A PILOT PROJECT
OF DIGITAL GEO-SPATIAL DATA FRAMEWORK IN CHINA

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Commission II, Working Group 5

KEY WORDS
Spatial Data Infrastructure, Digital GeoSpatial Data Framework, Digital Orthophoto, DEM, Integrated Spatial Database.

ABSTRACT
This paper presents some ideas about the design and implementation of the Digital GeoSpatial Data Framework (DGDF) in China Spatial Data Infrastructure (CSDI) according a pilot project. The DGDF consists of digital orthophoto maps, digital elevation models and several layers of vector data including transportation, drainage, boundary of administrative division, place name annotation and geodetic control point. The production technologies and processes to collect spatial data are described, and some requirements for establishing the DGDF are also proposed.

1. INTRODUCTION
As the rapid development of computer and information technologies, Geographic Information System (GIS) has come into practice since 1960's. In order to promote GIS development and spatial data sharing, it is necessary to establish a national Spatial Data Infrastructure (SDI).

The concept of SDI was proposed by US government in 1994 (US Spatial Data Commission, 1994), many nations are preparing to establish SDI. Chinese government has put China Spatial Data Infrastructure (CSDI) (Gong, 1997) into the plan of national economy and social development as part of the infrastructure. The central government and provincial government hope to build the CSDI in coming several years (Li, 1997).

The Digital GeoSpatial Data Framework (DGDF) is an important part of SDI. According the scheme of DGDF proposed by US government in 1994, the DGDF includes digital orthophoto, digital elevation model, and a few vector data such as geodetic control-point, transportation, drainage, administrative bounds and public cadaster.

In China, digital geospatial databases at 5 scales are to be developed, i.e., 1:4,000,000, 1:1,000,000, 1:250,000, 1:50,000, 1:10,000. The first four spatial databases are national level, while the last one is provincial level. The geospatial databases at scales of 1:4,000,000, 1:1,000,000, and 1:250,000 based on vector data form have finished, and the last two geospatial databases will be established. According the Chinese administrative system on surveying and mapping, the geospatial database of 1:10,000 scale is developed by every province, the others are built in central government.

Because the most cartographic maps in China are too old and it will take long time to re-survey and collect full-feature vector data, we will adopt new technologies and new product scheme like DGDF in USA.

This paper focuses on the following aspects: firstly, to discuss about the contents of digital geospatial data framework in China; secondly, to introduce the technologies of producing framework data and some tests; thirdly, to present the basic requirement and platform of creating the geospatial database; and finally, to give some conclusions.

2. THE CONTENTS OF THE DGDF IN CSDI

In order to establish the DGDF in China as soon as possible, some factors including high speed and efficiency to collect spatial, and the completion, importance, processing and expansion of the information should be considered. Therefore, the Digital Geospatial Data Framework should include the following contents.

First, the most important geospatial data is Digital Orthophoto Map (DOM). Digital photogrammetry or remote sensing will be adopted in the production of DOM with the scale 1:10,000 and 1:50,000. The production technologies to produce the digital orthophoto have come into practice in the high speed and efficiency. On other hand, the digital orthophoto includes abundant information. After acquiring the digital orthophoto, vector data can be captured according to the need of users.

The Digital Elevation Model (DEM) is not only used for generation of digital orthophoto, but also served as many applications in GIS such as road design, flood prevention and agricultural planning. The form of DEM can be grid, TIN or hybrid.

Several layers of vector data are necessary. These vector data should include administrative boundary, transportation and drainage, because they are important and easy to collect. Many GIS applications need the three layers of vector data.

Normally speaking, the cadaster, residential area, vegetation, pipe line and communication line are also useful in GIS. But collecting these vector data will take long time. Here these data are not included in the DGDF of China.

A DGDF should include geodetic control point database and place name database. Actually the two kind data are stored in table and display their positions on the digital map.

As a result, the Digital GeoSpatial Data Framework of China should include digital orthophoto, digital elevation model, administration boundary, transportation, drainage as well as the database of geodetic control points and database of place names. Other features can be added properly when users need. If only the geographic information above is produced, the working efficiency can be faster 5 to 10 times than vectorizing full-feature maps. It can meet the demand of rapid renewal of GIS caused by the rapid development of economy in China.

3. THE PRODUCTION TECHNOLOGIES AND PROCESSES OF DGDF

DGDF mentioned above includes three kinds of data involving digital orthophoto, digital elevation model and vector data. In this chapter, the production technologies and processes of various data will be introduced in detail according to different situations of equipment and different requirements to production quality.

The production of vector data is mature. However there exist different methods according different equipment. These methods include digital stereo photogrammetry, analytical photogrammetry, and vectorization of scanned maps, digitizing vector data on digitizer. In addition, if the digital orthophoto has existed, acquiring vector data from digital orthophoto is a good method.

According to different data resources and equipment, the digital orthophoto can be obtained by several methods. A main method is digital stereo photogrammetry (Zhang, 1997). It gets the digital orthophoto and DEM at the same time. If there exist DEM, which may be produced by other approaches such as analytical photogrammetry or interpolating DEM from vectorizing contour maps, digital differential rectifying can be used to produce digital orthophoto directly. If the analogue orthophoto maps were made by using optical instruments like rectifying instrument, orthophoto instrument, the digital orthophoto maps can be acquired after scanning the analogue orthophoto maps. With the development of remote sensing technology, the high-resolution image can be used as the data resource of digital orthophoto. Above these methods can usually meet the requirements in accuracy and reliability.

There also are several different technologies to produce DEM including fully automatic digital photogrammetry, interactive digital photogrammetry, analytical photogrammetry and interpolating DEM from vector contour lines. But different methods have their accuracy and efficiency. In order to evaluate the DEM accuracy, especially from digital photogrammetry, we have made a series tests. We have taken two maps and used five methods for DEM accuracy testing. The maps include flat area, hill area and mountain area, and DEM interval is 10m. The collecting DEM methods include: I) fully automatic digital photogrammetry; II) Interactive digital photogrammetry; III) to measure the elevation of the grid point by point through analytical plotter; IV) interpolating DEM after capturing contour lines through analytical plotter; V) interpolating DEM after vectorization of scanned contour line map. The testing sample data are from field surveying by using level or total station. The mean error of DEM by using above various methods to obtain is shown in Table 1.

Table 1 The mean error of comparing with DEM interpolating elevation and sample data

Result / Method	Flat area		Hill area		Mountain area	
	Point Num.	Mean error	Point Num	Mean error	Point Num.	Mean error
Fully automatic digital photogra.	152	2.88	83	2.60	41	4.73
Interactive digital photogrammtry	152	1.25	83	1.24	41	7.56
Measuring grid DEM by analytical plotter	152	0.87	83	1.05	41	2.43
Interpolating DEM from contour by analytical plotter	152	1.18	83	1.16	41	3.77
Interpolating DEM from contour by scanned maps	152	1.20	83	1.12	41	3.99

The test results have shown that the highest accuracy is from Method III measuring the elevation of the grid point by point through analytical plotter. Therefore we take the DEM from Method III as sample data, and calculate the mean error compared with the DEM from Method III and other methods. The results are shown in Table 2.

Table 2 The mean error compared with the DEM from Method III and other methods.

Result / Method	Flat area	Hill area	Mountain area	Whole area
Fully automatic digital photogram.	2.98	2.66	5.94	5.01
Interactive digital photogrammetry	1.39	1.52	2.79	2.71
Interpolating DEM from contour by analytical plotter	1.41	1.26	2.58	2.35
Interpolating DEM from contour by scanned maps	1.40	1.26	2.52	2.43

These results have indicated: the analytical photogrammetry and interpolating DEM by using scanned contour lines have high accuracy; the accuracy is better by using interactively digital photogrammetry than by fully automatical digital photogrammetry, because the interactively digital photogrammetry need to capture the topographical characteristic lines and more artificial editing.

IV. ESTABLISHMENT OF GEOSPATIAL DATABASE

The spatial data including digital orthophoto, digital elevation model and several layers of vector data are collected through above approaches. In order to manage and distribute the spatial data, it is necessary that an integrated spatial database with raster data and vector data will be built. The spatial data can be stored in file, or in commercial database management system. No matter which approach, the spatial database should be designed as a seamless ones in logical. The software for managing the spatial database should have the following functions:

a) The spatial data can be searched and queried in whole spatial database;
b) The vector graph should overlay on the image transparently. The new image can be directly used to update the old vector graph through capturing and editing;
c) A multi-resolution image database should be built in pyramid form so that the system can read the image data from different level according different display scale;
d) There are the functions including displaying, querying and panning in an integrated interface with DEM and image;
e) All spatial data can be transferred to other GIS or remote sensing processing system;
f) Visualization or mapping should be made according the sheet number or range user-given.

A GIS software named GeoStar as a platform for collecting and managing spatial data in China has been developed by Wuhan Technical University of Surveying and Mapping (Gong, 1997). GeoStar has the functions to produce the digital elevation model, digital orthophoto map and vector data in part III of this paper introducing various methods, and manage integrated spatial database. The structure of GeoStar is shown in figure 1.

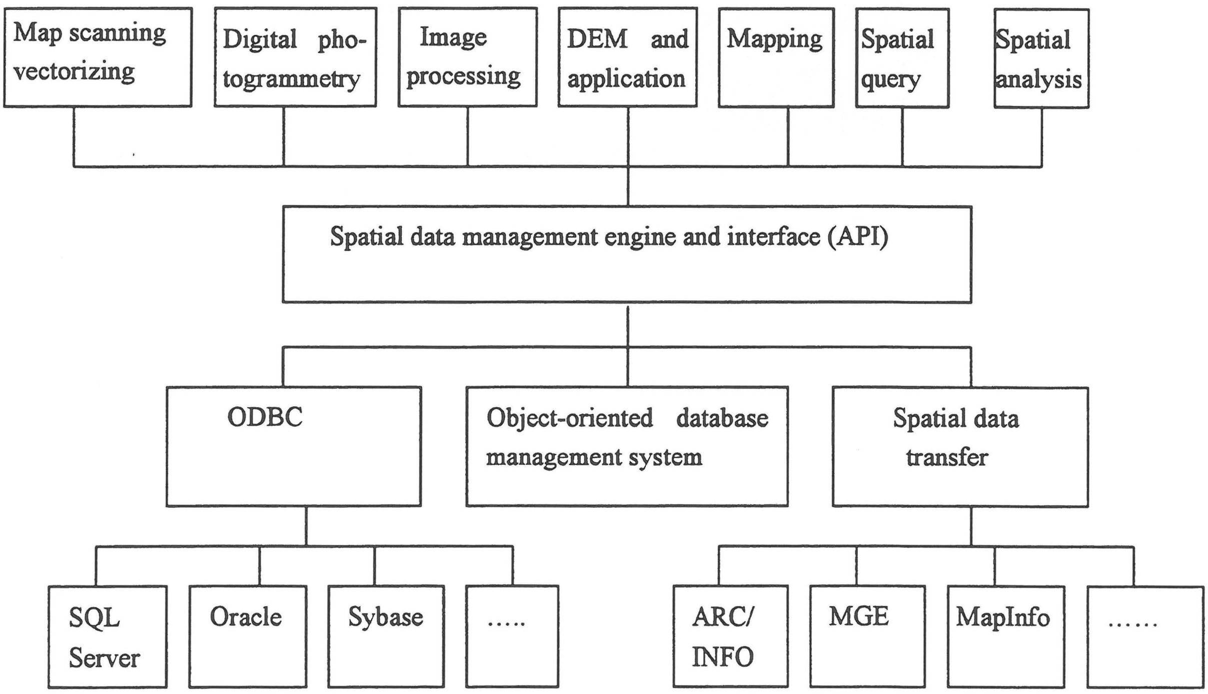

Figure 1 The structure of GeoStar

To establish the China Digital GeoSpatial Data Framework, there are still many problems to be solved. Therefore, the National Bureau of surveying and mapping in China have approved a project " The research of pilot project of CSDI". The Land Department of Guangdong Province and Wuhan Technical University of Surveying and Mapping carry out the project.

In order to research on an integrated spatial database for whole China, a pilot integrated spatial database including digital orthophoto, DEM, and several layers of vector data covering Guangzhu City has been created by using GeoStar. Using aerial photograph with 1:30,000 scale has created the orthophoto database with 1:10,000 scale. Figure 2 shows the image in different scale. Figure 3 shows vector graph overlay on digital image, it illuminates the advantage of the production. Figure 4 shows digital orthophoto overlay on DEM.

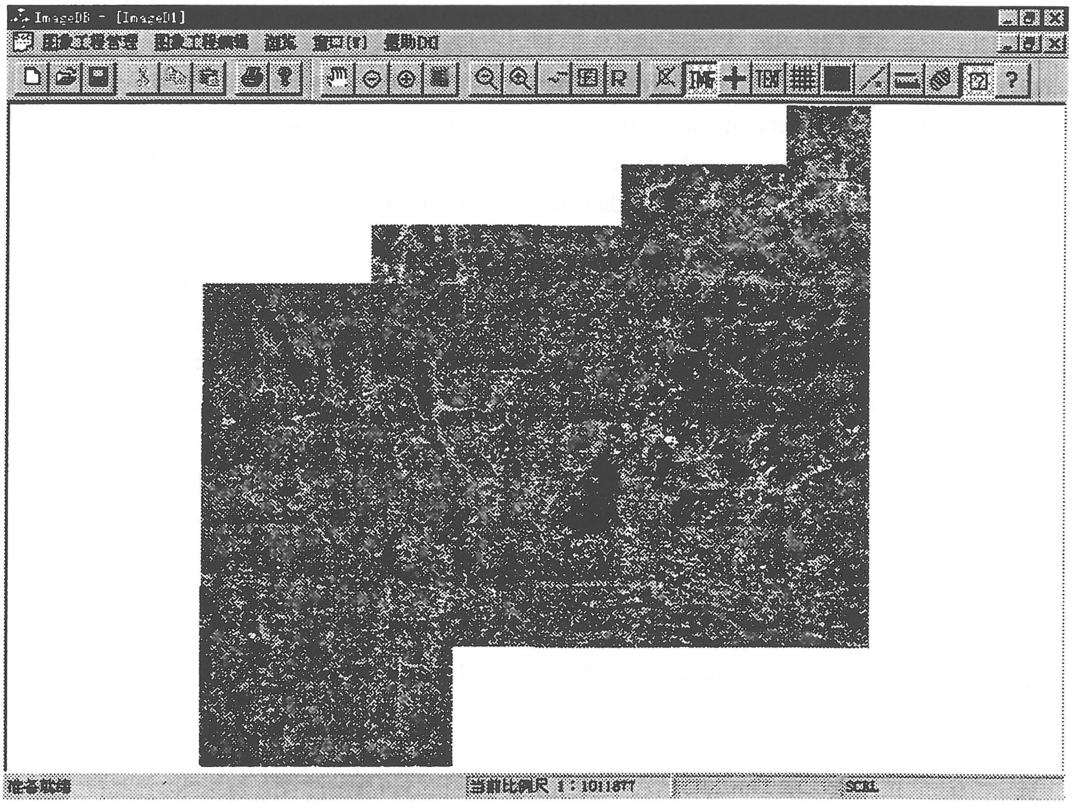

Figure 2A The digital orthophoto image of Guangzhu City

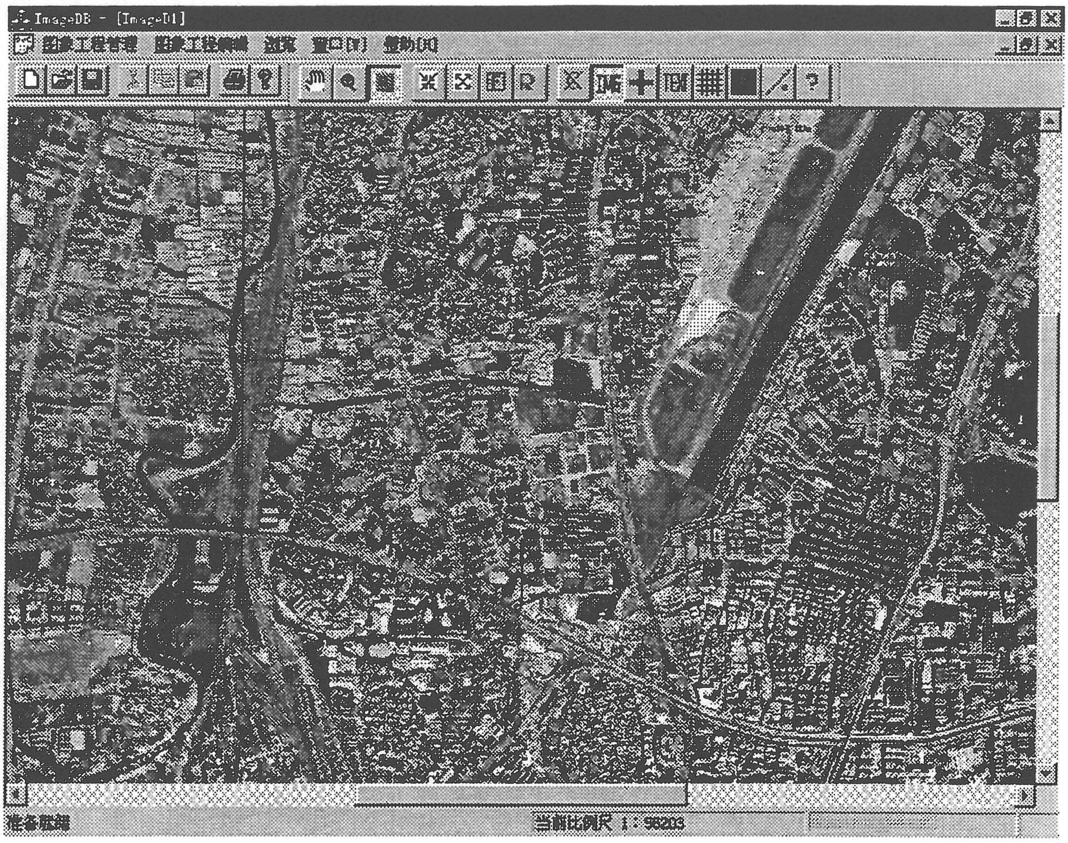

Figure 2B The digital orthophoto image with the 1:50,000 scale

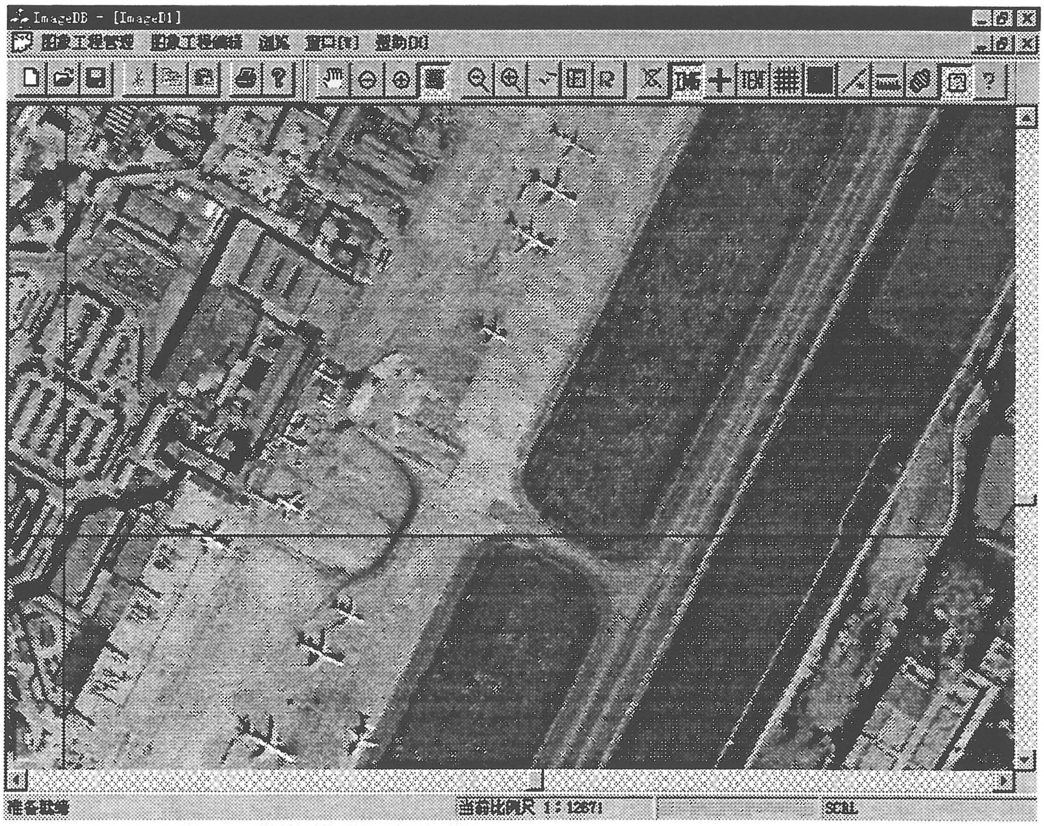

Figure 2C The digital orthophoto image with the 1:10,000 scale

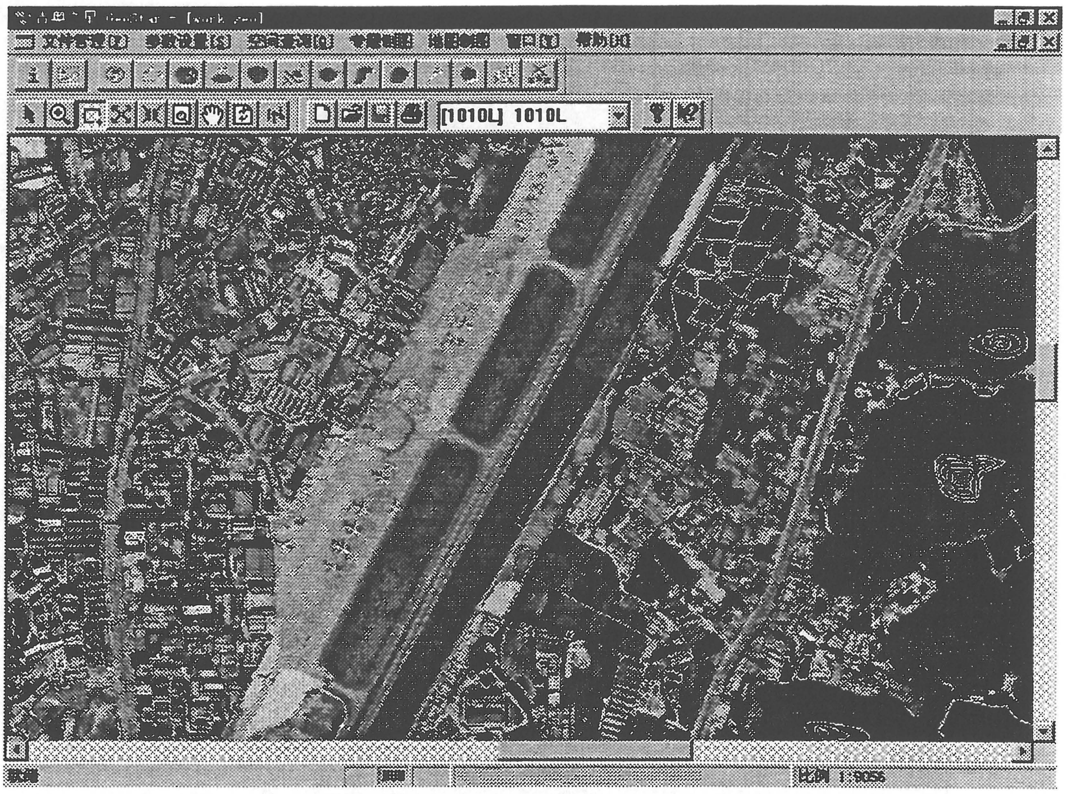

Figure 3 Vector graph overlays on digital orthophoto image

Figure 4 Digital orthophoto overlays on DEM

5. CONCLUSIONS

With the development of computer, digital photogrammetry, remote sensing and GIS, it is possible to establish national Spatial Data Infrastructure. The Digital GeoSpatial Data Framework in CSDI consists of digital orthophoto, digital elevation model and several layers of vector data including administration boundary, transportation, drainage as well as the database of geodetic control points and database of place names. The production efficiency of these framework data can be faster 5 to 10 times than vectorizing full-feature maps. It can meet the demand of rapid renewal of GIS caused by the rapid development of economy in China.

This paper discusses a series technologies used for collecting geospatial data. Most of them are mature and can meet requirement in accuracy. However, from the test, it is still difficult to get high accurate DEM by using digital photogrammetry. More research should focus to integrated spatial database including digital orthophoto, DEM and vector data, because this would be a large project for whole China. The pilot integrated spatial database only cover a city, which is just beginning for the research on the integrated spatial database.

ACKNOLEDGMENT

This paper forms part of "A Pilot Research on Provincial Spatial Data Infrastructure (under C95-02-02)", funded by National bureau of Surveying and Mapping. It also forms part of the following two projects: "Key Project Fund: The theory and key technologies on integration of remote sensing, GIS and GPS", funded by National Nature Science Fund Commission; "National Outstanding Young Researcher's Fund: An Object-oriented Integration Data Model In GIS", funded by National Nature Science Fund Commission.

This paper was written when Jianya Gong took an academic visitorship at Hong Kong Polytechnic University, which was funded by Croucher Foundation. The fundings from these sources are sincerely acknowledgment.

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