Design of Marine Bathymetry Data Model Based on S-100

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Abstract

Through the history of navigation of mankind , hydrographic bathymetry is of great importance in respect to the insurance of marine security and the advance of navigation career. With the accumulation of marine survey data, how to manage and integrate dispersed data effectively is becoming the primary problem of "Digital Ocean". S-100 is the IHO standard that was adopted as a basic model supporting the exchange and integration of hydrographic information services. In order to facilitate the communication of the marine bathymetry data via S-100-based navigational information services, we need to represent it according to an S-100-based data structure and formats. In this paper, we analyze certain types and characteristics of data representing marine bathymetry data and marine bathymetry information data model based on the S-100 Feature Catalogue Model (FCM) and its characteristics for users and data administrators.

Keywords

marine bathymetry data ; S-100; feature catalogue model (FCM).

1. Introduction

Three quarters of the earth's surface area is the ocean. The ocean provides a wealth of mineral resources, oil, natural gas and other resources. The marine powers have made every effort to carry out the continental shelf-based "marine engineering", and Seafloor topography is measured more frequent. Mankind has been trying to explore the shape and composition of the seabed, to the early 20th century, the bottom of the sea about its main characteristics, including mountain ridge in the sea, the sea, deep trench and submarine canyon in the map. In today's field of surveying and mapping, there are a series of cutting-edge tools [1]-[3] that provide side-scan sonar, multi-beam sounding, satellite ranging and global positioning system navigation, which provide more accurate and extensive submarine depth measurements and submarine composed of important information, greatly promoted the development of marine sounding, can make people get more detailed information on the seabed.

Currently the International Maritime Organization (IMO) is taking the lead in developing e-navigation as an information service framework. E-navigation supports sharing, harmonization and utilization of various marine and marine-related data both shipboard and onshore [4].Recently, the IMO adopted the International Hydrographic Organization (IHO)'s S-100 as the basis of the Common Maritime Data Structure (CMDS) of e-navigation. S-100 will support items such as imagery and gridded data, 3D and time-varying data (x, y, z, and time), and new applications that go beyond the scope of traditional hydrography; for example, high-density bathymetry, sea floor classification and marine GIS. It will also enable the use of web-based services for acquiring, processing, analyzing, accessing and presenting data. It is important to recognise that S-100 is not an incremental revision of the current Edition 3.1 of S-57. S-100 will be a new standard that includes additional content and support of new data exchange formats [5].S-100 comprises multiple components that are aligned with the ISO 19100 series of geospatial standards. Developing S-100 in this way will enable hydrographic data to be included in many more general geospatial applications than has been the case before. Therefore, it is interesting to apply the S-100 uniform standard to establish a data model for seabed sounding data, which allows the seabed sounding data to be shared all over the world and no longer spend a lot of time and effort on different problems[6].

In this paper, we analyze certain types and characteristics of marine bathymetry data and present methods for the design of an S-100-based marine bathymetry data model. We here in present this model for the use of both users and data administrators. This paper is structured as follows. In Section 2, the research on the utilization of marine bathymetry data and the implementation of maritime systems is summarized. In Section 3, certain types and characteristics of data representing marine bathymetry data are analyzed, and methods of converting these data to the S-100 Feature Catalogue Model (FCM) format are presented. In Section 4,the design of the FCM-based marine bathymetry data model for users and data administrators is introduced. In Section 5, conclusions are drawn and future work is anticipated.

2. Related work

2.1 Research on utilization of marine bathymetry data

The International Hydrographic Organization (IHO) established the Data Center for Digital Bathymetry (DCDB) in June 1990, which running a global digital ocean sounding data on behalf of more than 60 member countries Library. The main services provided by DCDB include: (1) the establishment of a global digital marine sounding data warehouse with a focus on marine areas with a depth greater than 100 meters; (2) IHO member countries are free to use the data provided by the Center and are also required to provide to the Center (3) the preparation of sounding data catalog, check the quality of data, maintain the integrity of metadata; (4) IHO work with other international organizations to develop data exchange formats and standards to promote the depth of data exchange data.

Since the introduction of multi-beam survey instruments in China in the 1990s, the application of multi-beam has been developing rapidly in China and has been widely used in ocean polymetallic nodule surveys, offshore continental shelf surveys, cable routing surveys and river surveying. Early CARIS Bathy DataBASE software system developed by Universal System Canada, the water depth measurement data and the results of data management in the database environment [7]-[10], and the recent years of multi-beam sounding technology in the format conversion, data error correction Filtering, digital terrestrial model construction, error analysis and other data processing has made many achievements, but the processing and management of multi-beam data, there is no uniform standard and format.

It can be seen that many studies still remain at the technical level of depth measurement, there are many lack of research on data processing, storage and application, and S-100 standard is IHO developed to meet the new requirements for standardization of sea survey data Measurement of spatial data standards. In order to make the depth of the data better use and sharing, the establishment of the depth data model is necessary.

2.2 Research on S-100-Based system implementation

Since the introduction of the S-100 standard, various S-100-based systems and services have been designed and implemented in the maritime field. In this regard, research has been conducted on methods of converged service platform design and implementation for geospatial and maritime data based on the S-100, WMS, WMTS, WPS and SOS standards. The proposed platform offers the advantages of supporting both S-57 and S-101, supporting the converged services of different geospatial data and Electronic Navigation Chart (ENC) data, supporting data services such as weather, AIS, and CCTV, and supporting the development of various maritime systems such as Electronic Chart Display and Information System (ECDIS), ECS, and VTS based on the Web-Application service [11].

Research on the development of an S-100-based feature catalogue builder to hold a variety of data types including ENC into e-navigation application systems or next-generation ECDIS also has been conducted. It supports the development of various services related to maritime information by creating an appropriate feature catalogue based on the registry and catalogue structure of S-100 .

In order to achieve the exact technical description of the specific application of the electronic chart, the S - 101 is created according to the new sea - ray measurement specification established by the S - 100, following the principles and methods of establishing the S - 100 specification. After the completion of the S -101, the International Hydrographic Organization plans to use 10 to 20 years to complete the transition from S -57 to S -101: 201x to 202x for the S-57 and S-101 can be converted to each other stage, From 202x years later, S-57 3. 1 officially withdrew from the stage of history and entered the S-101 as the only new era of electronic chart product specifications [12].

3. The marine bathymetry data

3.1 Analysis of characteristics marine bathymetry data

At present, the sounding device is more and more advanced, the technical more and more mature[13], for seafloor depth measurement precision is more and more accurate. Here we use the data collected from measured data is based on the multi-beam technology. Not only deep in the sounding data of the entire database data, there are some data about measuring equipment, and is closely related with the depth of the tidal information. Detailed information is as shown in the following table 1, table 2 and table 3:

Table 1 DepthData

DepthData	Contents	Null
DepthId	number	N
Time	date	N
longitude	Number(8,2)	Y
latitude	Number(8,2)	Y
Depth	Number	Y

The depth data table is mainly the data of the depth of the ocean, which is the most important data, including the depth ID, acquisition time, latitude and longitude, depth.

Table 2 Bathymetry Device

Bathymetry Device	Contents	Null
DeviceId	Number	N
DeviceType	Number	Y
DeviceName	Varchar2(32)	Y
BeamNum	Number	Y
BeamWidth	Number	Y
BeamAngle	Number(8,2)	Y
TransmitPower	Number	Y
Freqency	Number(8,2)	Y
TransmitInterval	Number	Y

In this paper, the data is from the multi-beam measurement. Therefore, the information of the bathymetry device mainly includes the device ID, the device type, the device name, the number of beam, the beam width, the beam angle, the transmission power, the frequency and the transmission interval.

Table 3 Tide forecast information

Tide forecast information	Contents	Null
TideId	Number	N
longitude	Number(8,2)	Y
latitude	Number(8,2)	Y
StartTime	Date	Y
EndTime	Date	Y
Tideheight	Number	Y

The ocean depth is closely related to the tidal data, so the tide prediction information is needed for sounding, and the tide forecast information table contains the tide ID, latitude and longitude, start time, end time and tidal height.

3.2 Method of data modeling based on S-100 FCM

The S-100 graphical representation is intended to provide a mechanism and a specific product that will meet the elements and data products that are intended to be presented in a machine-readable form and are compatible with the display. The conceptual data of the catalog and content is primarily focused on describing content and function, mapping the contents of the rules or expression functions to the appropriate graphical symbol display, displaying the same content in different ways, and maintaining the display mapping rules without modifying any data content. The diagram catalog contains concepts that describe functions as feature-to-symbol, and include symbols, color definitions, expression parameters, and expression management (such as display groups) [14].

Graphic representation defines a factor-centric, function-based description mechanism. The feature entities can be expressed using descriptive functions with geometric and attribute information; the relationships, attributes, and geospatial positions of the underlying entities are given by the product specification of the generic feature model. The expression information contains the data set that the geographic data needs to be described, and the drawing instruction is generated by the corresponding expression function. The description mechanism makes it possible to express the same data set in different ways without having to change the data set itself. This indicates that the future of a data set can be expressed into two-dimensional or three-dimensional ways.

The S-100-based FCM is a conceptual model of feature catalogue that are abstract representations of real-world phenomena, information types, their properties, and the associative relationships between them. It defines a method for classifying feature types, specifying how categories of feature types are organized into a feature catalog and how they are presented to geodatabase users. The feature catalog is indispensable for translating data into usable information, and it is through the feature catalog that provides easier understanding of the content and meaning of the data, which Promoting the hydrographic surveying data more widely distributed, Shared and used.

The S-100 standard specifies the model to use the same modeling standard language UML, the current tools to create UML models are IBM's Rational Rose, Sybase's Power Designer and Microsoft's Visio [15]. Rose software is the most widely used, but it is relatively large, suitabling for more complex system model design, and needing to IBM official website to buy, the price is expensive; PowerDesigner development efficiency is high, but its ease of use and humanity in general, the price is also relatively high; Visio is a separate software on the graphics solution, It has simple operation and easy to use, development of mature, good stability, and have all the functions and characteristics of the draw UML diagrams [16]. At the same time, in view of the need to build the UML model is mainly used for S-100 data analysis, Visio can meet the needs of this study, so this article selected Visio 2010 version of the S-100 data model as a UML modeling tool. FCM-based data modeling methods , as show in the figure 1.

The FCM model core elements mainly includes named type and feature type, both of which are abstract type, where the named type is the parent of the information type and feature type, and the property type is the parent of the attribute type.

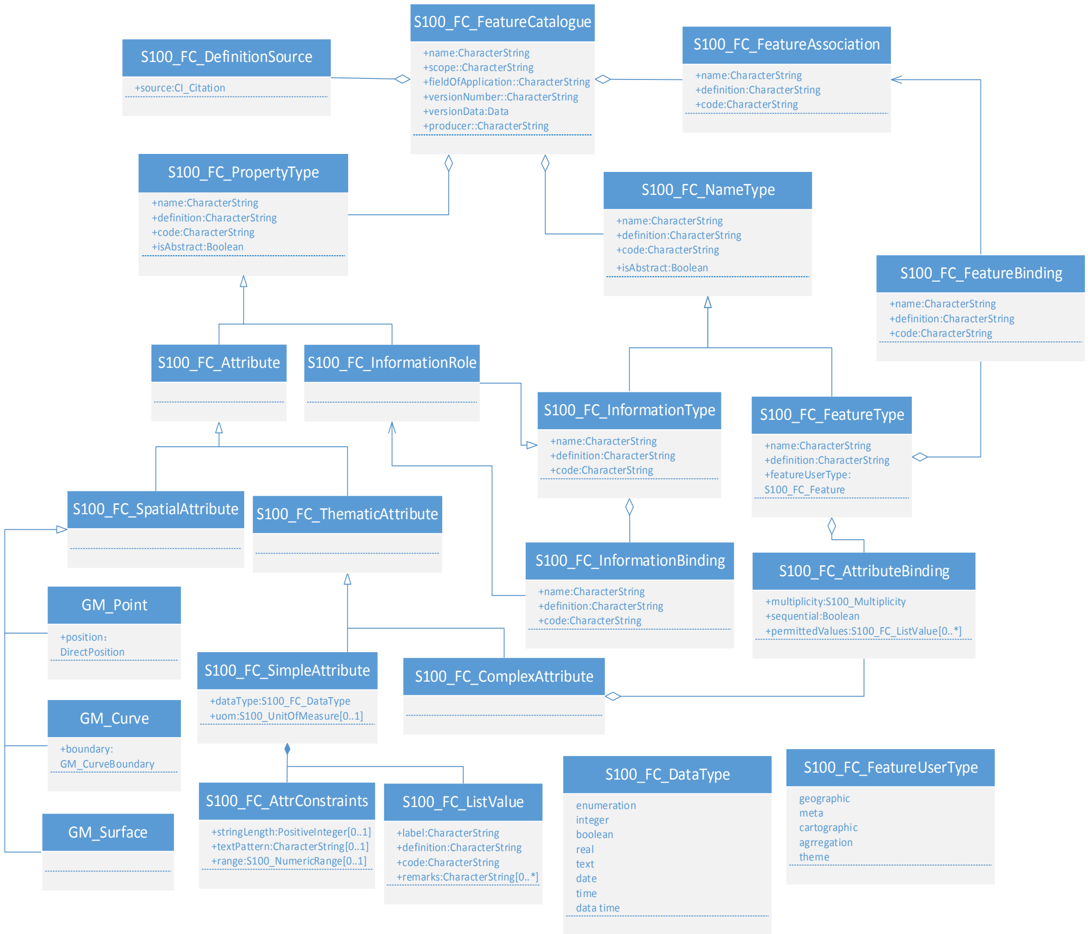

Fig. 1 S-100 Feature catalogue model (FCM)

3.3 The way of submarine sounding data conversion FCM model

The S-100 standard uses object-oriented design ideas to model the world really, and the class is the S-100 modeling core. A class describes a set of objects that share the same attributes and relationships. In the UML modeling process, a class represents a concept to be modeled, providing a way to map the universe to geographic data.

Marine bathymetry data are represented as features or information types based on the FCM of S-100. Feature types have one property at least. Attributes are represented as the relevant data types or enumerations. Also, attributes can be represented using the complex attributes that were introduced into S-100 version 2.0.0. The representation of a complex attribute is a way to represent a group of attributes sharing a common theme. Certain types and characteristics of each bathymetry element had to be converted to the FCM-type format in order to design the S-100-based marine bathymetry data model. The data from bathymetry research institution, bathymetry element data are converted to their respective FCM-based feature types. The data associated with those feature types are converted to the respective FCM-based information types. Attributes can be represented as three types. Basically, observed values are represented as data types that are supported by S-100. The values of code types can be represented as enumerated types. Also, they can be represented as a complex attribute, which is a group of common attributes sharing a common theme. As shown in the following table 4：

Table 4. Rules for conversion of Marine bathymetry data to FCM-based model format

marine bathymetry data		FCM-based Model	
Bathymetry,DeviceInformation		Feature Type	
Tide forecast information		Information Type	
Contents	Value Types	Attributes	Data Types
	Two or more attributes that are associated with a common theme		Complex Attributes
	Code Types		Enumerated types

4. Design of S-100-Based marine bathymetry data model

Based on the above analysis of the bathymetry data and the analysis of the S-100 FCM model, the following is a detailed design of the S-100-Based marine bathymetry Data Model. This paper creates a feature table based on the characteristics of the bathymetry data and its application. The two feature types are: depth data type, device data type, and information type that contains the tidal forecast information. The marine bathymetry element catalog contains the identity document (producer) and information (version number, version date, etc.), and with other necessary information element type. A feature type is a class of real world phenomena with common attributes. To illustrate the association between class objects, each class object is assigned an identity. The feature catalog table contains the name, scope, version number ,version Date, producer and three subsets, which of values are assumed to exist . As shown in the following table 5:

Table 5. Feature Catalogue

Class	S-100_FC_FeatureCatalogue(identity=1)	
Attribute	name	The marine bathymetry Data FeatureCatalogue
Attribute	scope	The associative of bathymetry Data Feature
Attribute	versionNumber	1.0
Attribute	versionDate	2017.04
Attribute	producer	CI_Responsible Department
Role	subtype	S-100_FC_FeatureType(identity=2)
Role	subtype	S-100_FC_InformationType(identity=3)
Role	subtype	S-100_FC_PropertyType(identity=4)

The feature type has two attributes and three roles, where the attribute contains the name, the feature user type, and the three roles are a parent class, and two subset classes. As shown in the following table 6:

Table 6. Feature Type

Class	S-100_FC_FeatureType(identity=2)	
Attribute	name	DataElement
Attribute	featureUseType	S-100_FC_FeatureUseType
Role	superType	S-100_FC_FeatureCatalogue
Role	subType	DepthData
Role	subType	BathymetryDevice

The information type contains less content, including only one attribute and two roles, as shown in the following table 7:

Table 7. InformationType

Class	S-100_FC_InformationType(identity=3)	
Attribute	name	MaritimeInfomation
Role	superType	S-100_FC_FeatureCatalogue
Role	subType	Tide forecast information

The property type is a property that describes the real world thing space attribute and the data itself. This class contains two attributes and three roles. The attribute contains the name, description, and the character contains a parent class and two subclasses, as shown in the following table 8:

Table 8. Property Type

Class	S-100_FC_PropertyType(identity=4)	
Attribute	name	depthProperty
Attribute	Description	Attributes and geometric properties
Role	superType	S-100_FC_FeatureCatalogue
Role	subType	AttributeDataType
Role	subType	GeometryPrimitive

The basic data types used by the S-100 can be divided into two categories: simple type and complex type. Simple types are used to represent a single type of value, including: boolean, integer, enumeration, real, text, date. Enumerated type is a user-defined data type that is a mnemonic column. Attributes with multiple values are ultimately defined as enumerated types, and enumerated types of attributes can only be taken from the list. The data attribute class is shown in the following table 9:

Table 9. AttributeDataType

	Name	Description
enumeration	AttributeDataType	A domain that specifies an attribute value
text	Boolean	Logical value,true or false
text	Integer	The value is an integer number
text	Real	The value is a floating point number
text	Enumeration	The value is a list of predefined values
text	Text	The value is plain text
text	DateTime	The value is a point in time
text	Date	The value is the Gregorian date
text	time	The value is 24 hours of time

According to the above analysis of the marine bathymetry data, the use of Visio tools to establish the Marine bathymetry data model based on S-100, as shown in Figure 2 below:

The marine bathymetry catalog consists of data elements, depth property, and maritime information. These have three abstract classes. They divide the overall database of sounding into S-100 standard classes. Each abstract class contains Subclasses, where the sub-class of data elements is the depth device data and depth data. The depth property subclass is composed of attribute data type and geometric type. The primitive geometric class is composed of point class, surface class and line class. Marine information is mainly related to the information associated with sounding, where only contains tidal forecast information. The tidal prediction information class is related to the sounding data because the tidal differences directly affect the ocean bathymetry data. At the same time observation ship is included the feature catalog model, it is associated with the directory class, while the depth of the metadata also has a related relationship with the feature catalog class.

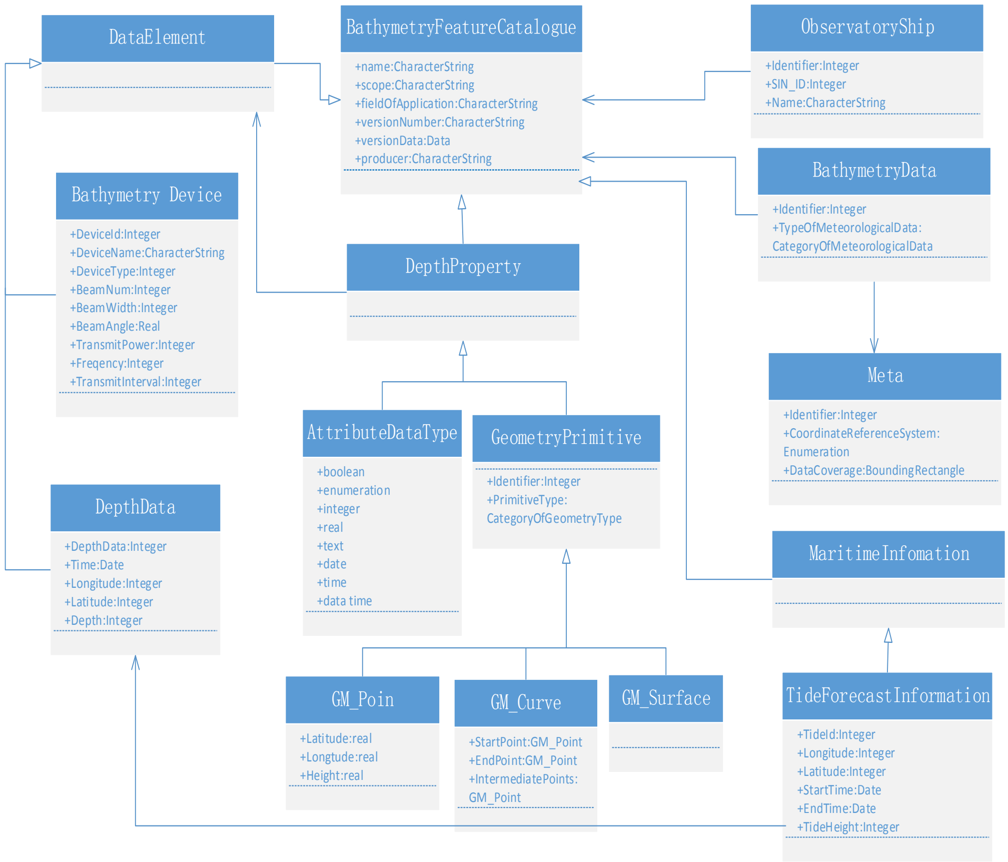

Fig. 2 Marine bathymetry data model based on S-100

5. Conclusion and outlook

5.1 Conclusion

Submarine information is of great significance to development of the oceans in the future, especially the ocean sounding data, which is an extremely important source data for submarine terrain reproduction. The available water depth data for the ocean numerical simulation has brought great convenience. The feature Catalogue model (FCM) of S-100 is a meta-model for definition of the feature-based data concepts and their relationships. It is used to design and develop product specifications and a variety of maritime services based on S-100.In the maritime field, Submarine terrain is complex and changeable, it is especially important to design and represent marine bathymetry data based on S-100 in order to provide effective e-navigation services.

In this paper, we introduce the current development and application of marine bathymetry technology, and introduce the development and application of S-100 standard. Then we introduced the FCM, which supports the development of S-100-based product specifications, and we summarize and classify marine bathymetry data .For support of S-100-based navigational information services, we converted marine bathymetry data to the FCM-based model format, we also analyze the FCM model of seabed bathymetry data in detail, and finally use Visio software to realize the FCM model based on S-100 ocean bathymetry data.

The results of this paper are as follows: (1) The S-100 standard is investigated and studied in detail, and the application of marine exploration data and the implementation of marine system are summarized. (2) Analyze some of the types and characteristics of ocean exploration data, express them in tabular form, and convert the data into the S-100 Feature Catalog Model (FCM) format. (3) Successfully designed the FCM-based maritime exploration data model designed for users and data managers and implemented it, which laid the foundation for the sharing, coordination and utilization of future ocean sounding data.

5.2 Outlook

In future work, for further support of S-100-based navigational information services, For better management of large amounts of data .First step, we will implement an online marine bathymetry database. As far as possible to achieve a data warehouse, so as to better marine research and management, to achieve sustainable development of the sea services. The second step, according to our database, we will study the possibility of using that database for ENC-based display marine bathymetry data, At present, users must use the chart schema and norms, through the form of reading to get the understanding of the marine geographical environment. This lack of realism in the performance of the method is clearly urgent need to be improved, the emergence of virtual reality technology to meet this development needs. The introduction of virtual reality technology makes the representation of marine survey information from two-dimensional static form to three-dimensional dynamic display, and the virtual reproduction of three-dimensional geographic landscape has a great progress. So we also plan designing to achieve the depth of the ocean three-dimensional visual interface, so that the depth of the ocean can be more intuitive and vivid display on the electronic chart.

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