DESIGN AND ACCOMPLISHMENT OF NAVIGATIONAL GEOGRAPHIC INFORMATION SYSTEM

Du Jinghai, Wang Houxiang
Department of Hydrography & Mapping
Dalian Naval Academy, P.R.China

Abstract

In this paper, the authors attempt to conduct an investigation in Navigational Geographic Information System (NGIS) design, spatial data processing and methods of establishing the system. The emphases are placed upon the concept, logic and physical designs, the encoding of the space reality.

Nowadays, many ships are equipped with Global Positioning System (GPS) , Electronic Chart Display and Information System (ECDIS) and/or Integrated Navigation System (INS), which make it possible to provide a great deal of digital navigational information for modern navigation techniques. Traditionally, paper charts play a major role in the presentation of positional information. However, charts of this kind lack the possibility of conducting quantitative analysis and scientific forecasting of the ocean geographic information. Thus comes up the idea of developing a NGIS. NGIS is a technical system that is supported by computer hardware and software, and can provide useful information for navigation. In addition to its rapid presentation of navigation geographic information, NGIS also can provide such efficient and precise performances as information collection, storage, management, analysis and decision-making for navigation, etc.

1. System Design

As a kind of GIS, NGIS should have some basic functions as follows:

1. 1 Data Collecting and Compiling

According to geographic coordination or geographic region, digital information of ocean spatial reality graphic data or attributive data can be obtained and then compiled by using some equipments (scanner, digitizer) and media (CD or DISK) .

1. 2 Inquiring

Inquiring includes the individual inquiring and relative inquiring of the spatial data and at-

tributive data.

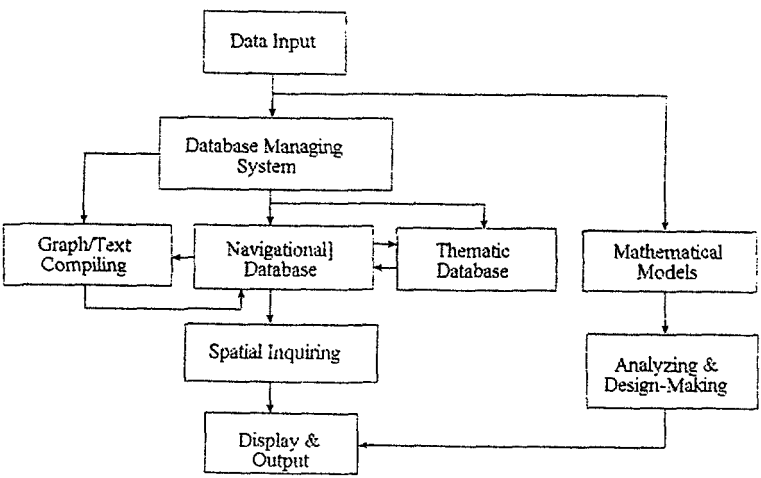
1. 3 Analyzing and Decision-Making

By using some mathematics models, the system can make the optimum selection of navigation routes. Also it can do statistical analysis about ocean environment for navigation.

1. 4 Output

As a main function, the system should be able to produce its last products, such as route charts, various graphs and other reports related with navigation.

The below graph shows the main function modules of the system.



2. The Design of Navigational database (NDB)

NDB is the main module of the NGIS. Under the support of Database Managing System (such as Oracle), it can undertake the various tasks of inquiring, such as position inquiring, attribute inquiring and topological inquiring, etc. Also, it should be related with the Thematic Database and can exchange data with each other. The data source of the NDB is composed of graphs (nautical charts, harbor charts, etc.), statistical data (of oceanographic survey) and materials (*China Sailing Directions*, *List of Lights*, *Notices to Mariners*, etc.).

2. 1 The design of concept model

Spatial reality: it is a subset of the set of ocean spatial objects. In the NDB, it should be distinguished, stored and managed. In this system, it contains mainly various navigation

routes: recommended routes, fixed route, separated route, deep route, two-ways route, etc.

Attributes of spatial reality: the quantitative / qualitative characteristics of the spatial reality. They are mainly the navigating directions (in/out), distances of navigating, points of turning direction, crosses of routes, aids to navigation and navigational obstacles, depths, etc.

Relations of spatial reality: Using nodes and arcs to describe separately the beginning harbor, ending harbor, turning points of routes and routes arcs. In this system, the route is defined as the line from harbor A to harbor B. The name of the route is a combination of the two harbors' names. For examples, the route between the harbor Dalian and Yantai is called the route Dayan. The whole route is made up of arcs . While the arcs are the segments between each two turning points, Arcs are encoded by numbers in sequence.

2. 2 The design of the logic models

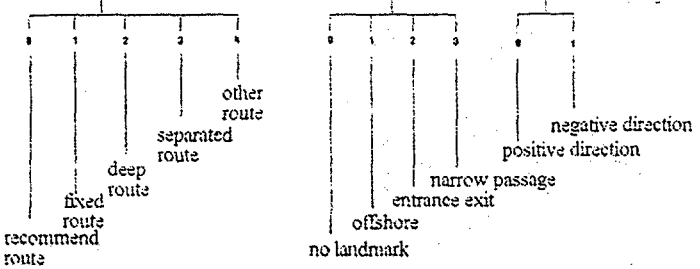
The units of the NDB are charts presenting routes and harbors. Each unit has its specific physical description and coding number. All units are included in the only indexing file. According to the Standard of Digital Hydrographic Data Transformation given by the International Hydrographic Organization, each unit code is consist of seven numbers(identifiers). The first three numbers present the offsets of latitude. The reference point of each unit is at the lower-left corner. The latitude, at the South Pole is zero, and to the North it becomes bigger. The longitude begins from Greenwich Meridian, and increases eastwards. The offset of latitude and longitude is 15'. Thus the unit code would be from 0,000,000 to 7,191,439.

Also, each unit has another code of chart scale. Code according to scale:

Code of Scale	Chart Scale	Unit Measure	Route Chart or Harbor Chart

The structure of the vectorial data of the route is presented as below:

Type Code of the Route	Code of the Harbor Name	Position Code	Direction Code	Code of Arc



Here, the direction code is positive when it is southward or eastward. When it is negative, the attribute value of the negative direction should be added 180°. The position code is given according to the relation between the route and landmarks. The arc code ranges from 00 to 99, sequenced from north to south and west to east.

Considering the computer software and hardware of the system, the NDB would be organized in relational models, i.e., the data of reality is organized and processed by using the 2D relation table. The table is described in relation of spatial geometry, text description, topology, parameter and place-name relation.

3. The design of thematic database (TDB)

The TDB is used to restore and manage the thematic attributive information related directly with navigation. Using relational database managing system, we have established the following database:

Database of aids to navigation in China seas.	HB.FOX
Database of navigational obstacles in China seas.	ZW.FOX
Database of nautical charts of China seas.	HT.FOX
Database of notices to mariners of China seas.	TG.FOX
Database of navigational route in China areas.	HF.FOX
Database of the oceans of the world.	HY.FOX
Database of the harbors of the world.	GK.FOX
Database of the straits of the world.	HX.FOX
Database of the islands of the world.	DY.FOX

Here, the records and attributes of the first five databases are stored and managed according to the relational data models. In the meantime, they should be able to exchange and share data with the NDB. The last four databases are used mainly for attributive inquiring.

4. The establishing of ocean analysis models

Analysis models are the important part of the NGIS, used for decision-making.

4.1 Statistical Graphical Models

This kind of models is used to analyze statistically the oceanic hydrographic details and to reduce various graphs and diagrams such as histogram, pie graph and rose graph. The model has two kinds, vector and scalar. The scalar model is used to express details such as temperature, salt and density of sea water. Any parameter P is considered to have a range of values in space, time and written as

$$P = P(X,Y,Z,T)$$

This elementary notation can be expanded to include vector fields by considering that a vector is comprised of two quantities, magnitude (M) and direction, and that direction can al-

ways be uniquely defined by azimuth (θ)and delination (Φ). Then we can write for a vector field

$$V = (M, \theta, \Phi)\ (X, Y, Z, T)$$

and consider that position vectors are a special case subsumed in the same notation.

4. 2. *Multi statistical models*

They are used mainly to the geographic environment of ocean and to do statistical forecasting of ocean phenomena. Among these models are relative analysis model, regression analysis model, trend surface analysis model and cluster analysis model.

5. Conclusion

Owing to the limitation of finance and other problems, our Navigational Geographic Information System is founded on the basis of micro computers. The hardwares are IBM PC 486, a scanner, a digitizer, a plotter and a printer. The softwares are DOS, Oracle, Foxpro, Borland C^{++}, etc. NGIS is a new technology. However, as an important part of automatic navigation system, it is believed that NGIS will somewhat quicken the steps towards the consequent replacement of paper charts.

Reference

[1]Li, Deren *Guide of Geographic Information System*. Beijing: Surveying and Mapping Press, 1993.

[2]Fang, Ying & Jiang, Ziliang *Navagation*. Tianjin: China Navation Press, 1986.