NHO	To know the type of area and accordingly infrastructure expected to be available there.
Berthing place (Jetty, wharf)	SOI, NHO	To know types of berthing available to vessel.
Topographic configuration	SOI	To familiarize navigators with the regional topographic variation of the area.
<b>Hydrographic</b>		
Depth value	NHO	To reveals depth of sea bottom at Chart Datum. This helps to understand undulation of seabed. It is shown on charts of all scale.
Wreck/ shoal	NHO	To reveals shallower bottom of seabed, which may dangerous for navigation. Shown on large & medium scale chart.
Sea-bottom	NHO	Represents the nature of rock of sea-bottom that helps in making decision for anchorage and also helps in accessing the stability of shoal. Shown on large and medium scale chart.
Anchorage Point	NHO	Requires for making safe and stable anchoring position of vessels. Shown in Large-scale chart.
Tidal Stream	NHO, Major Port Trusts	To provides direction and velocity of stream during spring and neap tide. It is placed at position of major ports in large-scale charts.
Buoys	NHO, Major Port Trusts	It provides visual navigation aids. It is floating object with distinct shapes. These are coloured as well as lighted. It's diameter, in general, is 5 m.
Beacon	NHO, SOI, Major Port Trusts	To provides visual navigational aids. It is a wide range of structure from simple pole to built-up tower. Some beacons are lighted.

**Table-2 Recording Process**

Object	Recording / Establishing Process
<b>Topographic</b>	
Geodetic Control Point	Established by geodetic triangulation survey and by making repetitive observation for a long period. The established geodetic parameters are highly precise.
Coastline	In hydrographic surveying, it is done by NHO by connecting geographic positional data observed by GPS at every 10 meters along the High Water line marks of coast. It is also done by SOI in topographic survey near the coast.
Tower/ Light House	It's geographic position established by transferring geodetic information of nearest LBM/ BM and also by making repetitive observations by DGPS system.
Public Amenities	Taken from Old charts. Further development changes derived from cadastral maps promulgated by marine port authorities.
Inhabitation	Inhabitant area shown in the form of the rectangular block. There are more blocks if size of an area is bigger.
Berthing place (Jetty, wharf)	Berthing points and its area are developed by port authorities, which promulgated invariably to concerned offices.
Topographic configuration	Topographic configuration represented by the depiction of contour and spot height.
<b>Hydrographic</b>	
Depth	Depths at sea-surface are recorded in hydrographic surveying by Echo sounder. These depth values further transferred at Chart Datum. The normal accuracy is 10 meter at scale of 1: 25,000.
Wreck/ Shoal	Demarcated by largest scale hydrographic shoal survey. The least depth observed over wreck/ shoal is representing depth of wreck/ shoal.
Nature of sea-bed	Decided by making observations over survey area and dividing the area into zones on the basis of nature of sea-bottom found.
Anchorage	Decided after analyzing the nature of the sea-bottom, depth at MHWS, distance from the shore, limit of port and traffic separation map.
Tidal stream	Established by observing the tidal data recorded at standard port and its analysis for finding direction, velocity at spring and neap tides.
Buoys	Developed by port authorities according to defined route for entering & leaving to the port. Characteristic of buoy depending upon its purpose. Its position is established by continuous observations of geographic coordinate by GPS.
Beacons	These are known structures and also structures developed by port authorities. These are permanent specific constructed structure to serve as daymarks. Their geographic positions are established by observation from GPS set.

**Table-3: Accuracy of Topographic & Hydrographic Objects**

Object	Symbol	Dimension at Scale 1:10,000 (Sq. mm)	Accuracy in position (sq. m.)
Control Point		0.9750	97.50
Coastline		0.2000	20.00
Beacon/ Tower		0.1963	19.63
Public Amenities		7.0686	706.86
Inhabitation		0.8000	80.00
Mosque		0.7850	78.50
Radio Mast		0.1772	17.72
Elevation		0.0314	3.14
Depth		2.0445	204.45
Wreck		0.1963	19.63
Tide gauge		0.1665	16.65
Anchorage		0.1590	15.90
Tidal stream		8.0998	809.98
Buoys		0.0908	90.80
Nature of sea-bottom		2.0445	204.45
Light house		0.1963	19.63