Sensors and Materials, Vol. 38, No. 7 (2026) 3701–3712
MYU Tokyo

S & M 4529

Project Practice and Application of the Beijing Platform for Common Geospatial Information Services

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(Received July 26, 2024; accepted June 3, 2026)

Keywords: geographical information, public services, Tianditu·Beijing, emergency disaster relief

The National Platform for Common Geospatial Information Services is a platform organized by the Ministry of Natural Resources, which aims to share open geographic information data and provide geographic information services to the public. The Beijing Platform for Common Geospatial Information Services is provided to the government and the public through the "Tianditu·Beijing" website. In this article, we discuss the construction of the Beijing Platform for Common Geospatial Information Services and its application in various scenarios such as government affairs management, information disclosure, grassroots governance, emergency disaster relief, and public life using all-round service capabilities such as data, electronic maps, and online services, to provide a reference for the construction and application of the geographic information public service platform.

1. Introduction

The National Platform for Common Geospatial Information Services, namely, "Tianditu", is an open and sharing platform for geographical information data led by the Ministry of Natural Resources. It is also an important part of "Digital China".[(1,2)] "Tianditu·Beijing" is the Platform for Common Geospatial Information Services and the Beijing node of the National Platform for Common Geospatial Information Services. Tianditu·Beijing has achieved excellent results in geographic information disclosure and application, geographic information resource catalog, online geographic information service data update, operation and maintenance, and feature work, and has won five-star rating for four consecutive years, ranking in the national leading level.

Despite these achievements, the original Tianditu·Beijing faced several challenges. First, there was a lack of data integration and linkage. The platform's data content was limited to basic geographic information from surveying departments and remote sensing imagery, with the minimal integration of natural resource and thematic data from other government departments.

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https://doi.org/10.18494/SAM5256

ISSN 0914-4935

For example, in urban planning, the absence of comprehensive natural resource data hindered the formulation of integrated development strategies. Second, the map update cycles were long, and the styles were traditional, which did not meet the diverse needs of users. The process from data collection to map publication was lengthy, affecting the timeliness of the maps. Third, the website's usability was limited, with insufficient personalized customization and weak self-service cartography capabilities. It also lacked mobile applications and the ability to load third-party data services. Additionally, the soft hardware environment needed optimization to handle increased service demands and ensure security. Lastly, the depth of professional application was insufficient, with limited integration and application in fields such as housing, environmental protection, transportation, water resources, education, and health.

To address these issues, the new generation of Tianditu·Beijing has implemented several improvements. In 2023, the Ministry of Natural Resources issued the "Guiding Opinions on Promoting the Construction of a New Generation of Geographic Information Public Service Platform", calling for an upgraded platform that strengthens data resources, improves update efficiency, enhances service functions and operational support, and promotes the transition from single-function geographic information services to comprehensive geographic information services.[3] To cooperate with Beijing's regulatory planning for smart city construction during the "14th Five-Year Plan" period and promote the goal of "one map for the whole city", the Beijing Municipal Commission of Planning and Natural Resources formulated the "New Generation Beijing Geographic Information Public Service Platform (Tianditu·Beijing) Optimization and Improvement Plan", which aims to meet the needs of smart cities for "one map of the city" and promote the overall improvement of Tianditu·Beijing.[4]

In this article, we discuss the construction of Tianditu·Beijing and introduce its diverse application scenarios in government affairs management, information disclosure, grassroots governance, emergency disaster relief, and public life.

2. Status of Foreign and Domestic Construction

In recent years, many platforms of geospatial information services have been built. In the following, we introduce the related research and platform construction.

2.1 Foreign construction

The development of foreign geographical information public service platforms started early. In 1993, the U.S. government launched the National Information Infrastructure initiative to incorporate geospatial information. Building on this effort, the government issued the Transparent and Open Government memorandum in 2009 and launched Data.gov, requiring federal agencies to publish high-value datasets for public access and use. To further promote the application of geospatial information, the Geospatial Platform project was launched in 2011 to connect these resources and provide more advanced online services. In the United Kingdom, the government began building the Digital National Framework in 2000, and in 2010 it released the data-sharing website Data.gov.uk based on that framework. In Europe, the European Parliament

and the Council of the European Union established formal regulations and long-term arrangements for spatial information infrastructure through EU legislation and created a unified service platform to support the sharing and use of geospatial, geological, and ecological data.[5] In Australia, the Australian Spatial Data Infrastructure provides a unified platform through which government agencies, businesses, nonprofit organizations, academia, and the public can find, evaluate, and download spatial datasets for further use.[6]

2.2 Domestic construction

In recent years, China has made significant progress in the field of geographical information.[7,8] Geographic information public service platforms have also been widely developed.[9] Domestic geographical information public service platforms are mainly concentrated in governments, enterprises, and research institutions.[10] The National Platform for Common Geospatial Information Services is composed of interconnected main nodes, provincial nodes, and municipal information bases, and realizes information sharing and collaborative services through unified technical standards and service interfaces.[11] Many large and medium-sized cities have established their geographical information platforms. For example, the Department of Natural Resources of Zhejiang Province promotes "geographic information intelligent services" and uses the "result service, map management, and measurement mark management and protection" modules as an application for the digital platform of provincial spatial governance. One scenario is to improve smart service levels and smart supervision capabilities to support urban planning, traffic management, emergency response, and so forth.[12] Some large enterprises such as Tencent, JD.com, and Meituan have established their own enterprise geographic information platforms, integrating a large amount of spatial data and geographic information services to support business operations, resource management, and so forth.

2.3 Necessity, uniqueness, and value of Tianditu construction

The construction of Tianditu, China's national geographic information public service platform, is essential for several reasons. First, it addresses the need for a centralized and authoritative source of geographic information, providing a unified and standardized service to government, enterprises, and the public. This platform integrates multisource heterogeneous spatial data, including vector data, satellite imagery, and thematic information, offering a comprehensive and up-to-date view of the country's geography. Its unique features include a distributed server cluster and microservice architecture, which enhance data processing and update efficiency, ensuring the freshness and reliability of the maps. Tianditu also stands out in its commitment to data security and integrity, employing advanced technologies such as unified network tunnels and domestic commercial password techniques for data transmission and storage.[13]

Compared with other map service platforms, Tianditu offers several advantages. While platforms such as Google Maps and Bing Maps are widely used and offer rich user experiences,

they are less comprehensive in integrating multisource data and have limited flexibility and extensibility for professional applications. Tianditu, on the other hand, provides a wide range of service functions, including standard map service interfaces, coordinate conversion, place name address matching, and geographic information spatial aggregation, facilitating user integration and the development of new application systems. It also excels in providing high-resolution imagery and real-time data updates, which are crucial for applications in emergency response and urban planning.

The platform's value is further highlighted by its applications in various sectors such as macro-decision support, emergency response, and public services.[14] It has been instrumental in major national surveys and has supported critical infrastructure in fields such as water resources, public security, and transportation. By providing a reliable and accessible geographic information service, Tianditu not only facilitates efficient governance and resource management but also promotes the development of the geospatial information industry, enhancing the country's overall information technology capabilities and contributing to the digital economy.

In summary, Tianditu's unique combination of data integration, update efficiency, service flexibility, and data security makes it a vital asset for China's geographic information needs.

3. Construction of Beijing Platform for Common Geospatial Information Services

3.1 Key technologies of Tianditu·Beijing

The Tianditu·Beijing platform adopts a distributed server cluster and microservice architecture to achieve the efficient integration of multisource heterogeneous spatial information, including vector data, satellite image data, natural resource thematic data, and other publicly available geographic information government data, forming a rich and diverse geographic information resource. We have developed multiple types of standard map service interface, as well as scalable, highly available, and flexible service interfaces for coordinate conversion, place name and address matching, and geographic information spatial aggregation. In terms of usability, through convenient map services and data interfaces, users can embed Tianditu·Beijing service resources into existing systems and build new application systems. Compared with other urban areas, the Tianditu·Beijing map services have a daily average of 125 million calls, which is at the forefront of China.

On the basis of unified standards and rules, the Tianditu·Beijing sub-node database was established using Docker technology. By utilizing a unified network tunnel and domestic commercial cryptographic technology, incremental data transmission and storage were carried out and timely aggregated to the national main database. In terms of efficiency and performance, Tianditu·Beijing has achieved online, real-time, and rapid updates of map data, strengthening data security capabilities while also changing the efficiency of map updates from quarterly to monthly key areas to real-time updates, ensuring the freshness of the map.

Figure 1 shows the system architecture diagram of Tianditu·Beijing. This system architecture diagram encompasses a comprehensive framework that integrates various data sources, processing stages, and output formats to deliver a wide range of mapping services. The data

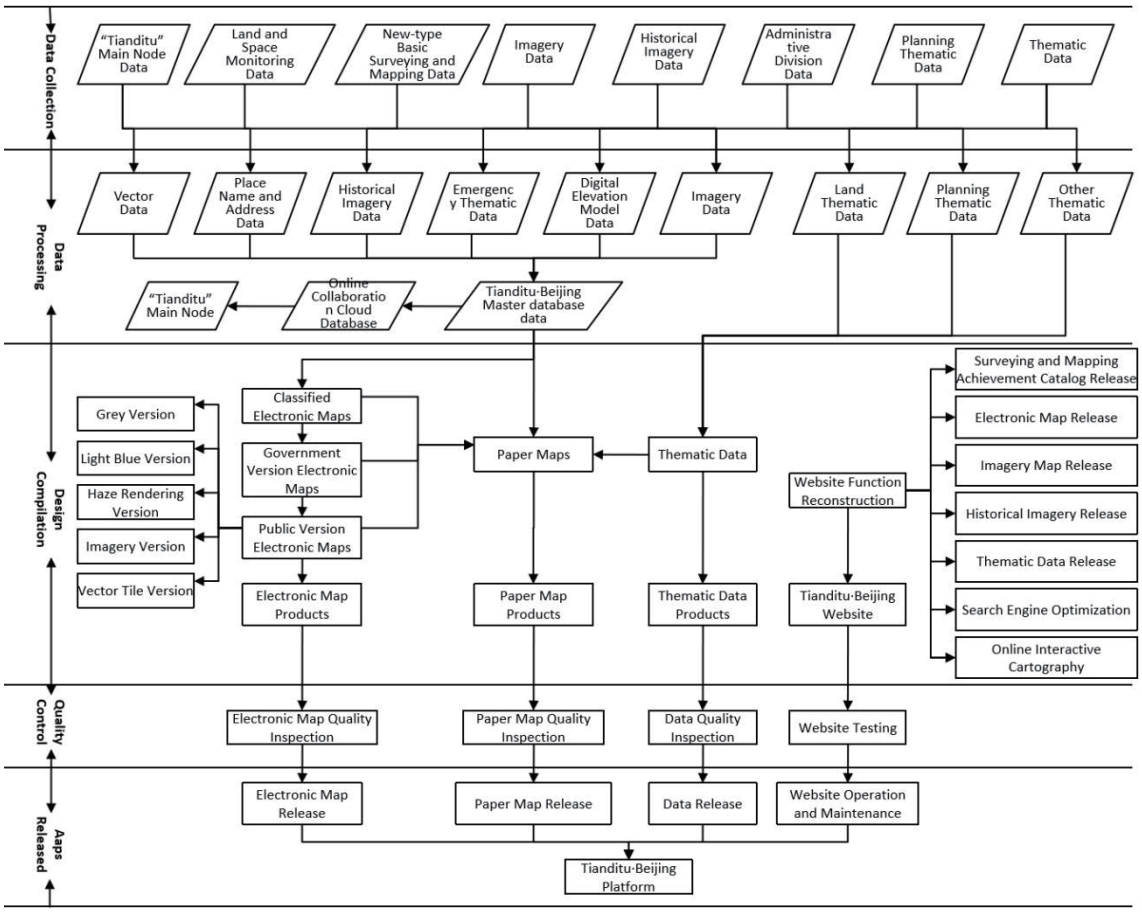

Fig. 1. System architecture diagram of Tianditu·Beijing.

collection phase involves gathering information from different sources, such as land and space monitoring data and new-type basic surveying and mapping data. These data are then subjected to data processing, design compilation, and rigorous quality inspection to ensure their accuracy and reliability. The processed data are further categorized into mother database data, which serve as the foundation for various map products and services. The system architecture of Tianditu·Beijing is structured to produce both electronic and paper map products. Electronic maps are available in different versions, including government, public, grey, light blue, and imagery versions, catering to the needs of different user groups. These maps undergo quality inspection to meet the required standards before being released through the Tianditu·Beijing website. The website also features a range of functionalities, such as historical imagery release, imagery map release, website function reconstruction, thematic data release, and search engine optimization, enhancing the user experience and accessibility of the mapping resources.

3.2 Data resource construction

Tianditu·Beijing has built three databases, namely, a vector database, an image database, and a thematic database. Through the national unified data model and standards, the platform

performs data fusion and production based on the latest national master node and provincial node data, forming a geographical information public service platform data set with complementary advantages and a high current situation.[15] On the basis of basic surveying and mapping, land spatial survey, place name census, and other thematic data, the vector database performs element selection, fusion, and update, and coordinates spatial relationships and logical consistency to make the fused data more current, accurate, rich, and so forth.[16,17] The vector database contains more than 6 million vector elements and more than 800000 place name addresses and POI data. The image database includes current and historical images, with a data volume of 4.6 TB and a resolution of 0.8 m. The image data are updated quarterly and can better reflect the spatial status of ground features. For the first time, a batch of precious historical images of Beijing from 1951, 1959, 1966, 1972, 1996, and so forth are included to provide long-term historical image services. The thematic database includes road basic surveying and mapping, geographical and national conditions, the protection of famous cities, place name culture, cultural tourism, and other special data, and has become an official channel for the government to disclose information to the public.

On the basis of the vector database, multiscale electronic maps of Beijing have been created, including 9–20 levels (1:1150000-500), a total of 12 scales, and a multistyle electronic map product array has been established, including public, government, vector, gray, and bright blue versions, and the terrain shaded map and vector tile map products are also released to meet the needs of different business scenarios.

3.3 Website construction

Tianditu·Beijing is an electronic map service website based on the Internet. It has functions such as electronic map browsing, point-of-interest (POI) search, POI annotation, online mapping, and map printing. It provides 24 h uninterrupted information in the form of a portal website and a service interface. “One-stop” map service meets the public’s needs for geographical location inquiries and online map calls. The website includes columns such as portal homepage, online map, thematic map, standard map, service resources, thematic channels, and typical applications.

4. Featured Applications

4.1 Service government affairs management

Tianditu·Beijing provides electronic base map data services for the Beijing Smart City “One Map” initiative. It supports electronic maps in multiple coordinate systems, including the Beijing local coordinate system, the Beijing 2000 coordinate system, and CGCS2000. The average daily map visits reach 800000 times. Through online, offline, and customized methods, it provides map and data services for more than 1200 commissions, bureaus, enterprises, and institutions in the fields of natural resources, ecological environment, water conservancy, scientific research and education, and public security. The relevant agencies served include the People’s Government of Beijing Municipality, Beijing Municipal Commission of Development and

Reform, Beijing Municipal Ecology and Environment Bureau, and Beijing Municipal Commission of Transport. Tianditu·Beijing provides the People's Government of Beijing Municipality with powerful map service guarantees for many key projects such as maps for major activities, the special planning of key areas, and various large-scale censuses. For example, Tianditu map positioning is provided for the "Public Opinion Direct" of the "Beijing 12345" platform, to quickly understand the location of demand and solve feedback problems on time.

4.2 Service information disclosure

Tianditu·Beijing is integrated with the electronic base map to dynamically access approved place-name results. On the basis of this integration, we developed a map-based publicity module for approved place names and publish the results of public announcements on the official website of the Beijing Municipal Commission of Planning and Natural Resources. On the basis of the Tianditu·Beijing website, we also developed the Land and Spatial Information Query section to map and display the approved results of various land and spatial planning items in Beijing.

Using 3D realistic imagery, we launched the "Cloud Land Photography" section on the Tianditu·Beijing website and released data on land development plots, enabling users to conduct online site inspection and browse 360° site information without visiting the site in person. In addition, multiple government affairs topic data layers are released, such as Beijing administrative district demarcation lines, urban land space monitoring topics, traditional place name protection lists, and barrier-free outstanding scenic spots, providing the public with authoritative geographical information data and promoting government affairs.[18,19] Information disclosure provides necessary spatial information support and has become an important measure to optimize the business environment.[20] The special data release of urban land space monitoring is shown in Fig. 2.

Fig. 2. Thematic data release of urban land space monitoring.

4.3 Service grassroots governance

In compliance with the new situation of urban management and new requirements for refined management, combined with the actual needs of streets and towns for maps, and on the basis of Tianditu·Beijing, we provide street and town management departments and territorial responsible planners with a street and town map service package, including street and town maps. There are three types of map package: standard map, extended map, and customized map.

The standard map package is a series of map products that can be directly distributed, providing basic and public welfare map services. The content includes a basic geographical base map of the administrative area boundary of the district, a vector map of streets and towns, and an image map. The map product is A0 in size and can be used as a wall chart or working map.

The extended map package is a free map service. It is provided upon application for users with certain geographical information system software usage requirements and operating capabilities. The main content includes multilevel electronic map tiles of streets, towns, and villages, administrative district boundaries, POI thematic data, and GIS software.

Customized map packages are aimed at the more personalized needs of streets and towns, providing customized value-added services such as customized map services, the construction of special columns on map websites, the development of mobile applets, and the construction of geographic information systems.

The street and township map service package provides diversified map products and information tools for grassroots governance in a lightweight and flexible manner, helps establish a geographic information space base, and empowers grassroots governance. It has been widely praised by grassroots users in streets and towns.

4.4 Service emergency disaster relief

From July 29 to August 2, 2023, affected by Typhoon Doksuri, Beijing suffered heavy rainstorms and floods, causing nearly 1.29 million people to be affected.[21] Fangshan District is an area severely affected by the disaster. Heavy rains damaged 10 roads above the county level, 230 rural roads, and 119 bridges, causing 77 villages to lose access to roads. After the Fangshan District suffered a severe rainstorm, Beijing responded quickly and used the Beijing Platform for Common Geospatial Information Services to provide emergency disaster relief with material airdrop point positioning, geographic information retrieval, emergency map production, and other services. The platform has played an important role in disaster relief work deployment, leadership decision-making, and the investigation of hidden dangers.[22]

4.4.1 Determining the location of emergency material airdrop points

For areas damaged by heavy rains, helicopters and drones are used to drop emergency supplies in the air to provide basic living security and establish emergency communications for the affected people. Owing to poor weather conditions, low visibility, and the mountainous area, if the destination point for material delivery is improperly selected or the location is not

sufficiently accurate, at least the material will be lost, or at worst, the aircraft will hit the mountain or even be destroyed and cause huge losses to life and property. On the basis of the Tianditu·Beijing data, Beijing provided the management with the names of the drop destinations for address matching and preliminary mapping; combined with the latest high-resolution remote sensing images, it conducted an interpretation of the surrounding environment of the destination and selected playgrounds, squares, and other more open sites or areas with obvious physical features for airdrops, provided coordinates of airdrop points to the relevant departments, and provided location determination services for the delivery and placement of emergency supplies in 9 streets and townships and 64 points to ensure that all supplies are successfully placed.

4.4.2 Provide emergency rescue geographic information analysis service

On the basis of the thematic data of Tianditu·Beijing, geographical information analysis services are provided for the formulation of emergency rescue plans. Tianditu·Beijing has highly current image maps, roads, and POI data, as well as rich and detailed housing thematic elements. For disconnected villages with no roads or signals, we use village POI data to locate and map locations, establish a digital account of the affected villages and surrounding roads, conduct comprehensive analysis based on satellite images, and formulate rescue plans to provide emergency rescue. We also provide data support for the relocation of disaster victims.

4.4.3 Production of maps for the elimination of safety hazards on rescue routes

After the July 2023 rainstorm and flood disaster in Beijing caused by Typhoon Doksuri, we promptly obtained postdisaster high-resolution satellite remote sensing images and worked with professional geological survey technicians to identify collapses, landslides, and debris-flow areas from the imagery. Using the data in Tianditu·Beijing such as the administrative division boundaries, roads, and POIs, we produced emergency maps for the elimination of safety hazards on rescue routes in Fangshan and Mentougou Districts, marking collapse, landslide, and debris flow disaster points in the two disaster-stricken areas, and provided them for use by front-line rescue teams. The maps were updated once a day, which provided timely guidance for rescuers rushing to disaster areas to avoid dangerous areas and ensure personal safety, help open rescue channels, and provide necessary geographic information technology support for emergency rescue.

4.5 Service public life

We standardize the drawing method of administrative division boundaries, produce 52 basic geographical base map of Beijing's administrative division boundaries as a basis for compiling various types of maps in our city, and update them annually. We standardize division boundaries, government resident names, and spatial locations, and provide them for free download and use by the public.[23] The base map provides an authoritative and accurate map reference for regulating the map market. It has been downloaded more than 140000 times since its release.

We publish thematic maps. Combining social hot spots, we publish special topics such as geographical condition monitoring results, the traditional place name protection list, the Beijing wetland list, Beijing administrative district boundaries, cultural relics, Universal Beijing Resort, Beijing University Red Building, and the site of early Beijing revolutionary activities, Beijing Grand Canal leisure theme tour, and so forth to serve the public life.

We provide multiple spatiotemporal data services. The Time and Space Photo Gallery column is set up to objectively present the confluence area of the five rivers of the Grand Canal, Green Heart Forest Park, Universal Beijing Resort, Canal Business District, and other areas from the perspective of "eyes in the sky" through a comparison of historical satellite images. These images bear witness to the rapid development of Beijing over the past 10 years.[24]

As of the end of 2023, the map service of Tianditu has an average daily call volume of approximately 100 million times in the Beijing area. There are 40000 registered users, 25000 developers, and 2000 active applications in Tianditu·Beijing. The platform has been providing high-quality online geographical information services to government departments, enterprises, institutions, and the public.

5. Summary and Outlook

Under the guidance of the Ministry of Natural Resources and the relevant requirements for smart city construction in Beijing, Tianditu·Beijing has continuously improved its service capabilities and played an active role in geographical information applications, the open sharing of geographical information, government map services, and map market regulation. In the future, Tianditu·Beijing will promptly release catalogs and standard maps of various surveying and mapping geographical information results under relevant requirements, expand the opening of basic geographical information and natural resource thematic geographical information, and promote the platform's transformation from a single geographical information service to a comprehensive geographical information service. Tianditu·Beijing will continue to improve its online geographic information public service capacity, play a greater role as a platform for Beijing's "one map" data service sharing and a window for geographic information public service, and promote information sharing, improve decision-making efficiency, and promote innovative development.

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