Overview of the Top-Level Design and Practice of the ReS3D China

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Abstract

This paper explores the construction of 3D Real-Scene China(ReS3D) as a pivotal element of national new infrastructure, aiming to establish a unified spatio-temporal foundation for Digital China through realistic, three-dimensional, and time-sequenced spatial data. This initiative supports the digital economy, digital governance, and Beautiful China objectives. From a top-level design perspective, the paper outlines the goals, tasks, and technical pathways of 3D Real-Scene China, highlighting the strategy of "building while using, promoting construction through application." However, challenges persist, including complex data acquisition and processing technologies, limited inter-departmental collaboration, and inadequate mechanisms for data standardization and sharing. By analyzing the synergy between top-level design and local practices, the paper examines the potential and challenges of 3D Real-Scene China in advancing high-quality development, providing insights for optimizing its construction trajectory.

1. Introduction

The Chinese government has emphasized the acceleration of Digital China and the digital economy, promoting deep integration between digital and real economies. The Overall Layout Plan for Digital China notes that Digital China is a strong support for building new national competitive advantages. China's geographic information data production system has traditionally relied on public funding, producing "4D"(DEM, DOM, DRG, DLG) products by scale. However, issues such as "useful but not user-friendly" data services and non-object-oriented 4D products have limited spatial analysis and decision-support capabilities, hindering their integration with big data. Against this backdrop, the central government has proposed a new geospatial information production system centered on ReS3D (Real-Scene 3D), aiming for intelligent technology, modernized production organization, and customized, networked application services.

2. Vision and Top-Level Design of ReS3D China

2.1 Basic Definition of ReS3D China

ReS3D (Realistic Stereoscopic 3D) is a digital description and authentic representation of the three-dimensional structure and appearance of natural and human phenomena in the real world. It exhibits three fundamental characteristics: stereoscopic representation, authenticity, and entity-orientation (Chen et al, 2025).

Stereoscopic representation, refers to reconstructing spatial forms, spatiotemporal relationships, and attributes of natural and human elements across terrestrial/marine environments, above/below ground, indoor/outdoor spaces, and above/below water through 3D reconstruction and modeling. This constructs a 3D spatial digital model integrating multidimensional spatial relationships.

Authentic representation, entails endowing the 3D model with realistic appearance, texture, and semantic attributes, supported by real-time or temporal capabilities to form a highly consistent geographic scene mirroring the physical world.

Entity-orientation, involves partitioning multi-typed, multi-granular fundamental geographical entities within the model based on continuous spatial occupancy and unified functionality. These entities associate and integrate socioeconomic-environmental information

2.2 Vision

ReS3D is a spatiotemporal information system that authentically, stereoscopically, and sequentially reflects ecological, production, and living spaces. Through "human-machine collaboration, IoT perception, and ubiquitous services," ReS3D enables real-time correlation and interconnection between digital and physical spaces, providing a unified spatial positioning framework and analytical foundation for Digital China.

In 2022, the Ministry of Natural Resources issued documents defining the goals, tasks, and roles for ReS3D China. The targets are as follows:

By 2025: Achieve national coverage of ReS3D at a 5-meter grid level for land and major islands, and preliminary coverage at 5-centimeter resolution for cities above prefecture-level. Establish a multi-level ReS3D service system (national, provincial, prefecture/county) combining online and offline modalities. Enable preliminary real-time linkage between digital and physical spaces in cities above prefecture-level. Provide spatial positioning and analytical support for Digital China, e-government, and the digital economy. Over 50% of government decisions, production scheduling, and life planning should be supported by online ReS3D spaces.

By 2035: Achieve coverage at better than 2-meter grid ReS3D for national land and major islands, and at better than 5-centimeter resolution for cities above prefecture-level and eligible county-level cities. Establish ubiquitous multi-level online ReS3D service systems. Enable real-time digital-physical space interconnection for cities above prefecture-level and qualified counties. Enhance ReS3D support for Digital China, e-government, and the digital economy, with over 80% of government decisions, production scheduling, and life planning conducted via online ReS3D spaces.

2.3 Top-Level Design Principles

Temporal and Dynamic Representation: ReS3D provides a time-sequenced, dynamic expression of the real world, and must be machine-readable. It achieves integrated representation of above-ground, underground, indoor, outdoor, and underwater environments.

Multi-Source Data Integration: ReS3D enables spatiotemporal matching and fusion of heterogeneous big data using spatial location, place names, and geocoding grids. Data value mining in digital space informs understanding and regulation of real-world processes.

Hierarchical Structure: China ' s ReS3D is structured into macro (terrain-level), meso (city-level), and micro (component-level) hierarchies.
Terrain-level focuses on digital mapping of ecological spaces for 3D visualization and spatial measurement, supporting macro planning and ecological restoration. City-level focuses on production and living spaces, including buildings, structures, transportation, water systems, and pipelines. Component-level addresses specialized and personalized needs through diversified investment (public finance and market mechanisms).

Systematic Layout and Collaboration: ReS3D China emphasizes national coordination and a unified plan, with tiered construction and resource sharing across central, provincial, and local governments.

Key Technologies and Institutional Innovation: Priorities include breakthroughs in self-developed 3D modeling software, AI algorithms, and institutional mechanisms to foster social participation, such as encouraging enterprise involvement in component-level ReS3D construction.

Temporal Updates and Dynamic Management: Terrain-level data is updated on a 3-year cycle; high-resolution imagery is collected quarterly or annually to ensure data currency.

Integration with National Development Goals: Coupling geospatial big data with other production factors enables rapid, precise, and intelligent matching of supply and demand in time and space, optimizing resource allocation, expanding land use, reshaping production models, transforming lifestyles, and promoting smart urban-rural governance and green, low-carbon transition for high-quality development.

Standardization: China has released a series of ReS3D operational standards, including Technical Specifications for Oblique Photogrammetry Data Acquisition, Technical Specifications for Oblique Digital Photogrammetry, 3D Model Data Format, 3D Model Data Service Interface, and Mobile Laser Scanning Systems, among others.

Technological Advancement: Rapid progress is being made in oblique photogrammetry, LiDAR point cloud processing, geographic entity unique identifier coding, 3D visualization and rendering, and Gaussian splatting, all of which are being applied in ReS3D projects.

3. Technical Framework for Res3D

The technical framework of Res3D China is built upon five key pillars(Chen et al, 2022): multi-source data acquisition, data fusion and modeling, semantic processing of geographic entities, visualization and analytical services, and data sharing with security assurances. These components collectively enable the creation of high-precision, dynamic, and secure 3D models that underpin Digital China's infrastructure.

3.1 Multi-Source Data Acquisition.

Res3D China relies on diverse data sources, including oblique imagery, LiDAR, Synthetic Aperture Radar (SAR)/Interferometric SAR (InSAR), and aerospace imagery, to produce high-fidelity 3D models. Aerospace imagery and SAR/InSAR data are accessible through shared platforms, with SAR data primarily acquired via satellite-based synthetic aperture radar and InSAR leveraging dual SAR satellites or interferometric radar-equipped aircraft to generate digital elevation models (DEMs). Oblique imagery is captured using domestic flight platforms equipped with large-scale oblique digital photogrammetry systems, providing rich textural information for large-scale 3D modeling. LiDAR data acquisition occurs through satellite, airborne, and terrestrial platforms: satellite-based LiDAR enables global coverage, airborne LiDAR (via manned aircraft or drones) facilitates large-scale point cloud collection, and terrestrial methods include 3D laser scanning, vehicle-mounted Mobile Mapping Systems (MMS), and handheld laser scanners. Additionally, drones equipped with multi-modal sensors can simultaneously capture oblique imagery and point cloud data. China's technological breakthroughs in laser emitters have accelerated the development of domestic measurement-grade LiDAR systems, integrated with platforms such as drones, vehicles, backpacks, and handheld devices, incorporating Simultaneous Localization and Mapping (SLAM), Global Navigation Satellite System (GNSS), Inertial Measurement Units (IMU), and vision sensors to adapt to diverse urban data collection scenarios. Compared to imagery, LiDAR offers higher acquisition and processing efficiency, stable measurement accuracy, and no need for control points. Advances in point cloud classification, driven by autonomous driving technologies, have improved accuracy and efficiency, making LiDAR the preferred choice for Res3D data acquisition. By the end of 2023, most provinces in China had adopted LiDAR for Res3D data collection.

3.2 Multi-Source Data Fusion and Modeling.

Traditional multi-source data fusion for Res3D China involves preprocessing oblique imagery, LiDAR, and SAR/InSAR data through denoising, filtering, geometric correction, and coordinate transformation. A global geometric consistency constraint model is constructed based on multi-modal data similarities, establishing initial scene correspondences and enabling refined feature matching for spatial alignment. Registered data are used to generate high-precision DEMs and Digital Surface Models (DSMs), with high-resolution texture information from oblique imagery mapped onto these models to produce 3D models with precise coordinates and detailed textures. Time-series deformation data from SAR/InSAR enhance surface deformation analysis. Different data sources exhibit distinct characteristics: oblique imagery, captured by drones with multi-lens cameras, provides rich textures and realistic visuals for large-scale 3D modeling; LiDAR generates high-precision point clouds with vegetation penetration capabilities, ideal for topographic surveys and engineering applications; SAR/InSAR is highly sensitive to surface deformations, suitable for geological hazard and infrastructure monitoring; and aerospace imagery offers broad coverage, low cost, and rapid acquisition for large-scale geographic information. The high cost and low efficiency of traditional modeling have driven innovations such as airborne LiDAR-oblique imagery fusion, close-range photogrammetry, and terrestrial LiDAR/imagery integration with oblique models. Emerging techniques, including satellite imagery-based Level of Detail (LOD) 1.3 building white model generation, automated LiDAR-based individualization, rapid texture mapping with oblique imagery, and Digital Line Graphic (DLG) integration with LiDAR or oblique imagery, are replacing manual modeling workflows. The fusion of Neural Radiance Fields (NeRF) with oblique modeling overcomes limitations in photogrammetric quality, significantly enhancing modeling outcomes.

3.3 Semantic Processing of Geographic Entities.

Semantic processing in Res3D China involves knowledge extraction to identify physically meaningful geographic entities within 3D models. This process defines basic entity types, attributes, and relationships in ontology construction, distinguishes instances from concepts, and establishes inheritance, equivalence, sibling, and attribute associations. Multi-tuple data are aligned and merged through entity alignment and knowledge fusion, with unique identification codes and cross-level, socially enabled coding mechanisms developed for geographic entities. This enables an information model supporting "dimensionality reduction, spatiotemporal enhancement, polymorphic coding, and relational coding," facilitating the creation of an integrated entity-based relational graph for infrastructure elements.

3.4 Visualization and Analytical Services.

Res3D China enables precise replication of physical environments, constructing full-element digital twin scenarios by lightweight processing and fusion of heterogeneous data, including terrain, imagery, oblique photogrammetry models, LiDAR point clouds, handmade models, and Building Information Modeling (BIM) data. By integrating real physics engines, Geographic Information Systems (GIS), artificial intelligence, IoT, and cloud computing, Res3D China simulates scenarios involving natural environments, human behavior, transportation, firefighting, and disaster preparedness, enabling dynamic digital twin simulation and analysis. External data, such as refined models, oblique imagery, point clouds, and BIM, are dynamically loaded to support comprehensive 3D scene simulation. Open-source HTML5 WebGL frameworks, combined with big data technologies, enable "zero-client" front-end access with robust 3D map visualization capabilities. Backend cloud rendering delivers geographic twin scene data as real-time video streams to web interfaces, ensuring synchronized front-to-backend interaction, with analytical results computed at the backend delivered as services to the front end.

3.5 Data Sharing and Security Assurance.

The widespread application of Res3D China necessitates robust security measures to address risks such as data leakage, integrity, and backup for sensitive geospatial and building detail data. Key technologies include commercial cryptographic algorithms for direct data encryption, transparent encryption/decryption using domestic cryptographic technologies for seamless geospatial data file protection and authorized access management, and digital watermarking to invisibly embed copyright, user, order number, distributor, timestamp, and other metadata for traceability of unauthorized data use or leaks. Secure data transmission is ensured through end-to-end encryption, virtual private networks and access control mechanisms that restrict data usage to authorized users, minimizing exposure risks across different authorization levels and classifications.

4. Current and Future Applications of Res3D

4.1 Overview of Current Usage Scenes

The construction of Res3D is a new exploration to build a new data model of national land space with the support of technologies such as the Internet of Things, big data and artificial intelligence. It is the first step in building a twin digital national land space.
At the national level, ReS3D outcomes are currently integrated into the National Territorial Spatial Fundamental Information Platform, serving as the base for the three-dimensional map and spatiotemporal database of natural resources. Applications include:

Verification for the third national land survey program, extraction of land change features, spatial planning and scenario simulation, rectification of illegal villas in certain areas, ecological protection and high-quality development of the Yellow River Basin (Ningxia section), among others.
ReS3D data supports a wide range of urban applications, providing an authoritative and unified spatiotemporal base for urban construction. It facilitates integrated 3D visualization, management, and application of above-ground, underground, terrestrial, and marine features, and — thanks to its detailed geographic and temporal analytical capabilities — becomes a crucial tool for refined urban management and a cornerstone of digital and smart city initiatives.
Additional application scenarios include smart construction and housing, heritage protection, and digital tourism.

4.1.1 Supporting Natural Resource Management. Res3D China provides a robust spatial positioning framework and analytical foundation for natural resource management. It facilitates the optimal allocation of resources across temporal and spatial dimensions, supporting the construction of a three-dimensional "One Map" for natural resources and the foundational information platform for territorial spatial planning. By integrating space-air-ground remote sensing technologies, Res3D China enables comprehensive monitoring of natural resources and territorial spaces, supporting applications such as land use planning, farmland protection, mining management, and ecological restoration.

4.1.2 Empowering Government Decision-Making. Through standardized service interfaces, Res3D China delivers ubiquitous, real-time, and multi-modal services to various government sectors. By integrating multi-source, multi-level, and cross-domain data, it provides a spatiotemporal foundation and data fusion platform that supports informatization construction and innovative governance models. Applications in smart policing, emergency response, urban governance, and intelligent construction demonstrate its role in providing critical decision-making support across government departments.

4.1.3 Driving Digital Economic Development. Res3D China enhances digital economic growth by enabling precise and intelligent matching of resources in spatiotemporal contexts. Through integration with artificial intelligence and big data technologies, it serves as a catalyst for industrial efficiency and digital transformation. It supports process reengineering and comprehensive scenario integration, fostering innovation in business models and operational workflows across various industries.

4.1.4 Enhancing Public Services and Quality of Life. Leveraging its capabilities in spatiotemporal scene recognition and situational awareness, Res3D China introduces on-demand, proactive, and personalized service models. It supports the creation of smart, convenient living circles by providing spatiotemporal information services for real estate, healthcare, transportation, education, and public security. These services enrich digital application scenarios, such as shopping, home living, and elderly care, improving public convenience and quality of life.

4.1.5 Promoting Digital Cultural Construction. By integrating with cultural heritage data, Res3D China enables the creation of digital 3D museums and tourism service platforms. It supports personalized route planning, 3D check-in recommendations, and immersive scene playback, enhancing visitor experiences. Additionally, it facilitates the digital preservation and virtual restoration of cultural heritage, contributing to national cultural park development, historic city preservation, and the growth of new cultural formats and consumption models.

4.1.6 Supporting Digital Ecological Civilization. In the context of China's transition to green and low-carbon development, Res3D China plays a critical role in ecological civilization construction. It supports in-depth studies of sustainable territorial development, environmental impact analysis, and disaster risk assessment. By integrating data from natural resources, mining, water conservancy, forestry, and meteorology, it enables digitized and intelligent environmental governance, emergency response, and post-disaster analysis, promoting harmonious coexistence between humanity and nature.

4.2 Future Key Application Areas

Res3D China, as a novel means and method for comprehensive spatio-temporal analysis, multi-dimensional visualization, and trend forecasting of socio-economic elements under modern technological conditions, can play a significant role in accelerating the construction of an economic layout and territorial spatial system that reflect high-quality development requirements, particularly in optimizing the layout of major productive forces.

4.2.1 Spatial-Related Strategic Planning Coordination Platform. This platform acts as a diagnostic tool for aligning diverse spatial strategies. It evaluates multiple coordination dimensions—spatial (e.g., geographic overlaps), temporal (e.g., sequencing of implementations), content (e.g., policy consistency), functional (e.g., role complementarity), and structural (e.g., hierarchical organization). ,Adaptability metrics include alignment with innovative concepts (e.g., green development), high-quality standards (e.g., efficiency and innovation), natural harmony (e.g., biodiversity preservation), and environmental resilience (e.g., climate adaptation). By "moving" planning contents into a unified digital space, it provides actionable insights, such as identifying conflicts in land use between industrial zones and ecological reserves, thereby informing adjustments to productive forces distributions.

4.2.2 Regional Intelligent Socio-Economic Sandbox. Inspired by sand tables but digitized, this tool enables immersive simulations of socio-economic scenarios. Key features include virtual-reality integration for realistic visualizations, multi-scale temporal modeling (e.g., from daily operations to long-term forecasts), full-element simulations (e.g., incorporating population, economy, infrastructure), and panoramic data loading. It supports services like predictive modeling of productivity layouts—e.g., simulating the impact of relocating manufacturing hubs on regional GDP—or diagnosing issues such as resource bottlenecks. This aids in policy-making, such as allocating resources for infrastructure projects or formulating measures to enhance economic resilience.

4.2.3 National Major Productive Forces Layout Assessment and Evaluation Platform. This networked system facilitates multi-level evaluations, blending standardized national indicators (e.g., GDP contribution, employment rates) with region-specific metrics (e.g., coastal vs. inland priorities). It employs integrated scales—macro (national policies), meso (provincial strategies), micro (local implementations)—and temporal models connecting past data (historical benchmarks), current states (real-time monitoring), and future projections (scenario forecasting). Regular assessments, triggered by development phase changes (e.g., post-COVID recovery) or strategic shifts (e.g., Belt and Road Initiative updates), ensure adaptive optimization.

5. Challenges and Technical Hurdles

Based on surveys conducted by the ReS3D City Committee of the China Association for Geographic Information Industry, significant bottlenecks persist in both technological and market mechanisms, requiring urgent breakthroughs.

5.1 Technological Innovation and Breakthroughs

Res3D China faces significant technical hurdles in several areas: temporal data construction, semantic relationship modeling, standardization, data security, and large-scale data management. Key challenges include achieving rapid individualization to reduce construction costs and enhance efficiency, enabling efficient change detection and dynamic updates, and developing lightweight processing techniques for massive 3D datasets to support growing demands for data management and visualization. Additionally, rapid or real-time data desensitization, coordinate system conversion, and secure data sharing remain unresolved. Coordinating the unique identification and semantic relationship modeling of entities across city-level and terrain-level scales, with varying granularities, poses further complexity. These issues necessitate innovative solutions to ensure Res3D China can meet the demands of scalability and real-time applications.

Rapid Object Extraction and Structured Modeling of Mesh Models. Currently, object extraction and structured modeling based on mesh models face dual challenges in efficiency and accuracy. Although large-scale 3D models can be rapidly generated through oblique photogrammetry and LiDAR, semantic segmentation and structured representation of geographic entities still rely heavily on manual intervention, which fails to meet automation requirements at the city scale. For instance, detailed modeling of building attachments (e.g., balconies, canopies) requires AI-driven recognition and parametric reconstruction, for which standardized technical workflows are yet to be established.

Dynamic Update and Spatiotemporal Fusion Mechanisms. Model update methods mainly rely on periodic re-acquisition and lack real-time change detection capabilities based on IoT perception data. While terrain-level data is updated on a three-year cycle, dynamic updating of high-precision city-level models remains constrained by data acquisition costs and computational power. There is an urgent need to construct a collaborative update framework for multi-source heterogeneous "air-to-ground" data, enabling incremental modeling and historical version management.

Association Between 2D Vectors and 3D Models. There exists heterogeneity in spatial reference and attribute structures between 2D representations of geographic entities (e.g., cadastral maps) and 3D semantic models (e.g., BIM). A unified spatial identity coding system (such as the MA identification system) is required to establish cross-dimensional entity mapping, while also addressing geometric discrepancies caused by coordinate system transformations (e.g., WGS84 vs. CGCS2000).

Scalable Application of Air-Ground Integrated Modeling. Despite advances in UAV and vehicle-mounted mobile mapping technologies, seamless integration of indoor and outdoor modeling still faces data fusion challenges. For example, registration errors between terrestrial LiDAR and aerial oblique imagery require multi-sensor calibration and SLAM algorithm optimization, but there remains a lack of cost-effective technical pathways for large-scale applications.

5.2 Market and Mechanism Bottlenecks

Computing Power and Infrastructure Cost Control. High-resolution data acquisition (e.g., 0.05 m oblique imagery) and large-scale modeling impose exponentially increasing demands on computing power. Local governments should explore "cloud-edge-device" collaborative computing, leveraging government cloud resource pooling to reduce local hardware investment, while encouraging enterprise participation in computing resource sharing ecosystems.

Cost Quotas and Market Regulation Deficiency. Currently, only a few regions (e.g., Shenzhen) have issued dedicated budget guidelines for ReS3D construction. The absence of quota standards in most projects leads to mismatches between fiscal budgets and practical needs. It is recommended to formulate scenario-specific pricing models (e.g., terrain-level, city-level) based on the Mapping Production Cost Quota, to curb quality risks from low-price bidding.

Insufficient Integration and Utilization of Multi-Source Data. Non-surveying departments (e.g., culture and tourism, transportation) have accumulated large quantities of oblique photogrammetry models, but discrepancies in data format and accuracy result in low utilization rates. A unified data aggregation platform should be established to standardize heterogeneous model resources through coordinate correction and semantic annotation.

Conflict Between Data Security and Sharing. The value of Res3D China lies in its high-precision, three-dimensional geospatial data, which is realized through widespread application and sharing. However, according to the Provisions on Geographic Information data, the use and dissemination of Res3D data are subject to stringent controls(C. Xue, 2022). The immaturity of related data security technologies further restricts the open use and expanded application of 3D geospatial data. Without effective mechanisms for secure sharing, the enthusiasm and initiative of stakeholders involved in Res3D China's construction are likely to wane, potentially delaying the overall progress of the initiative and limiting its societal impact.

Challenges in Post-Construction Maintenance and Updates. Achieving centimeter-level accuracy for terrain-level and city-level Res3D models with full coverage is a significant milestone. However, the subsequent individualization of component-level models and the maintenance and updating of comprehensive 3D data results entail significantly higher costs than initial construction. The precision and dynamic nature of Res3D data are its core strengths, yet the high costs of maintenance could restrict the continuous supply and broad application of these datasets. Currently, geospatial data provision in China is primarily driven by government-led public welfare projects, with government agencies and related enterprises as the primary users. However, the growing demand for socialized applications is likely to disrupt this supply-demand balance, necessitating new models for sustainable data provision and maintenance.

6. Future Works

6.1 Enhancing Technological Innovation and Foundational Support Capabilities

First, in terms of standards innovation, build upon the preliminary framework of Res3D standards, which encompasses categories such as overall design, data acquisition and processing, database construction and management, quality control, and platform services. Adhering to the principle of prioritizing urgent needs while progressing gradually, focus on developing foundational and critical standards initially. As practical implementations of Res3D mapping evolve, systematically expand to form a comprehensive standards system and checklist. Simultaneously, strengthen oversight and evaluation of standards implementation.

Second, regarding technology and equipment research and development, concentrate on key challenges including rapid modeling of large-scale entities, immersive collaborative rendering of massive data, and ubiquitous spatiotemporal integration and empowerment. Foster collaborative efforts to achieve breakthroughs. Conduct evaluations of software and hardware through relevant professional associations, organizing performance assessments for 3D modeling, data lightweighting, and related metrics.

Third, in building supportive environments, accelerate the development and deployment of various online platform systems and software/hardware equipment, integrating them organically with governmental informatics and intelligent e-governance initiatives at all levels. Promote the shared use of Res3D mapping as a spatiotemporal foundation and data fusion platform across departments and business systems, evolving mapping support from "business-generated data" to "data-generated business." Leveraging diverse network environments such as the internet and secure networks, provide suitable versions of Res3D data to platforms like smart city spatiotemporal big data systems, geographic information public services, territorial spatial foundational information platforms, and city information modeling (CIM) platforms, enabling ubiquitous service delivery of Res3D mapping outcomes.

6.2 Refining Novel Data Product Systems and Strengthening Data Resource Development

First, redefine Res3D product models to emphasize features such as three-dimensionality, entity-based representation, semantic enrichment, temporal sequencing, full spatial coverage, and capabilities for recognition, analysis, and expression. Analyze relationships between geographic entities and scenes, foundational and thematic geographic entities, and Res3D data versus traditional foundational geographic information data, while clarifying entity classification methods.

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Second, optimize engineering production processes for Res3D data by designing multi-level, multi-type, multi-modal products that are assemblable on demand and capable of deriving knowledge and services. Represented by Res3D products, these novel geographic information data offerings should reduce acquisition costs, enhance data quality, and sustain dynamic updates for terrain-level and urban-level 3D data.

Third, establish an application-oriented Res3D data system, encouraging broader enterprise participation in component-level Res3D construction. Driven by demand, introduce diversified investments, and align with needs such as unified registration of natural resources and immovable properties, as well as asset allocation and rights management, to advance layered and segmented component-level Res3D development.

Fourth, develop robust mechanisms for data submission and sharing to facilitate effective integration and connectivity between component-level Res3D and terrain-level or urban-level variants, preventing spatial fragmentation in construction outcomes. Achieve organic fusion of Res3D data with IoT sensor data and big data from the Internet of Things.

6.3 Strengthening Overall Coordination and Implementation in Construction

First, clearly delineate responsibilities across national, provincial, municipal, and county levels. At the national level, issue policy documents to further specify the primary responsibilities of mapping and geographic information authorities in public data construction for Res3D systems, with a focus on clarifying boundaries between provincial and municipal/county tasks. Guided by the principle of "measure once, reuse at multiple levels," assign departments and units to complete national and local construction tasks with varying emphases and levels of detail.

Second, coordinate the nationwide advancement of Res3D construction and applications. In high-precision Res3D areas, integrate existing results without redundant production; conduct new measurements in uncovered regions. Tailor application needs and objectives for terrain-level, urban-level, and component-level Res3D across eastern, central, and western provinces based on current conditions and future development requirements. Through national and provincial coordination, align municipal and county construction goals and tasks, formulate long-term plans, forward-looking deployments, and feasible timelines and roadmaps.

6.4 Balancing Application Expansion with Security Management

First, promote the application of preliminary pilot results, particularly in scenarios such as integrated territorial spatial mapping, natural resource surveying and monitoring, immovable property management, 15-minute community living circles, and industrial park oversight. Further explore the creation of innovative Res3D products that serve the public.

Second, focus on application demands to continually optimize products and services. Generate more usage scenarios and user needs by deeply integrating Res3D data supply with specific application contexts and production/lifestyle requirements. Advance integrated governmental, commercial, and civilian utilization, progressively forming a full-chain assurance from data and information to knowledge.

Third, expand the public-facing application of outcomes. At the national level, considering data security and its implications, explore graded and classified approaches to address public service issues for 3D data. Enhance experimental explorations of technologies such as domestic cryptography, digital watermarking, and blockchain in Res3D data security applications.

7. References

CHEN Jun, WANGYanhui,WU Hao, et al. Basic issues and development directions of high-quality development empowered by spatio-temporal information[J]. Journal of Spatio-Temporal Information,2023,30(1):1-11

CHEN Jun, et al. Overall Architecture and Main Technologies of Realistic 3D China. Acta Geodaetica et Cartographica Sinica 54.04(2025):636-649.

C. Xue, Y. Zhang and D. Jia, "History, Current Situation and Future Challenges of China's Geographic Information Data Governance," 2022 29th International Conference on Geoinformatics, Beijing, China, 2022, pp. 1-5, doi: 10.1109/Geoinformatics57846.2022.9963876.