Ocean Solid Monitoring Temporal and Spatial Data Organization, Management and Application

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***Abstract*—In the ocean dynamical environment real-time solid monitoring system of Taiwan Strait and adjacent maritime region, multiple monitoring data including remote sensing data, structured data is produced by the solid monitoring net from airspace, ocean surface and under ocean surface. The storage, management, online analysis service of the monitoring temporal and spatial data is key part of the whole system. Aiming to resolve the data organization and integrated analysis service of the monitoring data, this paper studies the characteristics, design and application of the temporal and spatial data warehouse of ocean solid monitoring information. Firstly, the characteristics and application model of the data warehouse of ocean solid monitoring information is introduced from the aspects of spatial, temporal, subject-oriented, multiple resource and decision-making oriented. Then the subject classification, design of concept module of the data warehouse of ocean solid monitoring information is introduced. The Star Schema is used to demonstrate the multi-dimension character of the ocean monitoring information. At last, the data warehouse of ocean solid monitoring data based application in shipwreck salvation decision-making support system of Taiwan Strait is realized.**

Keywords-data warehouse;Taiwan Strait;ocean solid monitoring;Information Service; WebGIS.

I. INTRODUCTION

China is one of the countries which have most serious ocean disasters in the world. In 2005 the ocean disaster resulted in 33.24 billion of economic loss to our state and 371 personnel casualty [1]. Taiwan Strait is a serious oceanic region which has special dynamical environment including storm time, oceanic wind, waves and so on. The solid monitoring system of Taiwan Strait and adjacent maritime region is an important part of Chinese Digital Ocean and Digital Fujian [2-3].

In the ocean dynamical environment real-time solid monitoring system of Taiwan Strait and adjacent maritime region, multiple monitoring data such as remote sensing data, structured data and half structured data are produced by the solid monitoring net from airspace, ocean surface, underwater space and ocean bottom [4]. The information service system is a key part to influence the application efficiency of the whole system, which can take good advantage of the technologies such as data warehouse, WebGIS and so on [5-6]. Ji Min etc. stated the frame of the marine GIS spatial temporal data warehouse, the data organizing hierarchies ,the algorithmic applying hierarchies , and so on[7]. Up to now, we haven't seen the technological implementation and instance on the study of the ocean solid monitoring data warehouse. In this paper some primary research achievement is given.

II. FEATURE OF THE DATA WAREHOUSE OF OCEANIC MONITORING

The ocean dynamical environment real-time solid monitoring system of Taiwan Strait and adjacent maritime region is composed of the oceanic shore/platform monitoring net, the high frequency terra wave radar monitoring net, the buoys monitoring net, boat based monitoring net and remote sensing monitoring net. The monitoring nets form the three dimension solid monitoring system which monitors the oceanic dynamical environment and ecological environment from underwater, ocean surface and air.

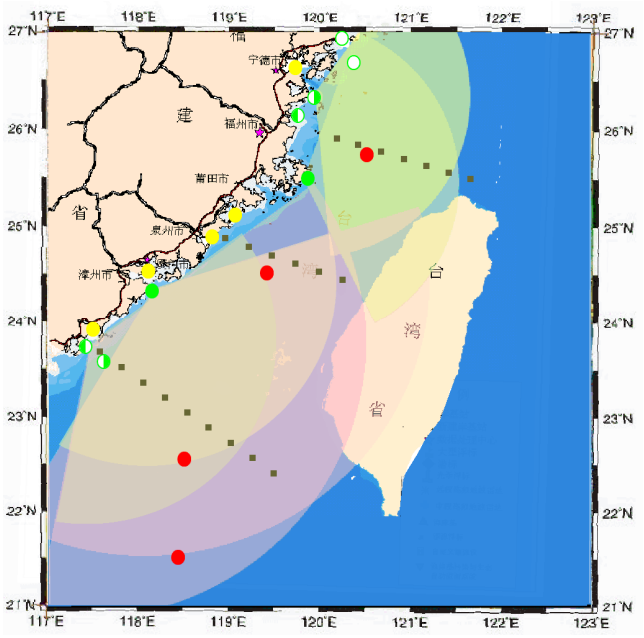

Figure 1. The location of ocean monitoring stations and monitoring region of Taiwan Strait and adjacent maritime region.

The monitoring result information mainly includes remote sensing image and recording information which is related with a spatial position. From the monitoring information format point view, it can be divided into three classes, i.e. the remote sensing image format information, the structured information

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and half structured information. The structured monitoring information can be positioned to the vector map by geo-coding tools in GIS. The two kinds of monitoring information must be processed in order to be used by different kinds of users. The remote sensing image format information is acquired by some image processing steps such as image rectification, image transformation, image extraction, image classification and so on. Most of the monitoring information exists in some different kinds of data files according to the different monitoring methods. So the first step to process this kind of monitoring data is to transmit it to database. Only the different kinds of monitoring data being stored in database tables, can they be managed and used expediently. When the monitoring data has being stored in database tables, they can be positioned onto the maps which have spatial reference. With the discrete monitoring information of the monitoring points, the ecological environment and dynamical environment can be seen in a discrete model. Using the geo-statistics module, the discrete monitoring information can be serialized to the whole oceanic region. Then the whole environmental and ecological situation can be seen on the map. The government and public can get the information through web. The location of ocean monitoring stations and monitoring region of Taiwan Strait and adjacent maritime region is shown in Figure 1.

III. Design of the Data Warehouse of Oceanic Solid Monitoring

In the design scheme, the whole system is composed of a chief data center in Fuzhou, a sub-center which is in Xiamen University, and some distributed monitoring stations. The storage, management, analysis and service of the monitoring information are key parts of the whole system. The whole data warehouse design and application frame is shown in Figure2.

The first step is the monitoring data acquirement. The monitoring information acquiring module completes the primary processing, storage and transportation of the oceanic dynamical environment monitoring data. The main data transmitting method includes the wire transmitting (DDN、CHINAPAC、PSTN and so on) and the wireless transmitting (GSM、VHF/UHF). The monitoring data acquirement should be real-time or within no more than one day. Before the monitoring data stored in the data warehouse, they should be cleaned to control the data quality. There are other data procedures which include standardization, geo-coding, metadata matching, data formation transformation, data classification cataloging and so on.

As for the data organization in the data warehouse, the star schema is adopted. Because the star schema has fewer table joining operations than the snow flake schema, it can improve the data querying efficiency. And the spatial-temporal data has more data indexing operation than usual data, so the star schema is more advantage than the snow flake schema. In the star schema, the spatial dimension and temporal dimension are the two main factor of the fact table. The other dimensions are organized according to the ocean monitoring information classification code. The logical relationship between the fact table and the dimension tables in the star schema is shown in Figure3.

The ocean monitoring data warehouse is used by the application analysis through the spatial-temporal data abstracting. The application subjects are divided into 6 subjects i.e., the marine ecological protecting, the ocean resource development, the ocean economic development, the storm tide forecasting and the shipwreck rescue decision-making support.

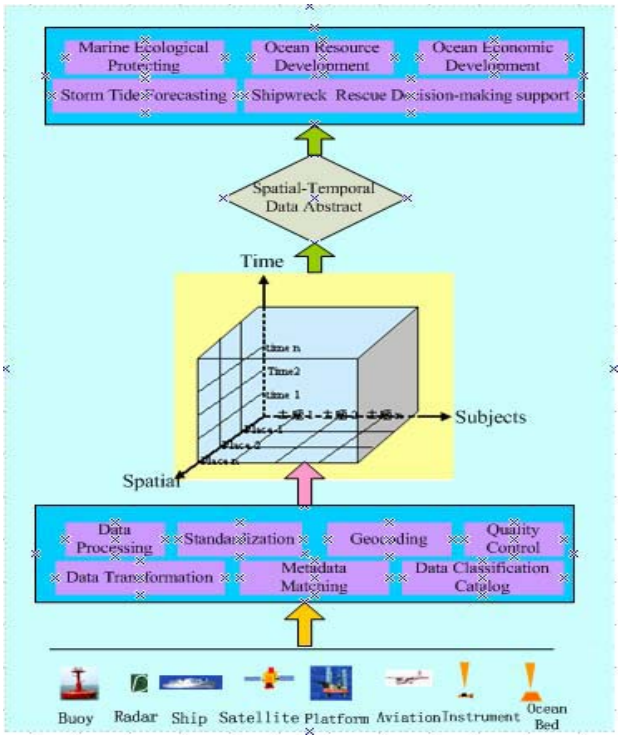

Figure 2. The frame of the ocean solid monitoring data warehouse design and application of Taiwan Strait and adjacent maritime region.

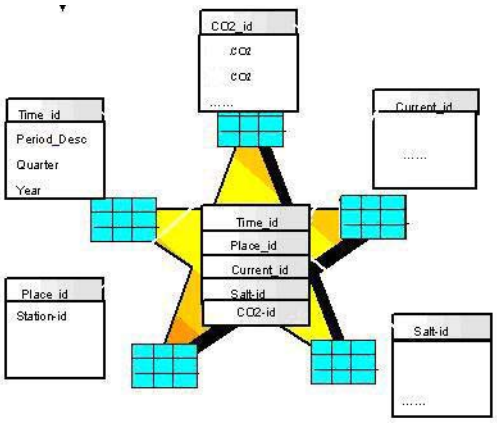

Figure 3. The logical relationship between the fact table and the dimension tables in the star schema

As for the software components, the data warehouse based oceanic dynamical environment solid monitoring system of Taiwan Strait and adjacent maritime region is composed of four modules, i.e. the monitoring information acquiring module, the monitoring data integration module, the monitoring data production development module, the monitoring information sharing and service module.

The monitoring data production development module completes the processing to the monitoring data. The result outputs of this module are different kinds of monitoring information productions. The software architecture of this module can be a C/S software system in an intranet. The result information is to serve different kinds of users. So this module has an interface with the information sharing and service module. The different kinds of data are geo-coded onto the maps to be spatial referenced.

The monitoring information sharing and service module completes the monitoring information sharing and service through Intranet or Internet. The basis of this module is a monitoring data warehouse and a geodatabase. And the software support includes a series of interoperation software packages which can be developed by web services technology and data warehouse technology. In the development of this module, the related standard and specification are the main reference. The software architecture of this module will adopt B/S structure to serve different kinds of users through Internet.

From the software module components stated above, we can see the whole service system is very complex. The development technologies include GIS, WebGIS, data warehouse, Web services, Interoperation technology, Database , XML and so on.

IV. APPLICATION MODE

The user classification is the basis of the service content design. The users of this system are mainly divided into five classes, i.e. the national oceanic information center, the Internet users, the national oceanic environment forecasting center, the government information network users of Fujian province and the management sectors of the Ocean and Fishery Management Bureau of Fujian province.

For the national oceanic information center and the national oceanic environment forecasting center, the service system completes the required information submitting and information download. The communication network between the national oceanic information center and the service system center is national data communication network (CHINAPA, DDN or FR) and transmission speed is more than 64KBPS. The communication network between the national oceanic environment forecasting center and the service system center is VSAT and transmission speed is more than 32 KBPS. The communication network between the users of the Electronic Government Information Sharing Platform and the service system center is the Electronic Government Information Network of Digital Fujian and transmission speed is 100M or 155M. The management sectors of the Ocean and Fishery Management Bureau of Fujian province are in a Intranet with the service system chief center. And the Internet users enjoy the information service through Internet.

The information service content include four classes of monitoring information, i.e. the first class information service (the real-time monitoring information service), the second class information service (the statistics analysis monitoring information service), the third class information service (the information service in grid model) and the fourth class information service (the forecasting information service).

The first class information service (the real-time monitoring information service) provides the real-time oceanic monitoring data at some time of a monitoring station in the style of text or table. For a period, the system can provide the time serial graph for a day or five days. All the information service are served based on the monitoring stations distributing map and interact with users with a mouse clicking.

The second class information service (the statistics analysis monitoring information service) content is mainly the statistics data which is renewed once a month. The information style includes the time serial graph, the plan map, the vector map of the oceanic dynamical environment and so on.

The third class information service (the information service in grid model) content is the isoline map and time serial map of the oceanic dynamical environment. The information region should cover 95% of the whole oceanic region. And the time frequency should be no more than 6 hours even within an hour.

The fourth class information service (the forecasting information service) mainly completes the tide, storm tide, oceanic wave and oceanic ecological environment forecast for the users. The purpose of these productions is to provide oceanic disaster forecast to guarantee the lives security and property security of the related people.

V. APPLICATION IN THE SHIPWRECK SALVATION

The temporal and spatial data service is used in the ocean current numerical simulation and the shipwreck salvation decision-making support system.

As the ocean current information which includes the flow velocity on horizontal direction and vertical direction of each corner point of the grid, the flow velocity and flow direction of any point in the area can be figured out through vector computation and linear computation. Thus we can compute the floating distance of the shipwreck objects in a time interval. The principle is the same in the computation of the floating distance and location in the next time interval. So the floating trail can be computed in this way.

Using the research achievement stated above, we developed the “Taiwan Strait shipwreck salvation decision-making support system” whose data flow and workflow is shown in figure 4. The software includes to parts, i.e. C/S (Client/Server) and B/S (Browser/Server). The C/S software was developed using Visual C++ and SQL Server DBMS. If the accident is shipwreck, the software can forecast the floating trail of the shipwreck objects such as people, ship and so on. As the ocean current numerical simulation need real-time data such as wind velocity and wind direction, the ocean current computation model is designed as a COM to be used repeatedly. When the result is forecasted, the result is stored in the database as case information. As rescue procedure is located in a distributed location, it is important that the forecasting information should be promulgated as soon as possible. We developed a website which can read the case database automatically. The time can

be no more than half an hour from the accident taking place to the information promulgated on web.

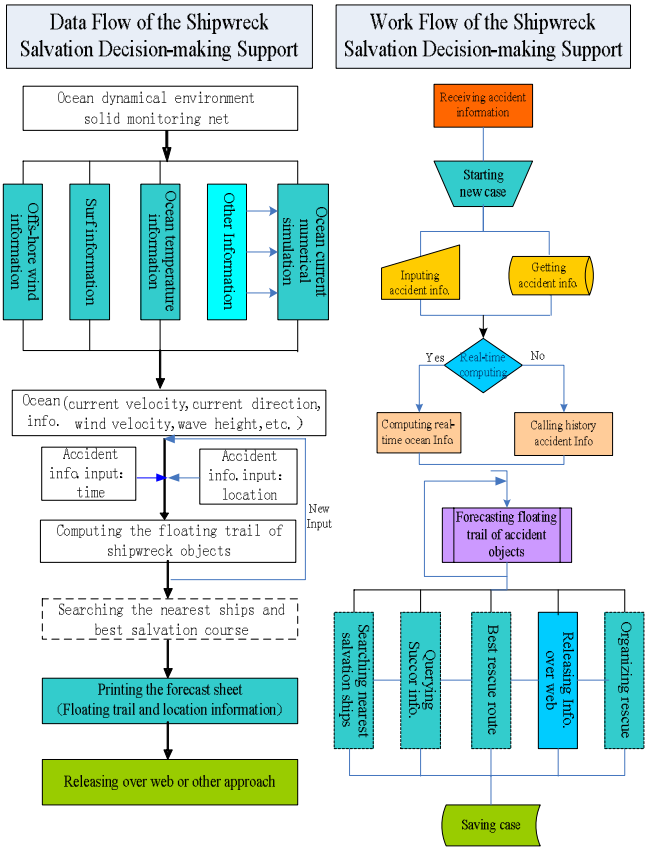

Figure 4. The data flow and work flow of the shipwreck salvation decision-making support system

VI. CONCLUSIONS

In this paper we studied the ocean solid monitoring data warehouse design and application of Taiwan Strait. Aiming to resolve the data organization and integrated analysis of the monitoring data, this paper studies the characteristics, design and application of the data warehouse of ocean solid monitoring information. Firstly, the characteristics and application model of the data warehouse of ocean solid monitoring information is introduced from the aspects of spatial, temporal, subject-oriented, multiple resource and decision-making oriented. Then the subject classification, design of concept module of the data warehouse of ocean solid monitoring information is introduced. The whole monitoring data warehouse is divided into 6 application subjects such as ocean ecological environment monitoring subject and so on. The Star Schema is used to demonstrate the multi-dimension character of the ocean monitoring information. The application in the shipwreck salvation decision-making support system demonstrated the value of the study achievement.

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