SDI construction and its applications in Wuhan Municipality, China

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SUMMARY

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 Wuhan SDI, the pilot project of Digital City project initiated by the Construction Ministry and State Bureau of Surveying and Mapping of China. After 10 years effort, the centralized multi-scale, 2D & 3D geo-spatial database were built up, which integrates the multi-scale topographic maps, aerial photos, satellite imageries in different times, the DEM and urban 3D models covered the Wuhan municipal area, about 8494km^2. the web service based geographic information platform were deployed, and the OGC standard interface were provided to enable authorized users to access the geo-spatial database freely. And also the data maintenance mechanism and standard were formed. The applications of the geo-spatial database and the platform in land resources administration, urban planning censes, real estate, policy GIS, urban management, social management and other fields are described in this paper.

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1. INTRODUCTION

Following the early activities of the US Federal Geographic Data Committee in the 1990s, many countries throughout the world are recognizing the importance of spatial information(Singh, P.K., 2009) and the related infrastructure required for its management to ensure effective decision making(Steve Jacoby and Jessica Smith, et al, 2002). After over 10 year's development, SDIs on different scales (national, region and city) are established, which have greatly enhanced local economic & society development and geographical application. This article mainly describes the construction and application of Wuhan SDI.

1.1 Background

Wuhan initiated construction of SDI in 2000, it was an important content of Digital Wuhan, and it is also the pilot project of the Digital City project initiated by the Construction Ministry. This project was completed in 2006 and was identified as China's first built Digital City SDI. After that, the second phase of Wuhan SDI continuted, it was the core of "Digital Wuhan Geospatial Framework" which was the pilot project promoted by National Administration of Surveying, Mapping and Geoinformation. This project was finished in November, 2011. The SDI project is a long-term plan, which can be divided into three stages: the first stage is to design the general framework, and work out the data standard, the data exchange standard, etc. The second stage is the implement stage, various database were built up in accordance with uniform standards. The third stage is to deepen the platform, using the latest technology such as Web Service(David J. Maguire, 2005), Data Fusion, etc. to upgrade the platform, at the meantime, we initiated the construction of Wuhan 3D Digital Map.

1.2 Target and tasks

Wuhan SDI is subset of the China NSDI, it is the fundamental part of Digital Wuhan. The objectives of the project can be summarized as following:
   (1) Design a framework of data production, management, updating workflow and the data standard;
   (2) 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;
   (3) Build up a distributed system for spatial data updating and centralized maintenance to make sure the data is up-to-date, provides quickly access to the data using GIS;
   (4) Build up the spatial data distributing and sharing mechanism based on the urban wide-band network, reduce the duplication of spatial data maintenance;
   (5) Deploy applications in the Wuhan municipal government agencies, especially in the Land Resource and Planning Bureau. Through the applications, enrich the spatial

database, so as to providing more spatial data to other applications.

1.3 Architecture

Wuhan SDI is composed of five systems: data, technologies, standards, management and application.

(1) Data. Wuhan SDI dataset have the characteristics of multi-source, multi-scale and multi-temporal, the dataset include the natural and social information such as topography, pipeline, realm and their basic properties. Based on this basic information, we can easily overlay other social and economic information.

(2) Technology. The construction of SDI needs a series of theories, technologies and workflow, which covers from data collection, processing, updating to data management, sharing, distributing and service. The technologies include earth information science, cartography, remote sensing, GPS, spatial data processing, virtual reality, computer network, security, artificial intelligence and expert systems, etc.

(3) Standard. The standard covers reference system, data model, data dictionary, data acquisition, data quality, data exchange and metadata standards.

(4) Management mechanism. It refers to relevant mechanism and policy which includes data producing, management, updating, distribution and sharing. In order to make best use of SDI, data integration & management agencies should be set up and responsibilities should be defined, thus to establish management mechanism to normalize the whole work.

(5) Applications. The SDI applications cover governments, industries and the publics. The government application includes E-government, decision making, emergency command, etc. Industry applications mainly refer to various topic-oriented applications developed based on SDI. Public applicatiions are internet-based, which enable the public access the maps, POIs, LBS services, navigations.

2. ACHIEVEMENTS AND CHARACTERISTICS

After over 10 year's effort, Wuhan SDI has completely been built up, the multi-source, multi-scale and multi-temporal spatial database covering the whole city were built up, and the common geographic information platform was depolyed, and a wide range of applications were utilized in different fields, at the same time, we also formed a set of standards, specifications and mechanisms. The characteristics are listed below:

2.1 Rich data content

With the rapid advance of technology, geospatial data is still at the heart of SDI, and data coordination will always be an important SDI activity.(Open GIS Consortium, 2013). After many years of continuous effort, different types of spatial data have been integrated into our uniform spatial database, and it is worth mentioning that the 3D city model has completely covered the main district, and in a leading position in China. Tab.1 lists the fundamental geographical data:

Tab.1 Data content of Wuhan SDI

No.	Data Content	description
1	Geospatial reference	Spatial reference data includes the ellipsoid, datum, projection and the control points
2	DLG	topographical maps, includes the 1:50000, 1:10000, 1:2000, 1:500 scale topographical maps
3	DEM	5m spacing grid covering whole city, 2.5m spacing grid covering central city
4	DOM	Remote sensing image since 2000, covering whole city having the area of 8494km^2
5	3DCM	Frame model covering 8494km^2, fine model covering over 600 km^2
6	Pipelines	
7	Street view data	Covering the main district of more than 500 km^2, and the whole length added up to more than 6000km
8	Geographical names and address	About 620,000 geographical names, more than 70,000 address
9	Government information	1402 layers
10	2.5D electronic map	Covering the main district

Besides, Wuhan SDI also integrated other thematic information, such as land administration information, planning data, public facilities data, natural resource data and social-economic information, etc.
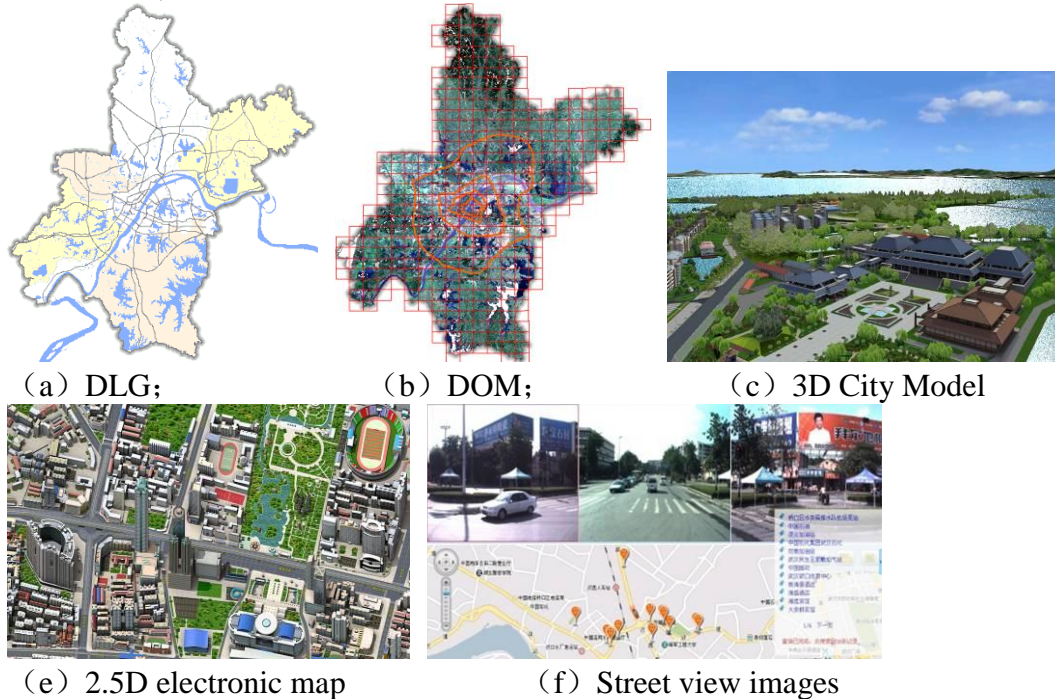

（a）DLG；　　　　　　（b）DOM；　　　　　（c）3D City Model

（e）2.5D electronic map　　　　　（f）Street view images

Fig.1 Data content of Wuhan SDI

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2.2 Large-scale, inter-discipline applications

Based on Wuhan SDI, we have successfully built various applications, among which some are government oriented, some are urban management oriented, and some are public service oriented. Up to now, more than 20 applications were built up, such as comprehensive information platform for land-use and planning, urban grid management system, urban construction lifecycle management system, population and houses management system, social comprehensive management and services system, etc. These applications are inter-discipline, together with isomerism data exchange and collaboration, and the number of agencies is added up to more than 80. Large-scale applications contributed to the formation of application mode, which in turn promoted more widely use of geographical information.

2.3 Combination of centralized and distributed sharing-service mode

Using the mode combining centralized and distributed, we set up Geographic Data Integration & Management Center characterized by physically dispersed and logic centralized citywide. It consists of a main data center and multiple sub data center, they work together to produce, management and maintenance geographical data(Michael G. Tait, 2005). Wuhan Geographical Information Center maintance the main center managing geospatial data resource, it provides a variety of services complying with OGC standards, and supports service registration, management and publish, other agencies is only responsible for their thematic data. All these data are logically unified, and the main center is the only entrance to the user. When receiving a request, the main center know how to get the data and extract it from its own database and other sub database, then back to the user.

2.4 Cross-platform service aggregation

Due to historical reasons, land use/cover data and urban planning data is managed separately by different GIS platform, in order to solve the problem of cross-platform and interoperability, we successfully realized effective aggregation of multi-source data and services using web services technology. By the support of unified resource discovery interface, we achieved the aggregation of MapGIS(a GIS basic platform widely used in China) and ArcGIS, avoiding the conversion between two different dataset. In the common platform, all data can be accessed by the unified interface without caring about which GIS platform is indeed running the service. Different data can be easily overlaid and queried, thus solve the problem of cross-sectoral, cross-platform data sharing.

2.5 A set of standards and specifications

During the construction of Wuhan SDI, we formulated a set of standards and specifications covering data acquisition, data processing, data management, platform construction, application and security standards, enhanced unified data management and application. At the same time, the establishment of a set of mechanisms for the platform management, maintenance and updating, it is not only useful to ensure the long-term operation of Wuhan SDI, but also useful to guide other cities SDI construction. The formation of the standards

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includes Technical Code for Three Dimensional City Modeling, Specification of Government Electronic Map Data, Specification of Government Information Layer and so on.

2.6 Customized online services

Spatial information services platform is designed to serve the municipal sector and the public at various level(A. Mansourian, 2008). Wuhan SDI provides common function such as online map viewing, querying and analyze, and it is can be also customized according to user needs. Users can utilize the data services and interfaces provided by the platform and customize the configuration of the services, thus to develop their own thematic application system to achieve the true sense of the thematic application service system, personalized features enhanced geographic information services.

3. APPLICATIONS

Base on Wuhan SDI, more than 20 applications have been established, serving for government, enterprises and the public. Through these applications, the SDI data content were enriched. Followings are some typical applications:

3.1 Applications in urban planning and land administration

Based on the 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 labor and boring job. After the successful establishment of the SDI, the data can be easily and quickly accessed, such that the staff can make more concentration on the scenario comparison, analyze and optimization.
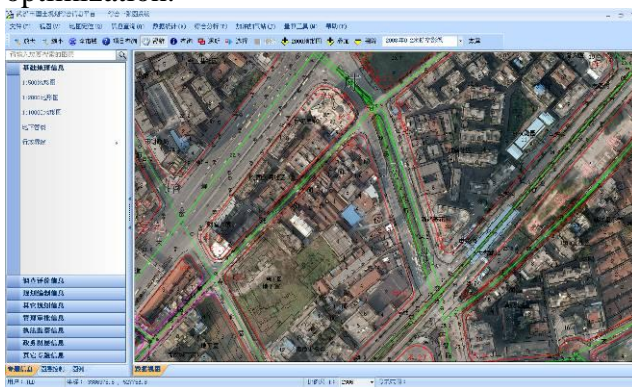

Fig.2 Quick access to various types of information

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3.2 Application in City Grid Management

City grid management is a new city management manner. As the basic unit of a certain geographical area, under the jurisdiction of the region is divided into a number of grid-like units, each grid assigned a supervisor, whose task is monitoring, handling local affairs, headed by clear levels geographical jurisdiction of city management responsibilities person, hierarchical management space, classification, region-wide management. Wuhan city grid management system is developed on the basis of Wuhan SDI, and realized centralized management of 7 districts, 88 streets, 939 communities, 8430 grids and 2,060,000 urban features, geographic information can be accessed by the city and district level through online service, thus improving the management efficiency, saving management costs.

3.3 Applications in social management and service

Social management innovation is a new issue of social management, it uses new social management philosophy, knowledge, technologies, methods and mechanisms to transform the traditional management models and methodologies to improve and reform, and its purpose is to make society better order, thus to gain more desirable political, economic and social benefits. This project is also developed based on SDI, it integrated various information comes from 21 geovernment departments, such as land resource and planning bureau, public security bureau, housing security and management bureau, civil affairs bureau, population and family planning commission, urban management bureau, industry and commerce bureau and etc., and developed social management and service information system which is the typical case of integrated application of SDI. Up until now, the urban areas were divided into about 9300 irregular grids, each grid is assigned an unique code. The functions includes information collection, contradictions resolving, analysis, command and dispatch, and established a mechanism of linkage among city, district, street, community and grid level, which enhanced social management and service levels, and effectively safeguard the city of peace, harmony and stability.

Fig.3 Wuhan social management and service platform

3.4 Applications in public service

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www.wpl.gov.cn is the website for the public, based on the SDI, the common geographic information such as transportation, water, residential area and other information related to public living were extracted and published on the internet, thus the public can view, query city map and various information like government agencies, financial sites, schools, hospitals, dining and leisure, so as to enhance the convenient of our living.

And we also provides lots of land administration and urban planning 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.
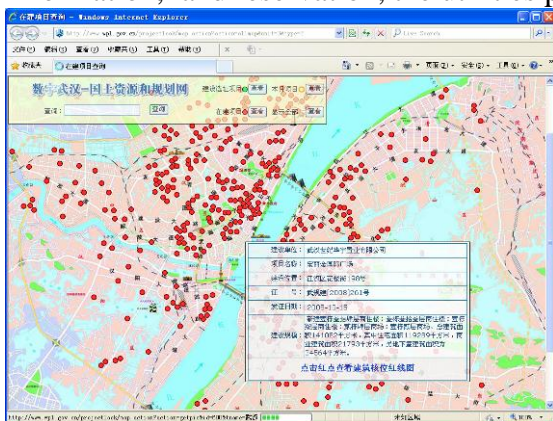
Fig.4 Constructing project query   Fig.5 www.digitalwuhan.gov.cn

4. DEVELOPMENT AND PROSPECT

After the construction during 10th and 11th five-year plan period, Wuhan SDI has been fully completed and widely used, and achieved good economic and social benefits. With the progress of society and the continuous development of the information technology, as an infrastructure, spatial information resources are constantly penetrated into urban construction, management, and all aspects of daily life, its value being more and more attention, and SDI is still in continuous development(Chaowei Yang, 2010). Smart city construction in the ascendant, Wuhan start the general plan and design of smart city in 2011, SDI and perception, network, cloud computing are considered as the infrastructures of Smart Wuhan, and has been approved by the municipal government, It can be predicted that Wuhan SDI will meet new opportunities for development.

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