FAST UPDATING OF NATIONAL GEO-SPATIAL DATABASES WITH HIGH RESOLUTION IMAGERY: CHINA'S METHODOLOGY AND EXPERIENCES

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ABSTRACT:

Geospatial databases are irreplaceable national treasure of immense importance. Their up-to-dateness referring to its consistency with respect to the real world plays a critical role in its value and applications. The continuous updating of map databases at 1:50,000 scales is a massive and difficult task for larger countries of the size of more than several million's kilometer squares. This paper presents the research and technological development to support the national map updating at 1:50,000 scales in China, including the development of updating models and methods, production tools and systems for large-scale and rapid updating, as well as the design and implementation of the continuous updating workflow.
The use of many data sources and the integration of these data to form a high accuracy, quality checked product were required. It had in turn required up to date techniques of image matching, semantic integration, generalization, data base management and conflict resolution. Design and develop specific software tools and packages to support the large-scale updating production with high resolution imagery and large-scale data generalization, such as map generalization, GIS-supported change interpretation from imagery, DEM interpolation, image matching-based orthophoto generation, data control at different levels.
A national 1:50,000 databases updating strategy and its production workflow were designed, including a full coverage updating pattern characterized by all element topographic data modeling, change detection in all related areas, and whole process data quality controlling, a series of technical production specifications, and a network of updating production units in different geographic places in the country.

1. INTRODUCTION

A modern country requires both accurate base maps and geo-spatial data which are basic components of national spatial data infrastructure (NSDI) [Kelmelis, et.al, 2003]. Base maps refer to the largest scale or highest resolution maps in the topographic mapping series of the country, and geo-spatial data is its digital format. But the latter contains more information than the traditional base maps. Since the middle of 1980s, substantial human and financial resources have been devoted to create geo-spatial data and maintain national geo-spatial data bases by National Mapping Agencies (NMAs) in the world [Chen and Che, 2003]. The United States Geological Survey (USGS) had set up her national geo-spatial databases by converting approximately 55,000 individual quadrangle base maps at 1:24,000-scale till the end of 1990s [Kelmelis, et.al, 2003]. The Ordnance Survey of Great Britain (OS) completed its digital database in the middle of 1990s at the very large map scale of 1:1250 (in urban areas), 1:2500 (in populated rural areas) and 1:10,000 (in mountains and moorland) [Newby, 2010]. The National Administration of Surveying, Mapping and Geo-information (NASG, formally SBSM) of China completed her first highest resolution geo-spatial databases at 1:50,000-scale with approximately 24200 map sheet in the middle of 2000s. These geo-spatial databases are irreplaceable national treasure of immense importance and have been widely used by government agencies, citizens, non-governmental organizations (NGO) and private sectors [Chen et. al., 2002].

Geo-spatial data is digital abstraction and representation of our real world and its value will decrease dramatically if they are not kept current (Ryan, 2002, Chen et.al, 2007). Up-to-date information provides a base for a large number of applications, including local, regional and global resources monitoring, land-cover and land-use change monitoring, and environmental studies [Hussain et. al., 2013]. Here the data up-to-dateness refers to the consistency of the data objects and the geographical entities in the real world [Heipke et.al., 2008]. When changes occur in the real world and exceed a certain threshold, the geometric and attribute components of the corresponding data objects need to be modified and updated. Frequent updating of map data has become a huge task for national mapping agencies. USGS started to create new digital topographic map products since 2009 by combining selected features from the National Map databases with new imagery, some other publicly available and commercial data source, leaving the base data of the National Map databases not updated [Craun, 2010]. A thorough updating of Chinese national 1:50,000 database was implemented by NASG from 2006 to 2011 to improve its data up-to-dateness and enrich the data contents. An annual updating was followed since 2012.

This paper presents China's updating methodology and experiences of national 1:50,000 data sets using high resolution imagery. Section 2 gives a review of related works. The updating strategy and major techonuly are described in Section 3. Section 4 nd n of primary imagery data and its integration with other source data are discussed in section 3.

2. RELATED WORKS

Geo-spatial data updating is different than its original database creation in both information extraction and the subsequent processing [Chen et.al, 2007a; Heipke et.al., 2008]. All the spatial data objects are extracted and represented through the collection and modelling of their geometric and attribute components as well as topological relations during the original database creation. The primary objective of the updating is to capture the changes since and to modify all the affected data objects. Identifying differences between the existing data sets and the current world is therefore a key issue of updating. This requires up-to-date source data, such as high resolution remote sensed images, larger scale data sets, crowd- sourcing data, and other publicly available and commercial data source. All the available up-to-date multi-source data needs to be collected and integrated to satisfy a predefined up-to-dateness requirement, such as half year, one year, etc. Such an updating may be implemented with a predefined periodic cycle (annually or multi-annually) or on the basis of an on-demand service [Cooper and Peled, 2001]. Many updating projects have been using remote sensed data at high resolution in topographic data updating [Holland et.al., 2006], land use updating [Malinverni et..al., 2011].

The extraction of change information from imagery is another hot topics and a large number of change detection algorithms have been developed [Malinverni et.al., 2011; Chen et.al., 2012]. However, change detection for updating topographic data is different than land cover change mapping. Existing topographic data should play as important prior-knowledge for change detection, but they had not been sufficiently used [Alexandre and ElÉOnore, 2007; Bouziani et.al., 2010]. They were often used as a simple classification result to compare to an image, or as a mask to extract the training sites on the image. The geodatabase holds other information (geometry, contextual relations between objects) that can be exploited in several steps of a change detection method [Baltsavias, 2004). They can be used as the seeds for tracking and topological constraints or other prior-knowledge [Alexandre and ElÉOnore, 2007; Pan Li, 中文].

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Assuring data quality is another key issue for updating with imagery. Both reality consistency and logical consistency need to be considered [Heipke et.al, 2008].The former is related the up-to-dateness of the imagery used and can be validated by comparison of the data to the real world. Further improvement can be achieved by filed inspection, or the utilization of any other auxiliary source data. The latter refers to the data model and can be checked by logical reasoning to keep the new data logically consistent with the existing data. For instance, spatial inconsistencies may exist between features after data updating and such spatial conflicts need to be detected and corrected [Chen et al., 2007b]. Other logical checking should be performed using the data set and the specifications of the data model, such as format specifications, topological constraints, uniqueness of identifiers, and domains of attribute values are typical relevant criteria [Heipke et.al, 2008].

A significant distinction can be found from the operational updating practices and experimental updating studies. For a mapping agency in charge of operational updating, it is desirable to capture and maintain topographic information as efficiently and rapidly as possible [Holland et.al., 2006]. Operational land cover updating requires close attention to product consistency and accuracy, and a practical approach to meet with product delivery dates [Hansen and Loveland, 2012],. An appropriate updating methodology needs to be developed by NMAs according to their user requirements, technical innovation, financial capability, partnership collaboration and others.

3. UPDATING STRATEGY AND METHODOLOGY

3.1 General strategy

National level geo-spatial database updating is a massive and difficult project, especially for the developing countries such as China with large area. In order to implement the first thorough updating of Chinese national 1:50,000 database in five years, the general strategy is to overcome the main challenges and develop systems to improve the efficiency and quality of geo-spatial database updating. Firstly, it should be to acquire to remote images covering the updating area, this is one of necessary conditions to updating geo-spatial database at such scale level database while there is no larger scale geo-spatial data to use. Secondly, the efficiency and robustness is very important for such huge task, so there should be a serials of tools for supporting to reduce the massive manual jobs. Finally, the selection and bettering of advanced technical mode is also a crucial strategy to benefit the economic cost and speed of the project.

3.1.1 Multi-source remote sensing images integration and use: Remote Images or DOM data is one of important products in geographic information database providing basic data image services, it is also taken as the basic data source for updating geospatial database based on image interpretation. Even though image data acquisition is becoming relatively easy with the support of new technologies such as digital aerial image processing , IMU / DGPS auxiliary aerial technology, high-resolution satellite imagery with less ground control. However，as mentioned above before, it is still a hard difficulty to acquire all images covering a very large area with a single senor such as big country of China in a short time.

To acquire the required image data of a large area for updating national 1:50000 database, there is no choice to use a variety of data sources to produce DOM. Generally, there are three main sectors of acquiring image sources, including aerial photography acquisition, ordering or satellite remote sensing images, and directly use image data collected from other departments.

From the viewpoint of economic costs, it is first choice to fully utilize and share DOM with other departments, since it is able to reduce the investment and waste. These image data sources could be from national level basic surveying and mapping, provincial level 1:10000 basic surveying and mapping , other departments and some special important projects, enterprises providing services, the required image resolution could be 1 meter (aerial image data) or 2.5 m (satellite image data) . However, generally, the existed data collection or sharing is not to meet to cover the required area and up-to-dateness. It is necessary to make use of aerial photography and satellite remote sensing means to achieve a complete coverage of the task area work. Aside from the funding factor, it should be considered there exist a large number of difficult areas of image acquiring like cloudy and rainy all year round, such as Sichuan, Guizhou, Chongqing and other area. In order to ensure access to the required adequate image data results, it is necessary to firstly make scientific assessment for each region to achieve a complete coverage of the time period, further to strengthen risk control, determine image data source selection priority in different circumstances, and dynamically adjust the progress of image acquiring tasks.

However, it should be noted that there are significant differences among the existed images collected from other sectors and acquired images by airborne or space borne because of the needs and requirements for different application, their precision, image color , coordinate systems , metadata, etc. It should use coordinate system conversion, image automatic registration, automatic mosaic methods to realize the geometry consistency and color consistency of multi- source orthophotoes by automatic processing.

3.1.2 Data Capture of Updating With Interactive Image Interpretation: Data capture is one of three main basic tasks (verifcication, data capture, and logical consistency checking) (Heipke, 2008 congress book). Generally speaking, in spite of all the advances in the field, there is still a large gap between the theoretical work on fully automated object extraction and practical applications (Helmut Mayer, Stefan Hinz and Uwe Stilla, 2008 congress book).

Classic data capture of updating based on image interpretation includes the process of photograph control, field check, map editing, etc., these processes have clear interfaces between outdoor and indoor work. Field work relies on analogy photograph and simple stereoscope; indoor work reles on analog stereo pair, manual editing and quality check. Obviously, the classic method working in the analogy environment requires more staff but has low efficiency, it is almost impossible to achieve nationwide coverage for short period of production. This is a problem necessarily to be solved while updating geospatial database covering very large area.

With the development of computer and spatial information technologies, it has been true to turn the classic method into the digital environment with more computer aids, the most difference is to integrate the field work and home work into one unity together without clear interface, that is to say, some work at home such as map editing or data quality check can be possible to carry out together with field work. The new technological workflow rebuilt as seen in Figure1.

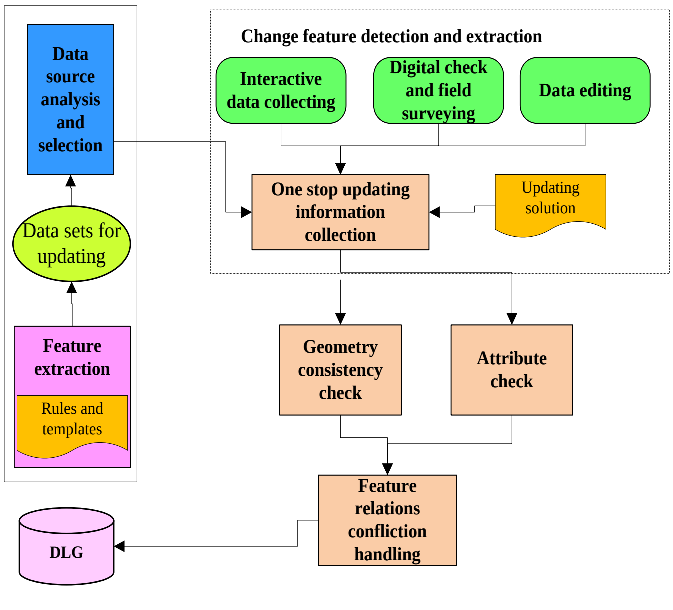

Figure 1. Change detection for updating from imagery

Based on the new integrated process of data capture from imagery, different production units flexibly arrange their production tasks according to their practical conditions, especially, for those with well-condition comprehensive technology, it could be permitted to update geospatial database with the new method of integrating field check work and map editing work to improve the efficiency of production and updating period.

3.1.3 Incremental updating: Incremental updating of geospatial database is one of more efficient methods. Incremental information is referred as changed content of geographic information between t1-t2 time, represented as Delta data captured. In the fundamental geospatial databases, geographic features can commonly use a " permanent unique identifier " to independently identify the ID, with geometric properties G and semantic property A. Its geometric property could be a combination of one or more graphic elements.

The core issue of incremental updating is to acquire incremental data accurately. Incremental data has three states including new, disappeared and changed. Currently, it is difficult to make computer accurately and automatically determine the states of actual evolution of a geographic feature before and after updating. In practical application of projects, the updating states of a feature need to be identified in an interactive way.

Comparing with fully updating mode, incremental updating mode only needs to capture and update geometric position and properties of changed features, also including relationships to be updated, it has advantages of lower cost and higher efficiency of updating.

Therefore, during the practical updating production incremental updating mode should be preferred to be used in order to improve production efficiency and reduce production costs.

3.2 Generation of large area image orthophotoes

For 1:50000 database updating, We produced 24761 mapsheets of DOM data, including 5065 mapsheets DOM data with multi acquisition date. For time phase of 1:50000 database, image acquisition date is not lower than the 2005 year. By analyzing the image data needs to be collected and integration, we updated more than 6000 mapsheets orthophoto data which acquisition date cannot meet the requirements.

3.2.1 Aerial orthophoto data production: In 1:50000 database update project, we have produced 6256 mapsheets DOM with one meter resolution using aerial photography data and high resolution satellite data (resolution better than 1 meters). In order to produce 1:50000 DOM data, The coverage area of 1 m resolution orthophoto data is shown in Figure 2.

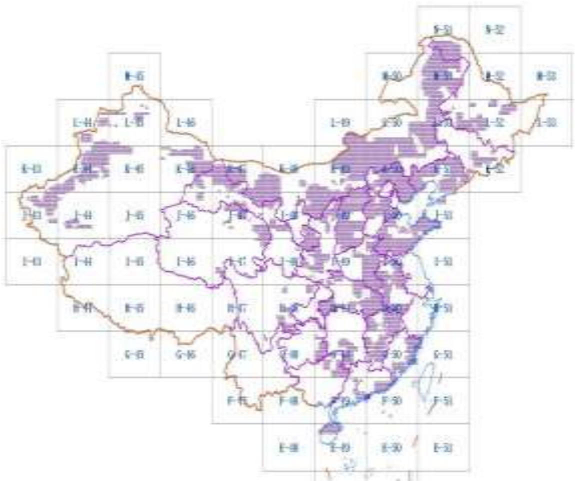

Figure2. The coverage of aerial images at 1m resolution

3.2.2 Satellite Orthophoto Data Production: We have produced 8713 mapsheets satellite orthophotos using SPOT5, P5, ALOS, IKONOS satellite image data. The coverage area of satellite orthophoto data is shown in Figure3.

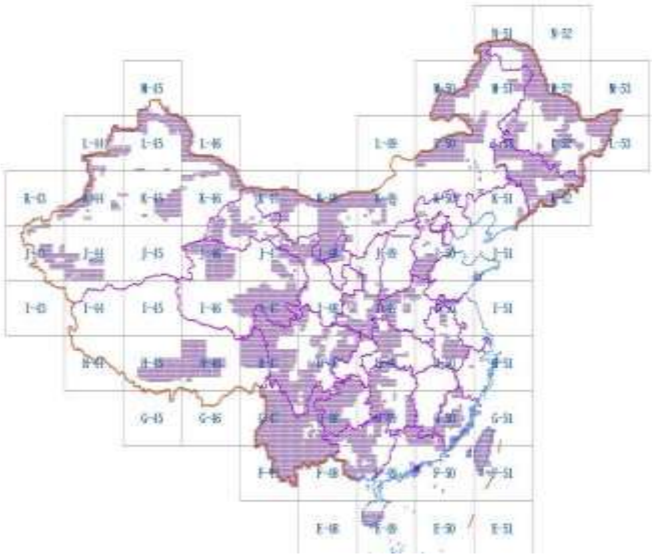

Figure3. The coverage of satellites Digital orthophoto images

3.2.3 Orthophoto data integration: From 2008 year to 2011year, we collected more than 9396 map sheets (some image data with multi acquisition date) , which was integrated process such image registration etc. The collected orthophoto data distribution shown in Figure3.

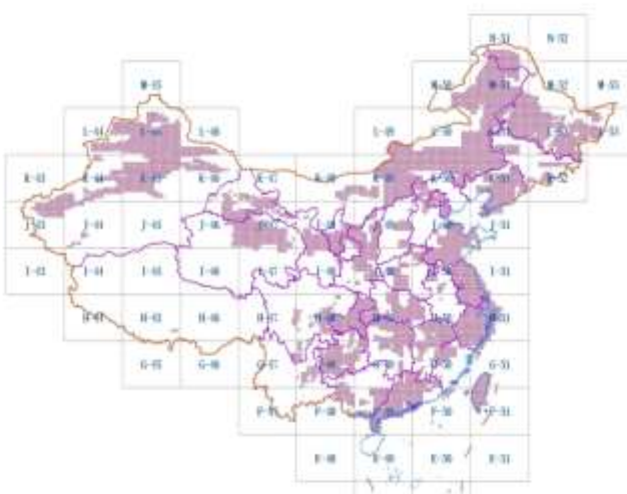

Figure 4. The coverage of collected digital orthophoto images

3.3 Interactive Change Detection Based on Orthophotoes and Image Information Extraction

From the point of view of workload and economic costs, change detection is geo-spatial database main work, but also difficult work. In particular, a large area of database updates need for effective change detection means and tools. Change detection mainly includes three key technology points: change information finding and utilization, change information extraction, relationships coordination and quality control. The overall technical processes are as shown below.

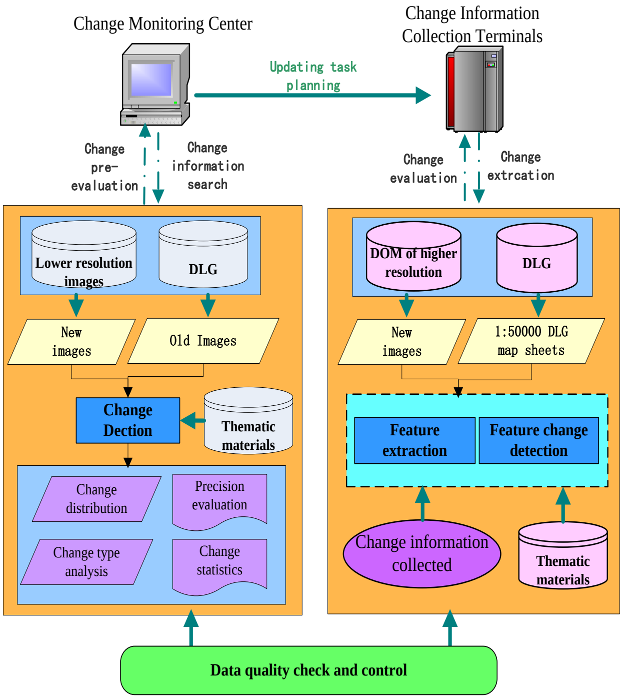

Figure5. Change detection for topographical features updating from imagery

3.3.1 Change Information Finding and Analysis:

Change information finding is the basis of change detection and data capture. Currently, there are several different ways to find change information.

Using data updating materials collected from other departments: The latest release of information about road changes, place name changes, boundaries changes, large-scale construction projects ,etc., should be collected from the authority departments, then the analysis of change should be given in the further step, and areas and feature types to be updated could be determined in terms of the required updating index.

Using remote sensing images: With the wide application of remote sensing images than before, it has been one of most efficient methods to use new remote sensing image against old images or vector data to make comparative analysis find changes. For very large area, especially, it might be a good choice to use lower resolution images to find changes, since the cost and efficiency could be better than high resolution images in evaluating the range and feature types for updating before carrying out updating data capture.

Using internet web information: It is another new way to make good use of modern internet technologies and web GIS to find changes, since most departments have established web portals to distribute all of kinds of information including changes of geographical features such as new built , modified or disappeared roads, buildings, rail ways and so on. However, there exist some difficulties, especially in automatically finding the reliable updating information from huge web data of texts and spatial information. It is necessary to develop related special system for capturing analyzing and marking change information of geographical features based on knowledge rules and web GIS.

The following table shows the different elements of the updates are generally applicable for change detection methods and update methods (● basically applicable, ○ partly applicable):

Methods	Control points	hydrography	Building	Transports	Pipeline	Boundary	Geomorphy	Vegetation	Place name
Using data updating materials collected from other departments	●	○	○	●	●	●		●	●
Using internet web information	●	●	●	●	●	●		○	●
Using remote sensing images		●	●	●			●	○	

Table1.Different change finding of methods for different features

3.3.2 Change Information Capture and Extraction:

Change detection and extraction of geographical features from imagery is one of main methods for capturing changed geographic features. The first step is to integrate all possible useful data into a production desktop software environment in terms of the requirements of the specifications of data product to be updated after finding and determine changed regions and feature types. These data should include old version data to be updated, new data source complying with the updating requirements of time and precision.

Then, based on new high-resolution orthophotoes and other reference data in the integrated data environment, changed information is captured and edited at home. During this process, changed information should be marked for further field checking and collection, if the position and attribute changes of some features could not be determined clearly.

In order to improve production efficiency of change information extraction, some of the following methods and means might be adopted.

(1)Seamless stereo image model generation and seamless integration of application technology: In common case, one unit of updating production area is covered by a serials of images, it is not convenient and efficient to directly use single stereo image model generated. A good strategy is to use all of single stereo image models to generate a seamless stereo model covering the unit of updating production, and integrate it as a kind of updating data sources into the updating production system. It will improve the efficiency of the work of image interpretation and field checking.

(2) Seamless exchange of indoor work and field work data: Data capture based on image interpretation includes two key steps of work, indoor work and field work. It is very crucial issue to integrate the data in the two steps for the higher efficiency. In traditional method without mobile spatial data capture instruments, the two steps are clearly separated, sometimes, the

software used indoor work and field work are different, data or information generated in the two steps need exchanged. In order to avoid the problems resulted from data exchange or transformation between the process of indoor work and field work, it is good choice to use the same data model and data structure used in indoor work and filed checking. Furthermore, of course, it is better to use same software platform to carry out the indoor work and filed checking.

3.3.3 Data Quality Control : Quality control is an important part of change detection in geospatial database updating of large area, the contents include two aspects: one is control of the usability and up-to-dateness of data with the latest images and other related information; the other is the assurance of precision and validity of change detection by the means of sample testing, visual inspection and "pseudo change" removal and logical consistency constraint relations checking and so on.

In order to realize or improve the efficiency of data quality check and control in data updating production, a set of data quality check models and rules are necessary. The models are in fact the constraints of relations models describing reality and relations between old and new features, even between various vector and raster data. Derived from these models, a serial of rules can be established for data quality control in an interactive environment, composed of three kinds of rules geometry, attribute and logic. Geometry rules mainly include the check of self-intersection of line, orientation, pseudo node, geometry type, map edging, etc; Attribute rules include the check of completeness, consistency value validity, etc; Logical consistency rules mainly refer to as the check of consistency relations of features, such as the relationship between water and contour, residential areas and roads.

It is difficult, even impossible to use a sole manual method to complete the data quality check in geospatial database updating production. In actual operation, there are three ways to be selected flexibly for data quality checking:

(1) Manually checking: Update results data are overlapped with DRG, DOM, field surveying results and other related data to check feature graphics, attributes, data tables, etc. in a manual way, and the correctness of update results can be determined. Obviously, this method is simple and easy to operate, but time cost is relatively much.

(2) Automatically checking：In order to reduce the manual work, some errors and inconsistency can be checked automatically with a software tool integrating the model and rules of attribute, graphic, logical relationship between graphical features, mentioned as above.

(3) Human-computer interactively checking：In some situation, errors and inconsistency can not been determined completely relying on computer programs, it is necessary to check in an interactive way, operators judge whether features and relations are correct or not.

3.4 Updating Database Method

Here, database update refers to the integration of captured data results into existing spatial database by three basic operations, i.e., creating, removing and modifying, to realize the integrated management and application services of updated features. Database updates must be performed in with the support of a specific spatial database management system. The main tasks include multiple types of massive data management and integration, updated data results quality check and control.

Spatial database integrated management and service release can be built based on C/S, B/S, or a combination of both methods, depending on data volume and application purposes. In order to provide stable and reliable spatial data management and services supporting massive data volume , generally, current commercial large spatial database engines such as ArcSDE or common open source database technology can be employed for the custom development, management and service with simple , efficient and reliable characteristics.

In the data update process, the related metadata also need to be updated, including data type, range, data volume, data update time etc. For the data of online service, the updating process is performed through data update tools, therefore clients does not need to re-connect to the server and can directly get the latest updated data.

4. LARGE AREA UPDATING PRACTICE

1:50K database updating project was implemented in China during 2006-2011. The updating range covered 80% of area of China, with 99% population and inhabitants and varied morphology such as coast, desert, mountains, forest. The project had two objectives：to improve the data up-to-dateness from 20-30 years to 5 years, and enrich the data contents from 100 layers to about 410 layers. There existed three difficulties: (1)Huge task: update 19,000 map sheets covering 7.6 million km2, get the best covering result under the current conditions; (2) New technologies: requires a transition from the exiting database develop. tech. to updating systems, the work flow need to be constructed, data quality need to cover the whole production process; (3)Limited budget: relative low budget for such a huge task with 5 years period.

4.1 Developed Production supporting systems

Since there are many differences between database update production and the "initial geospatial database construction", some key technologies of updating were developed to form the updating production technology system supporting for the large area updating production in China.

The following figure shows the overall architecture of update production technology system, composed of four main parts, multi-source data integration, change information detection, updated data processing, updated data distribution. With the aid of this system, based on the existing terrain data and maps, the new remote sensing images are used to capture changed data together with field check, to update 1: 50000 topographical database and related products.

Each part of this technical system includes a series of practical tools. Multi-source data integration section includes fast processing of ortho-mages , multi-source image integrated processing, semantic integration of thematic data from different departments; change information capture and measure includes portable data collection based on imagery, web based change information searching and processing, place name input and editing, metadata input and editing, etc.; updated data processing includes spatial conflict detection, DEM refinement interpolation and database-driven update topographic maps production, etc. ; updated data distribution includes updated data integration management, updated data service and release. In addition, the production technology system also includes data quality check and control system, and related standards such as update production methods, management, data quality technical standards, and so on.

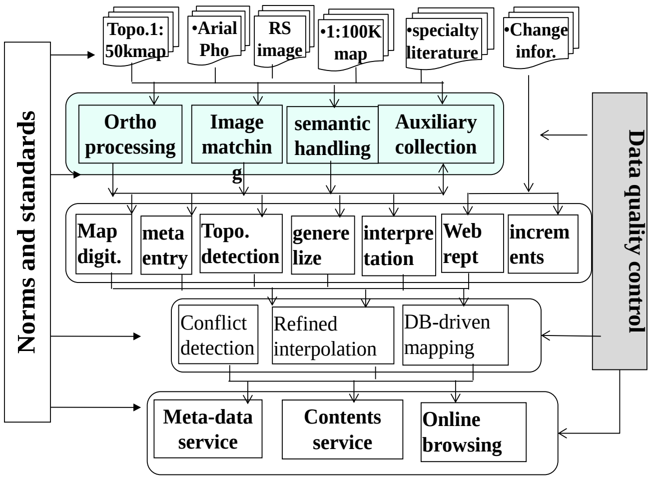

Figure 6. The framework of production system in support of updating 1:50000 database

4.2 Updating 1:50K database of China

The implementation of large area change acquisition and updating with imagery was employed by a series of software tools mainly including map updating software based on image interpretation.

The software is able to achieve the integration of data from multiple sources, changes in information collection, the quality check to final updated data submission to the entire production process. The software includes the following functional modules: multi-source data integration and management, imagery interpretation and data editing indoor, field collection, data quality check and so on.

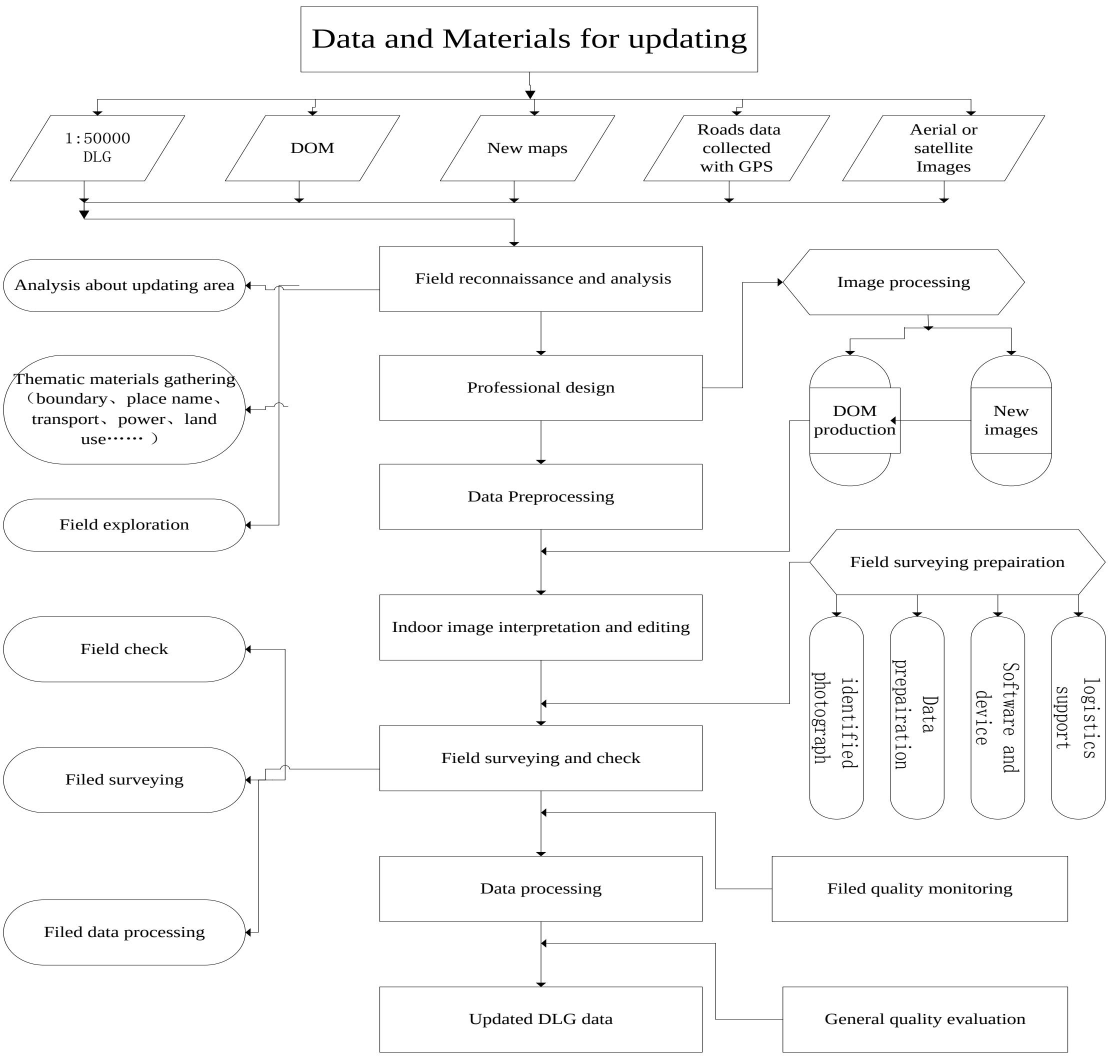

Figure 7: The production workflow of 1:50k database updating based on image interpretation

Data integration and handling of various sourced data is the first step and base of whole data updating based on imagery after all possible and necessary data are collected. The raw multi-source data sets includes DRG, DEM, aerial photos, satellite images, stereo images and GPS road data, updating information files, as well as final updated results files and intermediate files These different data files are integrated into a unified visual software work environment and read for the launch of carrying out updating from imagery. The work environment software in fact integrates many functions such as vector data and imagery data import and export, data integrated management, data classification storage, data overlaying, visualization and analysis.

The second step of main updating work is indoor image interpretation and editing and field data collecting. Indoor image interpretation and editing is implemented in plane (orthophoto) or three-dimensional environment (stereo images) with the aid of thematic materials from different departments. Field data collection and check is generally implemented after indoor work with the aid of handheld portable devices (PDA) integrated GPS.

The final step of main updating work is quality check and control, including geometry, attributes, topology and many other content check and control. Geometry check is able to make updating data keep spatial location and edge matching within the requirements, attributes check keep attributes of features complete and reliable, and topology and logical aspects of data check and modifying can keep right direction of points and lines , right relations among water , contours , roads , place names and other features and annotation, and avoid node errors (suspension points , pseudo- node) , segment errors (self-intersecting , discounts, redundant , fault intersection) , polygon errors (gap between polygons).

In 2011, the updating of 1:50000 DLG were completed, 14170 map sheets of them, about 80% were updated by imagery interpretation, shown as the following figure.

Figure 8. The coverage of 1:50000 DLG updating based on imagery interpretation

4.3 Updated Results

According to the statistics, 1:50000 DLG data before updating include key features only, after updating, all features are included, new features are added including soil, vegetation, pipelines in this circle of updating. Most data of boundary, residential areas features are updated. 30% of the data of hydrographic features and terrain features are updated. The detailed comparison result is shown in the following Table. Feature classes increase from nearly 100 classes to more than 400 classes; the number of feature objects increase from more than 66 million to more than 144 million.

Table.2 Comparison of 1:50000 DLG between before and after updating

Features	Before updating	After updating	Change statistics
Control points	● From paper map of 1:50000 during 70-90 years	● Consistency with National and Provincial Geodesic Database	● Increased by 50%。
Hydrography	● From paper map of 1:50000 during 70-90 years ● Partly updated with TM or SPOT images	● Fully updating ● Adding low level hydrographic features	● River data increased by 40% in terms of length ● Lake and pond data increased by 40% in terms of area ● Hydrographic infrastructural facilities increased by 50%。
Transport	● Only updating road of national, provincial, county level with GPS,before 2004 year ● Carriage way digitalized from maps ● On other types of road information	● Fully updating ● Road data almost are new ● Added low level transport and facilities features。	● The total length of the railway increased by 10% ● The total length of the national and provincial roads increased by 23.4%. ● The length of highway increased more than 45,000 kilometers, about 1.65 times. ● The total length of the county and town roads increased by 17% ● Carriage way road increased by 65%, total length reaches more than 6.55

			million kilometers ● Road ancillary facilities contain more than 1.49 million, increased by 12 times.
Habitation and facilities	● From paper map of 1:50000 during 70-90 years ● No habitation points and infrastructural facilities	● Fully updating ● Added habitation point and infrastruction facilities features	● Hash-style habitation and ancillary facilities increased by 36 million elements. ● The area of habitation increased by 40%.
Place name	● 2000-2001 year	● Fully updating ● Field surveying and check	● Place Names reached 6 million, increase by 16%.
Pipeline	No	● New	
Boundary	● From paper map of 1:50000 during 70-90 years ● Not complete	● Fully updating with the materials of national provincial, county boundary ● Keep consistency with new boundary information	
Terrain	● From paper map of 1:50000 during 70-90 years	● Updated 8963 map sheets	● Over 40% of area updated
Vegetation and soil	No	● New	

The uptodateness of data after updating reaches within 2006 - 2010, improved by 20-30 years. However, 1:50000 DLG data before updating are mainly formed by digitalization from paper maps during 70 to 90 years, seen in the following table.

Table.3 The up-to-dateness of 1:50000 DLG after updating

Year	Map sheets	Ratio(%)
2006	3447	18
2007	2958	16
2008	3713	19
2009	4149	12
2010	4883	25
Summurry	19150	100

Table.4 The up-to-dateness of 1:50000 DLG before updating

Year	Map sheets	Ratio(%)
1955-1959	74	0.4
1960-1964	237	1.2
1965-1969	751	3.7
1970-1974	1495	7.4
1975-1979	2137	10.6
1980-1984	2796	13.9
1985-1989	2311	11.5
1990-1994	3579	17.8
1995-1999	4826	23.9
After 2000	1947	9.7

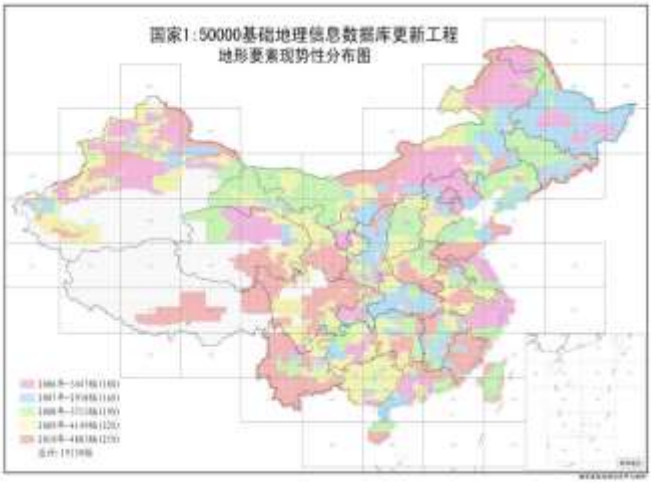

Figure 9 The up-to-dateness (year) distribution of 1:50000 DLG after updating

5. SUMMARY

A modern state requires accurate up to date maps and keeping them up to date on a regular basis is a massive task for a country the size of China. SBSM of China has solved this problem by using the latest data sources and developing new techniques. The methodologies developed in this paper are suited to regular updating in other rapidly developing nations and establish a model which can be followed in similar circumstances throughout the world.

The basic task was change detection, but this required the use of many data sources and the integration of these data to form a high accuracy, quality checked product. This in turn required up to date techniques of image matching, semantic integration, generalization, data base management and conflict resolution; automatic processing could be used in many cases but intelligent human interpretation and judgment remained essential.

We conclude by emphasizing that images play an essential role in updating geospatial databases, because only from images one obtains an overview of the whole area and is thus able to consistently capture and import into the database all relevant changes. While it can be difficult to obtain imagery at frequent intervals, e. g. due to clouds, terrestrial approaches are much more flexible with respect to suitable conditions for data capture. However, they can only capture individual changes and thus risk to violate neighbourhood and/or overall consistency. Thus, the two approaches should be used as complementary methods rather than in competition with each other.

China has made a great progress in the implementation and technology development , developed regular method of updating has been a model for similar developing countries in the world.
The completion of the updating of the 1:50 000 map databases is an outstanding achievement, both in technical terms and in terms of efficiency and speed of completion. The methodologies used are suited to regular updating to meet the needs of a rapidly developing nation and establish a model which can be followed in similar circumstances throughout the world.

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