

Research on engineering mode of production service integration of basic surveying and mapping: a case study of Heilongjiang Province, China

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Key words: Basic surveying and mapping, Integration of production and service, Production technology system, On-demand service

1. SUMMARY

Traditional surveying and mapping work organization and management, project production, achievement models, and application services can no longer meet the development requirements of the new era, and it is necessary to achieve its own reform and development in implementing of the "Two Supports, Two Services" of "Supporting economic and social development, serving the needs of various industries, supporting natural resource management, and serving the construction of ecological civilization". In response to the fragmented problem of traditional surveying and mapping production and services, combining with the practice of basic surveying and mapping production and service in Heilongjiang Province, this article analyzed the current situation and demand pain points of basic surveying and mapping construction, promoted the practice of collaborative production, updating, and fusion of multi-type, multi-element, multi-regional, and multi-scale geographic information data through "integration of production and service".

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2. INTRODUCTION

As the spatial information infrastructure for economic and social development, basic surveying and mapping is a basic and public welfare undertaking that serves economic construction, national defense development, social progress and ecological protection. In recent years, the state has issued a series of policy documents such as the *Medium- and Long-Term Plan for National Basic Surveying and Mapping (2015–2030)* and the *Opinions of the Ministry of Natural Resources on Accelerating the Transformation and Upgrading of the Surveying, Mapping and Geographic Information Industry to Better Support High-Quality Development*, explicitly requiring the construction of a new basic surveying and mapping system and the strengthening of data element support (Wang et al., 2023). Since the establishment of the Ministry of Natural Resources, significant changes have taken place in the industry definition, core businesses, key technologies, product forms and service methods of surveying, mapping and geographic information work, as the sector fulfills its statutory duty of serving economic and social development as stipulated by the *Surveying and Mapping Law* and undertakes the new responsibility of supporting the Ministry's "two unifications" in natural resource management (Li et al., 2012). Heilongjiang Province, a major border province in Northeast China, covers a vast territory with complex terrain (including plains, mountains, wetlands and permafrost regions). Its basic surveying and mapping work is not only crucial to the implementation of provincial strategies such as agricultural modernization, ecological protection and border area development, but also shoulders the important responsibility of safeguarding national geographic information security. Faced with the practical problem that the two core businesses of traditional basic surveying and mapping production and geographic information public service in our province are relatively independent and lack effective connection, it is imperative to accelerate the construction of a new basic surveying and mapping production system. With the goals of connecting production directly to services and services directly to applications, we need to optimize production management, transform technological processes, innovate product and service models, enhance production efficiency, product quality and service level, comprehensively promote the transformation of basic surveying and mapping from production-driven to service-driven, and establish a new "integration of production and

service" model featuring direct data delivery and one-stop service access. This is not only a critical and indispensable measure, but also a key task for shaping the new landscape of the surveying and mapping system.

The traditional basic surveying and mapping production mainly adopts a "3S + 4D" technology and product system structure, which relies on 3S technologies for functional division and targets the production of 4D products. It produces and updates surveying and mapping products in a static, snapshot-like and relatively slow manner according to fixed time cycles. During the 14th Five-Year Plan period, supported by informationized surveying and mapping technologies and centered on the construction of Realistic 3D Heilongjiang, our province has continuously optimized the organizational structure and production division of basic surveying and mapping in accordance with the operational requirements of the technical system and production-service processes for basic surveying and mapping in the new era. We have upgraded and transformed the technical and product systems of basic surveying and mapping, and steadily advanced the establishment of a mechanism for the construction and updating of provincial-level basic geographic information resources. These efforts have enabled the province to achieve the capability of acquiring remote sensing images covering the entire territory with 2-meter resolution (updated quarterly) and sub-meter resolution (updated annually). We have realized the full-coverage annual update of 1:10,000 basic geographic information data integrated with framework elements, as well as the annual update of the provincial basic geographic information database. Breaking away from the fixed-scale map sheet production mode implemented by regions during the 13th Five-Year Plan period, we have established a basic geographic information resource system that covers the entire province, integrates multi-scale data and supports dynamic annual updates.

3. DEMAND FOR INTEGRATION OF BASIC SURVEYING AND MAPPING PRODUCTION AND SERVICES IN HEILONGJIANG PROVINCE

Demand for Effective Support of Public Service Capabilities by Basic Data. At present, the basic geographic information resources are not sufficiently abundant, and a gap still exists between the supply and demand of public services. Problems such as low coverage rate, insufficient update frequency, poor currentness, and inconsistent standards and specifications are prevalent in the large-scale geographic information data of provinces, cities and counties. The construction process of basic surveying and mapping in some cities and counties is slow, accompanied by unbalanced regional development, and lacks the overall planning and management for dynamic monitoring of key projects and key areas. The supply of high-quality and high-level products such as the materialized, 3D, stereoscopic and knowledge-oriented new basic surveying and mapping products is insufficient, and the integration with industry data is inadequate. As a result, despite the sharp increase in data volume, it is still difficult to effectively meet the practical needs.

Demand for Automation and Intelligence in Large-scale Production of Basic Surveying and Mapping Data. The in-depth integration and application of basic geographic information with emerging information technologies such as big data, cloud computing and artificial intelligence are far from sufficient. The potential of cluster image processing systems, high-performance computing equipment, and large-scale data acquisition and processing equipment has not been fully exploited (Li et al., 2008). It is urgent to rely on the geospatial big data center, and take advantage of new approaches including crowdsourcing and crowd-sourced data, intelligent collaborative surveying and mapping, and automatic image interpretation to break through the current bottleneck in production capacity.

Demand for Establishing an Overall Management Mechanism for "Collaborative Surveying and Mapping". The mechanisms for the overall planning, construction and management of data resources and system platforms at the provincial, municipal and county levels are incomplete. The phenomena of "multiple data sources" and "information silos" are quite serious, and there is a lack of a unified database for the entire government. It is necessary to establish a working mechanism featuring "overall planning, hierarchical construction, collaborative sharing and efficient operation". We should explore different division-of-labor models based on scale, entity category, space and administrative power, so as to realize cross-regional and cross-industry data sharing.

4. CONSTRUCTION IDEAS

In response to the existing problems in current basic surveying and mapping production and the demands for application services, and based on years of practical exploration in basic surveying and mapping data production by the Heilongjiang Administration of Surveying, Mapping and Geoinformation, this paper sorts out and improves the business workflows and data flows in production operations, and summarizes a set of rapid and efficient technical systems for production and updating featuring "on-demand and timely updates", as well as an organizational management system based on "provincial-level overall planning and collaboration among cities and counties". The paper aims to establish a basic geographic information update mechanism and technical system that integrates framework element updates with full-element updates and combines integration of production and service, so as to promote the collaborative production, updating and integration of multiple types of geographic information data. These efforts will continuously enrich the service content of basic geographic information data and improve its currentness, realize the annual update of 1:10,000 basic geographic information data covering full elements in the main urban areas and framework elements in general areas of 13 prefecture-level cities and 125 counties/districts in Heilongjiang Province, drive the integration and updating of data at prefecture-level city nodes, form a province-city integrated construction mode, and enhance the service capacity of "Mapworld·Heilongjiang". The overall technical roadmap is shown in Figure 4-1.

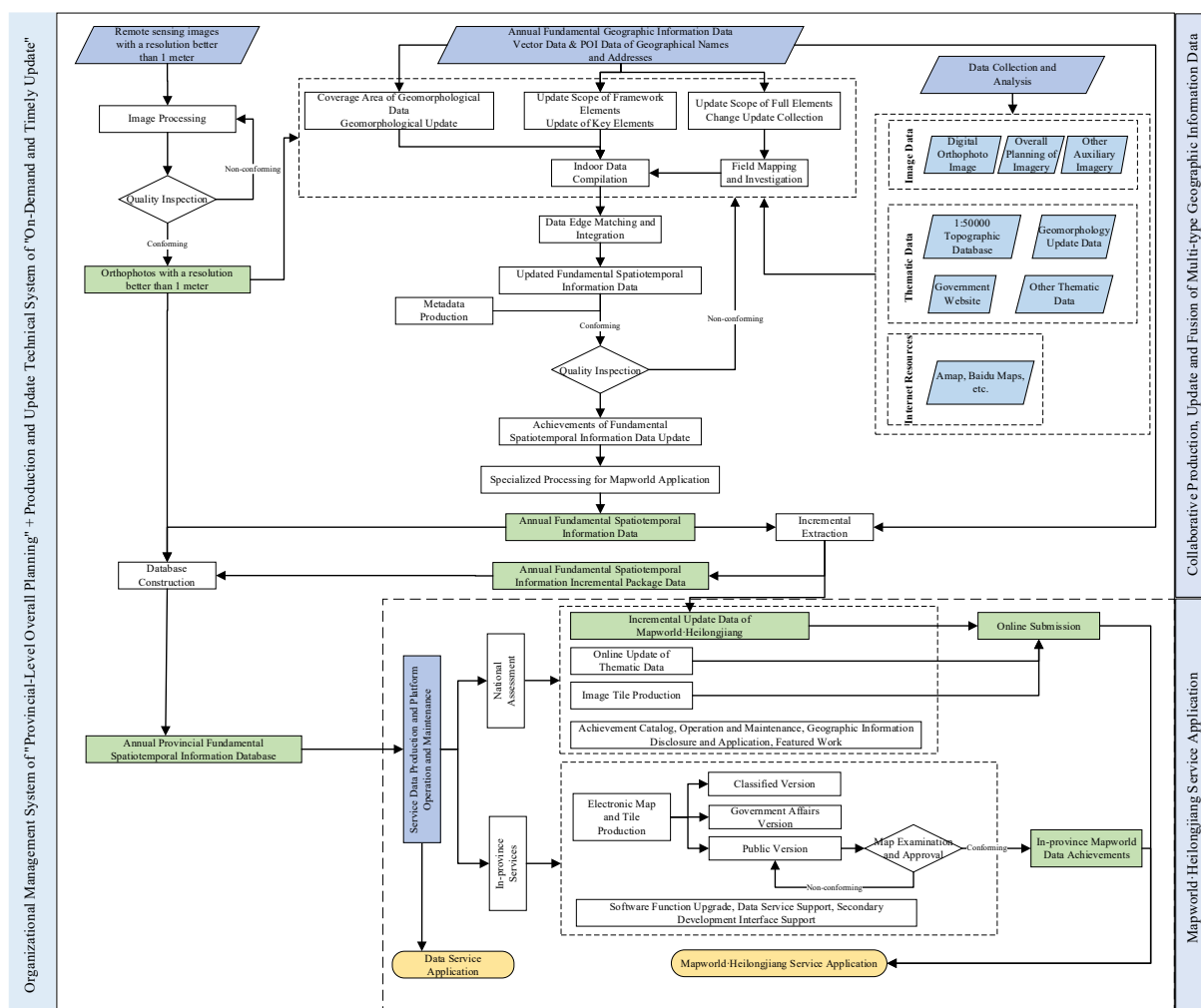


Fig.4-1 General technology roadmap graph

5. KEY TECHNOLOGIES

5.1 Organizational Management System Under the "Provincial-Level Overall Planning" Model

In the traditional production and application services of basic geographic information data, problems such as the concurrent implementation of multiple projects, overlaps in some production content, and disconnects between production and service links are prevalent. These issues make it difficult to meet the "on-demand" and "rapid-response" requirements for basic geographic information data in current application services. There is an urgent need to conduct top-level design and optimization in terms of organizational management models and working mechanisms (Huang et al., 2023). Combined with the actual situation of Heilongjiang Province, through a comprehensive sorting-out of various production projects, technical systems,

personnel and equipment, as well as application service demands, an organizational management mechanism under the "provincial-level overall planning" model has been designed and constructed, as shown in Figure 5-1.

First, a working mechanism for the collaborative production of multiple projects has been established. This mechanism conducts overall planning for major projects undertaken by our bureau, including provincial basic surveying and mapping, annual national land change surveys, satellite image-based law enforcement, Realistic 3D Heilongjiang, and Mapworld. It has thus formed a "project collaboration" working mechanism characterized by compatible production standards, merged production procedures, connected production timelines, and integrated production outcomes, which has significantly improved production management efficiency. Second, the production management model has shifted from map-sheet-based to county-based. Combined with practical application and management needs, production operation and achievement management units oriented towards administrative divisions and divided by counties have been established, making it more convenient for provincial departments, bureaus, cities and counties to apply surveying, mapping and geographic information achievements.



Fig.5-1 Organizational control system graph of provincial co-ordination

5.2 Collaborative Production and Update Process for Multi-type Basic Geographic Information Vector Data

To address the problems of inadequate update coverage and timeliness, insufficient large-scale data, and inflexible on-demand services in basic geographic information, this paper conducts in-depth analysis and research on the existing production processes. It designs and develops the organizational forms, data content, production methods, product models, and supporting technologies of basic surveying and mapping under the new system. This achieves the reengineering of basic surveying and mapping production processes, multi-business collaboration, and production chain extension, so as to satisfy the collaborative production, update, and integration of geographic information data across multiple types, elements, regions, and scales. The process flow is shown in Figure 5-2.

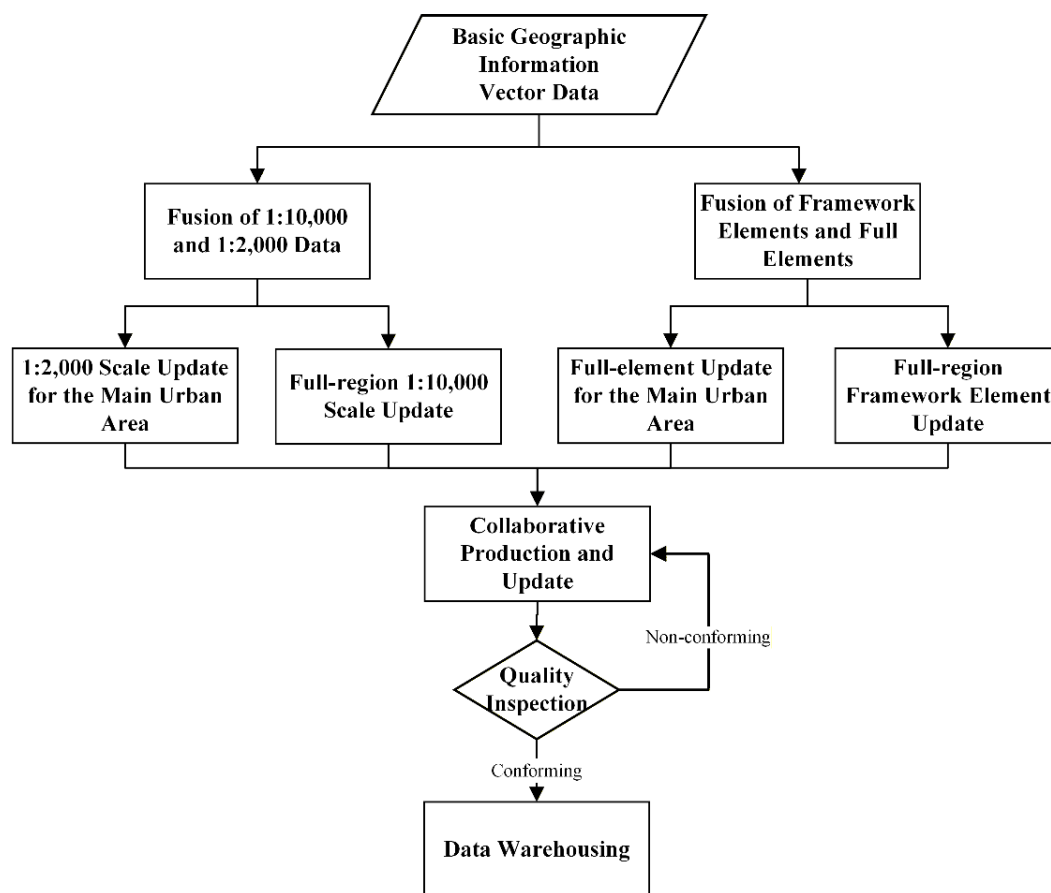


Fig.5-2 Process flow graph of multi type vector data collaborative production and update

First, it realizes the integrated production of provincial 1:10,000-scale and municipal/county large-scale basic geographic information data. To begin with, the 1:10,000-scale map-sheet data of the entire province are integrated by county to form the baseline data. Subsequently, data

conversion is carried out for prefecture-level cities that have large-scale data for their main urban areas; for those without large-scale data, new surveys are conducted using images with a resolution better than 1 meter in accordance with the 1:2,000-scale requirements. Finally, in the annual production work, it undertakes the annual update of 1:10,000-scale vector data across the province, the annual update of 1:2,000-scale vector data in the main urban areas of the 13 prefecture-level cities and their counties/districts, as well as the annual update of provincial POI data of geographical names and addresses. Second, it implements the coordinated update of framework elements and full elements of basic geographic information. During the data production process, full-element updates are performed for the main urban areas of the 13 prefecture-level cities across the province, while framework-element updates are carried out across the entire territory. The main update contents include water systems, highways, railways, and geographical names.

5.3 Service-Oriented Technical System for Integrated Production of Basic Geographic Information Vector Data

Conventional basic surveying and mapping production only addresses the updating of basic geographic information data and the construction of databases, while the resulting products cannot be directly applied to geographic information public services. By conducting a comparative analysis of the differences between conventional basic geographic information data and geographic information public service data in terms of data elements, data attributes, product accuracy, update identifiers and other aspects, this paper establishes service-oriented technical specifications for the integrated production of basic geographic information vector data, thereby realizing the integrated production of conventional basic geographic information data and geographic information public service data.

First, it expands and refines the specifications for 1:10,000 basic geographic information data. With reference to the *Technical Requirements for Collaborative Update of Mapworld*, it adds information such as boundary lines of schools and communities, road polygons, geographic name POIs, and data attribute items, to meet the requirements of geographic information public service data. Second, it establishes a technical mode for incremental data updating. Through a series of technical measures including setting unique element codes, judgment condition control, and extraction of changed elements, it realizes the technical mode for annual incremental data updating, which provides basic support for incremental data updating and extraction.

5.4 An Integrated Production Technical System for Basic Geographic Information Image Data Featuring "Combination of Static and Dynamic Data"

In the process of application services for basic geographic information data, remote sensing image data and related services account for approximately 70% of total usage. The demand for

remote sensing image data with high frequency, high resolution and multi-temporal phases is growing increasingly strong. There is an urgent need to strengthen capacity building in such aspects as remote sensing image data acquisition channels, data production and processing, and the application of new technologies, so as to better fulfill the work requirements of "two supports and two services", and provide high-quality support for natural resource management and economic and social development. The integrated production technical system is shown in Figure 5-3.

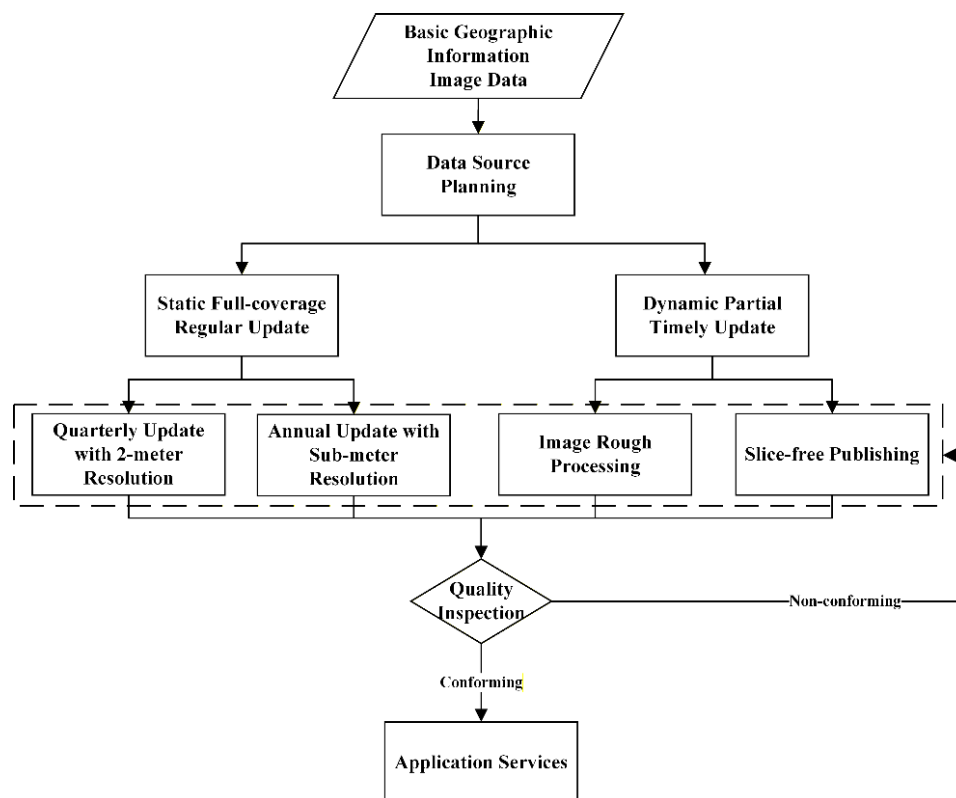


Fig.5-3 Technology roadmap graph of remote sensing image data production coordinating dynamic and quiescent update

First, it promotes the integrated application of multi-source data. Taking public-welfare satellite image data such as the Ziyuan series and the Gaofen series as the mainstay, supplemented by commercial satellite data including Beijing-2, Jilin-1 and Changguang satellites, this system rationally formulates the application principles for multi-source satellite remote sensing image data in light of regional characteristics and the respective features of each satellite data type, such as resolution, coverage scope and revisit cycle. Second, it conducts integrated production across multiple projects. Through comprehensive analysis of the time nodes, currentness requirements and data quality standards of projects including national land change surveys, provincial basic surveying and mapping, satellite image-based law enforcement and Mapworld, it realizes the parallel implementation and sequential advancement of multiple projects as well

as the reuse of data achievements. This enables the quarterly update of 2-meter resolution remote sensing image data and the annual update of sub-meter resolution image data across the entire province. Third, it establishes a "slice-free" rapid service technical system for remote sensing images, which achieves the service mode of "acquire immediately, process immediately, apply immediately" for remote sensing images, satisfying the application demands for high-frequency coverage without stringent requirements on image accuracy.

5.5 Architecture of the Service-on-Demand Integrated Database for Basic Geographic Information

To better satisfy the unified storage, management and dynamic updating of multi-type, multi-scale and multi-temporal basic geographic information data under the new model, as well as to support service-on-demand tailored to different application scenarios, it is necessary to upgrade and reconstruct the original basic geographic information database, so as to achieve the goals of "one database with multiple functions, on-demand assembly and customized services" (Luo et al., 2025; Wang et al., 2022). The architecture of the integrated database is shown in Figure 5-4.

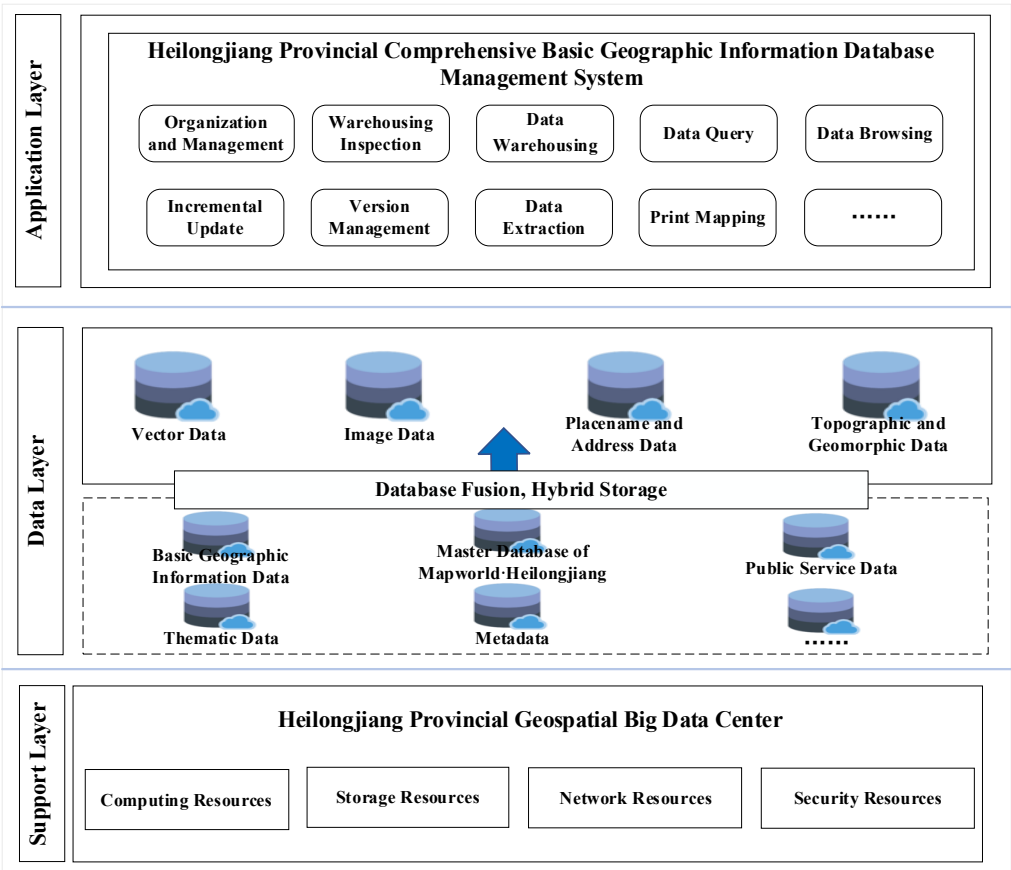


Fig.5-4 The architecture graph of service on demand geodata integrated database

First, it upgrades the structure of the integrated database. From a top-level design perspective, it develops a database architecture covering basic geographic information data, urban large-scale framework data, the master database of Mapworld·Heilongjiang, public service data, thematic data, metadata and other data categories. This architecture is compatible with the element types, storage formats and quality requirements of various data types, and establishes the association relationships among multi-type data. Second, it upgrades the database management system. It redevelops functional modules including data organization and management, quality inspection rules, data warehousing, incremental updating, version management, data extraction, mapping and printing, so as to meet the demands for data storage, management and utilization featuring dynamism, incrementality, multi-type integration and on-demand extraction.

6. EFFECTIVENESS OF INTEGRATED PRODUCTION AND SERVICE

Since Heilongjiang Province began to explore the integration of basic surveying and mapping production and services in 2020, five years of practice and optimization have yielded remarkable results in terms of data freshness, production cost reduction, update coverage capacity, production efficiency, data service on demand, timely data update as required, and geographic information public service capability. Through a series of management and technological innovations, a new basic surveying and mapping system has been initially established, which has effectively promoted the transformation, upgrading and high-quality development of the sector.

First, it has effectively guaranteed the update coverage of basic geographic information data and improved its currentness. The province has realized the annual update of 1:10,000-scale vector data across the whole territory, the annual update of 1:2,000-scale vector data in the main urban areas of 13 prefecture-level cities and their counties/districts, the annual update of POI data of geographical names and addresses across the province, the quarterly update of 2-meter resolution remote sensing image data across the province, and the annual update of remote sensing image data with a resolution better than 1 meter. This has effectively ensured the update coverage and currentness of basic geographic information data, laying a solid data foundation for the application of basic geographic information data services. Second, it has optimized the production and technical processes and established a provincial-level technical system for incremental data updating. Through a series of technical explorations including unique element coding, judgment condition control and changed element extraction, a technical mode for annual incremental updating has been realized. Third, it has broken the original map-sheet-based production and management model. Focusing on database updating, it has established production operation and achievement management units oriented towards administrative divisions and divided by counties, making it more convenient for provincial departments, bureaus, cities and counties to apply surveying, mapping and geographic information

achievements. Fourth, it has developed a digital orthophoto image production mode that improves image currentness, enhances public service capacity and takes into account the application in the following year. Each year, a certain area of digital orthophoto images of the current year is additionally produced. On the one hand, this improves the service supply efficiency of Mapworld·Heilongjiang and its competitiveness in the national sequence evaluation; on the other hand, it ensures the connection between the production of the current year and the next year, and these images can be directly used for the update of basic geographic information elements in the next year. Fifth, it has created a "project collaboration" approach for updating terrain element data. By coordinating major projects undertaken by our bureau, including provincial basic surveying and mapping, annual national land change surveys, satellite image-based law enforcement and Mapworld, a "project collaboration" working model has been formed, which conducts terrain element change detection, surveying and supplementary mapping, editing and integration at the county level as the production unit. Sixth, it has developed replicable and promotable experience and practices. A series of work plans and technical specifications such as *Construction and Update of Basic Geographic Information Resources in Heilongjiang Province* and *Specifications for Terrain Element Data in Heilongjiang Province* have been compiled, which can provide references for the implementation of related work. Seventh, the efficiency of geographic information public services has been significantly improved. Relying on the "integration of production and service" technical system, the richness, coverage and currentness of data resources of Mapworld·Heilongjiang have been effectively enhanced, and its user groups, application service fields and social influence have all been significantly strengthened.

7. CONCLUSION

The "integration of production and service" constitutes the core component of the "two direct connections" innovation system developed by the surveying, mapping and geographic information sector in Heilongjiang Province. It represents an important exploration aligned with the development needs of the surveying, mapping and geographic information industry in the new era, as well as an effective practice guided by both goals and problem-solving. Through the implementation of "integration of production and service", the sector has significantly enhanced its capabilities to support natural resource management and serve ecological civilization construction, as well as to meet the demands of various industries and facilitate economic and social development. Looking ahead, we need to continuously align with new trends, new tasks and new requirements such as the national "One Map" construction, the development of new basic surveying and mapping, the construction of realistic 3D mapping, and the replacement with independent and controllable technologies. With the goals of improving the production efficiency of surveying, mapping and geographic information, reducing production costs, and enhancing the currentness and quality of data, we will continue to introduce and innovate production technologies and organizational management methods,

steadily improve the effectiveness of the "integration of production and service" initiative, and promote the high-quality development of the surveying, mapping and geographic information industry.

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BIOGRAPHICAL NOTES

Jiqiang TAN, Male, PhD. He is mainly engaged in the management and research of basic surveying and mapping, public geospatial information services, smart cities, and remote sensing monitoring of natural resources.

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