SDI CONSTRUCTION AND ITS APPLICATIONS IN URBAN PLANNING AND LAND ADMINISTRATION, WUHAN, CHINA

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KEY WORDS: SDI, GIS, Urban planning, Land administration

ABSTRACT:

Over the last decade a number of spatial data infrastructures (SDIs) have been successfully established at various government levels world-wide. This paper introduces the establishment of Digital Wuhan SDI, the pilot project of Digital City project initiated by the Construction Ministry of China in 2001. The objectives of the SDI project include building up a centralized spatial database, the data production, maintenance mechanism and standard. The process of SDI construction includes the data content, database design and data processing of urban topographical maps, DEM, remotely sensed imagery, locational naming, and applications in urban planning, land administration and some other agencies are described.

1. INTRODUCTION

Following the early activities of the US Federal Geographic Data Committee in the 1990s, many countries throughout the world are recognising the importance of spatial information and the related infrastructure required for its management to ensure effective decision making (Steve Jacoby and Jessica Smith, et al, 2002). Spatial data infrastructures (SDIs) consisting of policies, standards and procedures aim to provide an environment that encourages co-operation in data production and sharing (Federal Geographic Data Committee 2000, Rajabifard et al. 2000). Over the last decade a number of countries and states have successfully established complete spatial data infrastructures (SDIs) incorporating core digital map bases such as the cadastre or land parcel layer, topography, hydrology, road networks and administrative boundaries (Steve Jacoby and Jessica Smith, et al, 2002). At the same time many cities or Local Governments world-wide have established their own SDIs although they are more commonly referred to using the generic term of geographical information systems (Suwanarat et al. 2000).

This paper describes the successful establishment of Digital Wuhan Spatial Data Infrastructure, including the data content, database design and data processing of urban fundamental topographical maps, DEM, remotely sensed imagery, and locational naming, and its applications in urban planning, land administration and other government agencies.

As background, Wuhan Urban Planning and Land Administration Bureau is responsible for the establishment of Digital Wuhan SDI in Wuhan Municipality. The bureau is also in charge of such departments as Information Center, Institute of Surveying and Mapping, Institute of Urban Planning, Institute of Transportation Planning, and eight sub-bureaus. The Information Center is the core member and the umbrella agency for these departments to establish the SDI, The Institute of Surveying and Mapping is responsible for topographical map data production, maintenance, the Institute of Urban Planning is responsible for planning related information production.
In 2000 the bureau initiated the urban planning spatial database project, which purpose is to integrate the most common used spatial data to meet the need of its activities. This is a solid foundation for the SDI. The Digital Wuhan SDI was initiated in 2001, and the project was also a pilot project of the Digital City project initiated by the Constriction Ministry in 2001. The SDI project is a five-year plan, which is divided into three stages: The first stage is to design the general framework of SDI, and work out the data standard, the data exchange standard, etc. The second stage is the implement stage, various database should be built up, which include, topography, administration boundaries, cadastral parcels, ortho maps, DEM, etc. The third stage is the application development, based on the spatial database; the applications for urban planning, land administration and transport administration are to be developed.

2. THE STUDY AREA

2.1 Study Area

As the capital of Hubei Province, Wuhan is the largest mega-city in central China and in the middle reaches of Yangtze River (Fig. 1). The Yangzet River and the Han River pass though Wuhan and divides Wuhan into three parts. Wuhan municipality is administratively stratified as district, sub-district (organized by street committee) and neighbourhood (by residential committee). Wuhan has a population of near 800 million with the total area of 8549 km^2 and urban areas of 1100km^2.

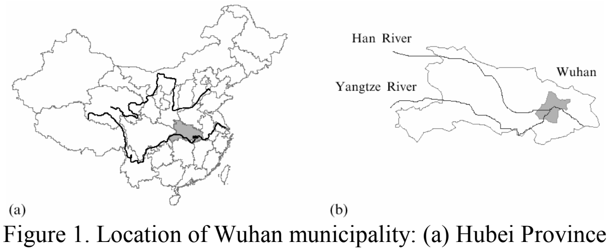

Figure 1. Location of Wuhan municipality: (a) Hubei Province (shaded area), and (b) Wuhan (shaded area) in relation to Hubei Province.

2.2 Objectives

The objectives of the project can be summarised as following:

- To design a framework of data production, management, updating workflow and the data standard.
- To build up the multi-source, multi-scale and multi-temporal, centralized urban spatial database covering the whole Wuhan municipality using the same GIS platform, spatial database, and standards.
- To build up a distributed system for spatial data updating and centralized maintenance to make sure the data to be up-to-date, provides quickly access to the data using GIS.
- Build up the spatial data distributing and sharing mechanism based on the city wide-band network, reduce the duplication of spatial data maintenance.
- Deploy applications in the Wuhan municipal government agencies, especially the Urban Planning and Land Administration Bureau. Through the applications, to enrich the spatial database, thus providing more spatial data to other applications.

2.3 Data Sources

Data are produced by different departments. According to the purpose of SDI construction, the data most needed are listed below:

- Spatial reference data includes the ellipsoid, datum, projection and the control points.
- The fundamental topographical map, which includes the topographical maps, includes the 1:50000, 1:10000, 1:2000, 1:500 scale topographical maps, DEM and remote sensed imageries.
- The cadastral parcel data, which records the land tenure, location, area, etc. information, which is the base of land administration.
- Utilities and facilities, includes the pipelines, sewer and also the public facilities such as schools, hospitals.
- Natural resources data includes the geology, mineral and land cover data.
- Geographical names and address, for the purpose of locating and querying.
- Administrative boundaries. For Wuhan municipality, the administrative level is divided into three levels: district, sub-district (organized by street committee) and neighborhood (by residential committee).
- The construction control information includes the urban historic buildings, historic zones and the utilities preserved land use, and also the flight protection zone.
- Social-economic information, include the statistical unit, census information and economic information. The statistical unit is the base unit to collect statistical information, and also the unit can be aggregated into higher-level statistical units.

The data were produced by different departments with different data format and different precision, to integration the data using the same software, the data standardization and convert to the same format is necessary. For effectively convert the data and minimize the data loss in the data conversion process, a standard is first put forward to pre-process the data for data conversion, the data convert can be performed. After the data were standardized, they are all converted into the ESRI Shape format.

3. THE GENERAL FRAMEWORK

The SDI is built within the network environment. the database software Oracle and the spatial data gateway ArcSDE are selected for spatial data storage and management, and the system developed based on ArcGIS to display, query, updating, manage, maintain the spatial database. The system is composed of the data maintenance sub-system, the info query sub-system and the information publish sub-system. The ArcGIS, ArcIMS and Mapobjects software are chosen for application development. The maintenance sub-system is developed using ArcGIS, the ArcMap is used for spatial data mapping, editing. Batch import, export, updating data is developed using Visual Basic for application in ArcCatoalog, the spatial data view, query sub-system is developed by Mapobjects embedded in Visual Basic, the ArcIMS based map publishing sub-system employed the Internet technology so that the users can access the data via city wide-band network. The figure 2 illustrates the general framework of the SDI.

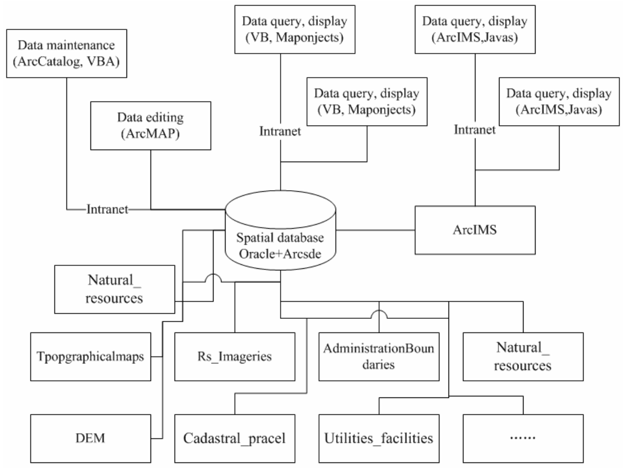

Figure 2. The general framework of the Digital Wuhan SDI

4. SPATIAL DATABASE CONSTRUCTION

4.1 Data Organisation

Large volume of data with different spatial content, format should be organised and integrated. Of the most popular data organisation method, by map sheet or by layer, either has its advantages and disadvantages. By map sheet means to store the large data into map sheets, by layers means to divide the data vertically into different layers, such as buildings, roads, water bodies, vegetation. Since that the data is stored into RDBMS, each layer is stored as one or more linked table or tables, and each feature in the layer is represented as a record in the RDBMS, taking the advantage of the large volume data management ability, the data are organised by layers. The data organised using the ArcSDE geodatabase concepts, according to the data category, 8 feature datasets were designed to store the data, for each feature dataset, the Gauss-Kruger projection with Krasovsky ellipsoid is selected as spatial reference with the same spatial extent, within each feature dataset, feature class is selected to represent the layer. The SDI in nature is a multi-scale spatial database, for the data structure, McMaster and Veregin (1996) proposed a hierarchical data structure for the data organisation. In this database design, the simple way is used, for the multi-scale data, the different scale topographical data are organised into separate datasets. Table 1 is the feature datasets and the feature classes.

Feature dataset	Feature class	Feature type
Administration Boundary	xiangjie	polygon
	qujie	polygon
	jiedao	polygon
	cunjie	polygon
GeographicName	geoname	point
TopographicalMap2K	grid2000	polygon
	building	poyline
	road	poyline
	vegetation	poyline
	waterbodies	poyline
	annotation	anno
	elevation	point
	countor	line
	adminbound	line
	……	……
TopographicalMap500	grid500	polygon
	building500	polygon
	……	……
Cadastral_pracel	pracle	polygon
Utilities_facilities	swage_line	line
	swage_point	point
	……	……
Natural_ resources	landcover	polygon
	mineral	point
Construction control	plan_control	line
	historic_zone	polygon
DEM	DEM	raster
RsImage	aerialphoto	raster
	quickbird	raster
	spot5	raster
……	……	……

Table 1. The feature datasets and feature classes

Most feature datasets are organised as feature layers, except such raster dataset as the remote sensing imageries and DEM are organised. For topographical maps of 1:2000 and 1:500 scale, the maps are produced and updated by map sheet, when converted into RDMBS, the map sheet grid feature class is introduced to record the metadata for the topographical maps. For the map sheet grid, the grid has the same coordinates with the map sheets, in the grid, each polygon represents a map sheet, Figure 3 illustrates the map sheet grid.

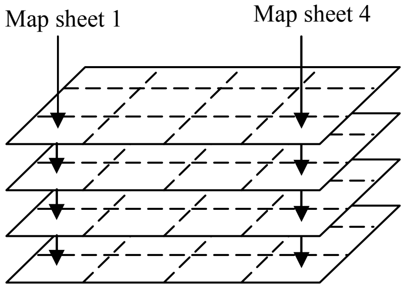

Figure 3. The map sheet grid

The polygon records the information of grid id, data upload time, the map sheet production time, etc of the correspond map sheet, the production time is also the updating flag for the map sheets. And also, the grid is a level of index, when upload the data, the features in the logical layer in the map sheet are converted to the correspond layers in the feature class; also the grid id is assigned to the features attribute. The production time of the map sheet is recorded in the Updatetime field in the correspond grid for the updating purpose.

For the physical storage of the data, the feature data, raster data, and redo log files are stored in different oracle tablespace located in different hard disks, thus to enable the oracle flexible architecture and optimize performance.

Feature type: simple feature Geometry type: polygon		
Feature class:grid2000		
Field name	type	length
ID	Object	4
Xuhao	Char	10
Tuhao	Char	10
Mapflag	Integer	2
Updatetime	Date	8
Logintime	Date	8
Shape	Shape	4
Shape.Area	Double	8
Shape.Len	Double	8

Table 2. The grid for 1:2000 scale topographical maps

4.2 Data Processing

After all the data were processed and standardized, the data were loaded into Oracle via ArcSDE spatial data gateway using ArcCatalog and customised tools, the data includes:

1. Spatial reference and control information: More than 10000 control points with different accuracy were put into database.
2. Topographical maps
    a. 1:500 scale topographical maps in urban areas of 380 km^2.
    b. 1:2000 scale topographical maps in urban and town areas of 1800 km^2.
    c. 1:5000 scale topographical maps covers 860 km^2.
    d. 1:50000 scale topographical maps covers 8549m^2.
    e. 1:8000 aerial photos acquired in 2001, covers 1200 km^2.
    f. Ortho-rectified QuickBird imageries with resolution of 0.61 meters acquired in 2002 and 2004, covers the urban areas of 1160 km^2 and 270 km^2, respectively.
    g. Ortho-rectified SPOT5 imageries with resolutions of 2.5 meters acquired in 2002, covers the whole Wuhan Municipal areas.
3. Extended data
    a. Geographical name, which includes more than 10000 names, with different types such as

administrative names, river names, mountains, buildings, road names, etc.

b. Administrative boundaries, includes detailed boundaries of 13 districts, 108 streets and the 2033 villages.

c. DEM: for the urban areas, the elevation points, contours, water bodies, and other features are selected from 1:2000 scale to create TINs, and then convert to grids with resolution of 2.5 meters, for the whole Wuhan municipal area, the DEM with resolution of 5 meters is created from 1:10000 topographical maps.

4. Cadastral data, the registered cadastral parcel in the urban areas about 110 km2 includes land tenure, location, tax, land use, etc.

5. Utilities and facilities
   a. Pipelines: all kinds of pipelines include swages, cable TV, service pipe, power, gas etc, have been surveyed, with total length about 7980 km.
   b. Public facilities, includes the capacity, area, build-up area of schools, hotels are surveyed.

6. Natural resources
   a. More than 70000 mineral holes information.
   b. Land cover: the land cover information covers the whole Wuhan municipality.

7. Construction control information
   a. Urban planning control information includes the road control, water protection area, the green land protection area.
   b. Historic building protection area.

4.3 Data Maintenance

The centralized spatial database were built up and maintained by the Information Center. To make the database up-to-date, a detailed data update plan and mechanism is made. Since the data come from different agencies, data production agencies are responsible for data updating, the Information Center is responsible for data integration and data maintenance, The Institute of Surveying and Mapping is responsible for topographical data updating, the updating process is a remote control to the central spatial database via the city wide-band network by customised tools developed in ArcCatalog. The privileges accessing the database are strictly controlled. The users of the database are divided into 3 groups, the administrator, the data owner and data viewer. The administrator has the all privileges to control the database, the data owner has the privilege to select and update the specified feature datasets, and the data viewer has the privilege to view, query, and select the specified feature datasets. To ensure the database security, a hot backup job is created to backup the data to the tape weekly.

5. APPLICATIONS

The Digital Wuhan SDI has been used in urban planning and land administration after its establishment, and numerous benefits have been achieved.

5.1 Applications in Urban Planning and Land Administration

Based on the Digital Wuhan SDI, the application tailored for urban planning and land administration is developed. The application have the abilities of quick access the quality, various, up-to-date spatial data needed in examination activities, the data can be accessed via the intranet of the bureau and also via the wide-band network, this has greatly improved staff productivity and customer satisfaction due to quick access to quality, electronic information, and also the comprehensive, quality information provides protection against loss of staff with ‘local knowledge’. And the information can be shared between the bureau and the sub-bureaus, for most of the urban planning projects, topographical maps, cadastral parcels, land lease information, and planning control information are needed in the examination procedure. Before the establishment of the SDI, the data collection has long been a labour and boring job. After the successful establishment of the SDI, the data can be easily and quickly be accessed, such that the staff can make more concentration on the scenario comparison, analyse and optimisation.

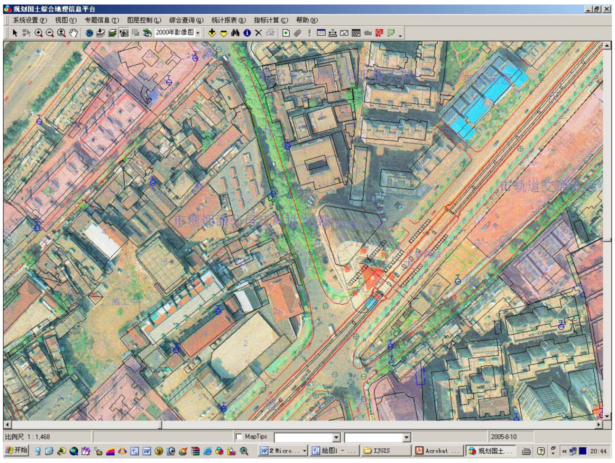

Figure 4. Quick access to various spatial data

5.2 Applications in Decision Making

The Digital Wuhan SDI has been used in the site selection for the Chemical Ethane Factory by using the GIS multi-criteria evaluation method. The topographical maps, DEM, mineral information, the road networks together with other data are selected to determine the best site. Also the SDI has many successful applications for the site selection decision.

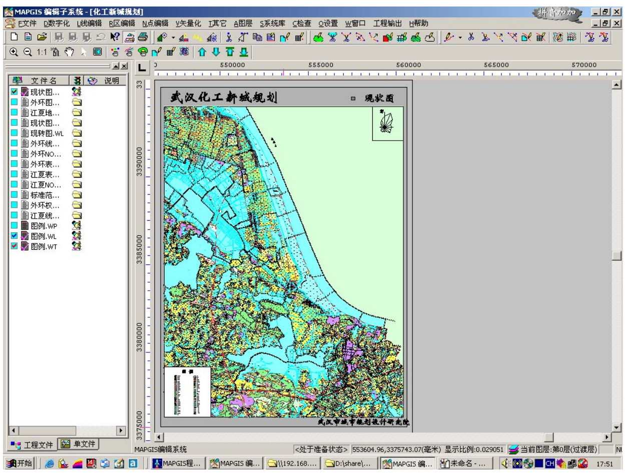

Figure 5. Site selection for the Chemical Ethane Factory

5.3 Applications in Public Service

The Digital Wuhan and Urban planning and land administration online website (www.wpl.gov.cn) by Wuhan Urban planning and land administration bureau provides lots of urban planning and land administration information to the public, which includes: the approved construction projects, the regulation planning, the green land protection, the water bodies protection, the historic protection zone, the land lease information, land reservation, the utilities projects, the demolition of the old buildings, etc. The website provides a interactive method for public participation. The website also provides a navigation map for the public, the detailed maps includes road networks, lakes, rivers, geographical names, street names, bus stops and routes, and provides the functions of bus routes, and the optimise route query, location query, etc.

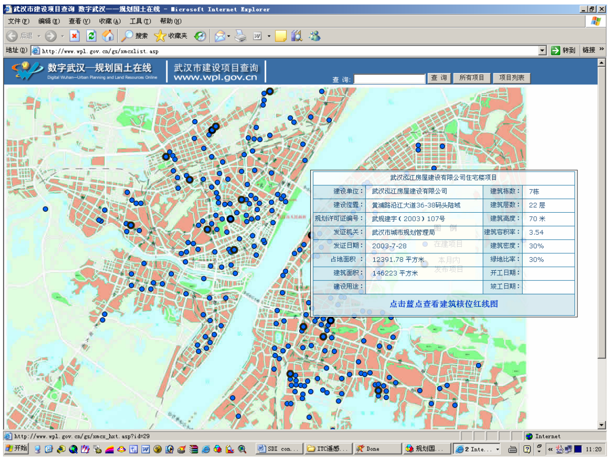

Figure 6. The approved construction projects on the website

The SDI was also provided to the other government agencies via the wide-band network, which changes the way of information usage. In the past, all the data needed shared by copies, thus the maintenance of the spatial data is laborious. The departments have to maintenance all of the spatial data themselves, and the spatial data updating is time consuming. With the establishment of the Digital Wuhan SDI, the government departments can access the data via the network, they only need to maintain the data produced by themselves, thus results a marked reduction in duplicative spatial data maintenance activity.

6. CONCLUSIONS

After 5 years of efforts, the Digital Wuhan SDI is nearly accomplished. The multi-source, multi-scale and multi-temporal spatial database, which incorporates the fundamental topographical maps, urban planning and design maps, land resources information, approved and examinations information and urban 3D models, have been built up. All these data are managed using the same GIS and RDBMS in the Information Center, and these data have been widely used by governmental agencies, and numerous benefits have been archived.

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ACKNOWLEDGMENTS

The authors gratefully wish to acknowledge the members involved in the SDI project.