White Paper: 3D Real Scene Empowering High-Quality Development in Qingdao （2023-2024）

Qingdao Municipal Bureau of Natural Resources and Planning, Shandong Province, P.R. China

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Editorial Board

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Preface

The 3D Real Scene serves as a true, three-dimensional, time-sequenced representation of spatiotemporal information, reflecting human production, living, and ecological spaces. It is a strategic data resource and production element vital to the development of digital government and the digital economy. The concept of a "3D Real Scene China" has been integrated into various national strategies, including the national opinions on accelerating the comprehensive green transformation of economic and social development, the overall planning for Digital China construction, the "14th Five-Year Plan" for new infrastructure construction, and the "14th Five-Year Plan" for natural resource protection and utilization. Following the deployment requirements of the overall layout plan for the construction of a digital China, nationwide efforts are underway to accelerate the development of 3D Real Scene.

Qingdao has actively implemented the national strategic deployment. With guidance and support from the Ministry of Natural Resources and the Department of Natural Resources of Shandong Province, Qingdao launched the 3D Real Scene Qingdao project in March 2021. By March 2022, it became the first city in China to complete the construction of a high-precision 3D Real Scene covering both land and sea areas. This project replicated and mapped the physical world into digital space, accurately restoring the integrated urban landscape of Qingdao, encompassing its mountains, sea, city, islands, and bays. It marked a leap from 2D to 3D upgrades in the city's geographic information data. As the supporting platform for the "city brain" of Qingdao, it provides a unique and authoritative 3D digital space foundation for the entire city. In 2024, 3D Real Scene Qingdao became the first in the country to complete a comprehensive update, exploring update mechanisms and technologies, thereby offering the "Qingdao Model" for updating 3D Real Scenes in megacities and contributing to the time-sequenced construction of the 3D Real Scene China.

The acceptance expert group, headed by Academician Li Deren, a member of both the Chinese Academy of Sciences and the Chinese Academy of Engineering, concluded that the 3D Real Scene Qingdao project has created the "Qingdao Speed" for 3D Real Scene construction. It has provided a "Qingdao Model" for the 3D Real Scene China and contributed invaluable "Qingdao Experience". The project has reached a leading

position nationally and the core technological achievements of the 3D Real Scene Qingdao project were awarded the First Prize in the National Surveying and Mapping Science and Technology Awards in 2023.

As the city's sole and authoritative digital spatial foundation, the results of the 3D Real Scene Qingdao project have been shared across more than 40 sectors, providing geographic information and public services for over 100 digital application scenarios in the city, with annual platform service access exceeding 100 million visits. It has delivered dedicated services to departments such as the Municipal General Duty Office, the Integrated Emergency Command Center, the Urban Management Bureau, and the Fire Rescue Brigade.

The project has played a significant role in various areas including land space planning, land protection and utilization, urban development, historical and cultural preservation, urban renewal, social governance, digital economy, public transportation, ecological conservation, forest fire prevention, disaster risk reduction, and more. It has also been applied to corporate digital transformation, major infrastructure design and construction, and industrial park operation management. This integration has facilitated the convergence of the digital economy with the real economy, continuously empowering Qingdao's digital city development and driving high-quality socioeconomic growth.

1. Construction of 3D Real Scene China

1.1 Background

China is accelerating the construction of a digital China and developing its digital economy, promoting the deep integration of the digital economy with the real economy. The country has successively issued policy documents to advance the development of 3D Real Scene China, deepening the application of spatiotemporal information. Utilizing spatiotemporal data for decision-making, analyzing in 3D space, and making decisions based on spatiotemporal knowledge have become key strategies to drive high-quality socioeconomic development and digital transformation across society.

3D Real Scene, as a true, three-dimensional, time-sequenced representation of human production, life, and ecological spaces, is categorized into terrain-level, city-level, and component-level. It serves as a critical new type of national infrastructure. Through "human-machine compatibility, IoT sensing, and ubiquitous services," 3D Real Scene achieves real-time linkage between the digital space and the physical world, providing a unified spatial positioning framework and analytical foundation for Digital China. It is a vital strategic data resource and production element for digital government and the digital economy. The Ministry of Natural Resources requires accelerating the construction of 3D Real Scene China. Specifically, this involves achieving nationwide coverage with terrain-level 3D Real Scene over the mainland and major islands, as well as city-level 3D Real Scene covering the urban development boundaries of prefecture-level cities. Component-level 3D Real Scene will be developed on a case-by-case basis.

1.2 Construction Progress

The construction of 3D Real Scene China has progressed through three stages: pilot exploration, localized application, and comprehensive deployment. Significant progress has been made in each stage.

Currently, 31 provinces, municipalities, and autonomous regions have incorporated 3D Real Scene construction into their basic surveying and mapping plans, natural resource protection and utilization plans, or geographic information development plans. Additionally, 21 provinces, municipalities, and autonomous regions have developed specific implementation plans for 3D Real Scene construction.

According to data released by the Ministry of Natural Resources, as of 2022, approximately 7 million square kilometers of terrain-level, city-level, and component-level 3D Real Scene models with varying levels of detail have been created nationwide. Approximately three-quarters of the country's mainland and major islands are now covered by these 3D Real Scene data. These developments provide essential spatial geographic data elements for socioeconomic development and people’s daily lives, offering a unified spatiotemporal foundation for the “Beautiful

China” initiative.

In 2024, Shandong Province has continued to advance the construction of the 3D Real Scene Shandong through coordinated efforts at the provincial, municipal, and county levels. This resulted in the creation of a terrain-level 3D Real Scene that integrates "2D and 3D, land, sea, islands, above-ground and underground, above-water and underwater." The initiative has also aggregated multi-level, multi-granularity city-level 3D Real Scene data for 16 cities and nearly 100 counties (cities, districts). It integrates multi-source and multi-type data, expanding component-level 3D Real Scene data in key areas, including municipal facilities, underground utility corridors, and underground spaces. Additionally, it has integrated multi-source IoT sensing information, enabling real-time access and scene integration with video surveillance cameras and drone aerial photography.

By 2025, the preliminary construction of the 3D Real Scene China is expected to be completed, establishing the capability for real-time interaction and connection between digital and physical spaces in prefecture-level cities. This will provide a 3D spatial positioning framework and analytical foundation for digital China, digital government, and the digital economy. It is anticipated that over 50% of government decision-making, production scheduling, and life planning will be conducted through the online 3D Real Scene platform. By 2035, the application of 3D Real Scene results will extend from prefecture-level to county-level cities, with the applicability of these applications increasing from 50% in 2025 to 80%.

1.3 Applications

The Ministry of Natural Resources has adopted the guiding principles of "Data as the King, Innovation as the Core, Application as the Foundation, and Security as the Basis" to drive the construction and application of the 3D Real Scene China. Focusing on five core functions—spatiotemporal benchmarks, spatiotemporal correlation, spatiotemporal analysis, spatiotemporal intelligence, and spatiotemporal security—the ministry actively guides and nurtures the demand for 3D Real Scene applications. In August 2024, in collaboration with the National Data Bureau, the Ministry of Natural Resources selected and released the first batch of 60 exemplary cases. These cases cover a wide range of application scenarios, including disaster prevention and control, smart security and dispatch, historical and cultural preservation, territorial spatial planning, farmland protection, digital rural areas, smart ports, ecological protection, and social governance.

Department of Natural Resources of Shandong Province has adopted a "using while building, using to promote building" approach, collaborating with the Provincial Big Data Bureau to organize the "Top Ten Innovative Application Scenarios" contest. This initiative aims to create exemplary application scenarios through a variety of measures, fostering an application ecosystem. Similarly, provinces like Hunan and Sichuan have also held competitions for innovative 3D Real Scene applications, supporting the transformation and upgrading of the surveying and mapping geospatial

information industry, advancing the construction of 3D Real Scene projects, and enhancing the focus on application-driven outcomes to promote high-quality development in related industries.

At the "Promoting High-Quality Development" press conference held by the State Council Information Office on September 19, 2024, Liu Guohong, Deputy Minister of the Ministry of Natural Resources, highlighted the different applications of various levels of 3D Real Scene models. The terrain-level 3D Real Scene captures topology and geographical landscapes, primarily serving macro-level application scenarios. The city-level 3D Real Scene provides detailed representations, down to the 3D shapes of buildings, and is mainly used to support smart urban management. The component-level 3D Real Scene is aimed at detailed application scenarios, such as creating precise "3D archives" for the preservation of historical buildings and cultural heritages.

In summary, the 3D Real Scene China has evolved into a strategic national data resource and a new type of infrastructure, whose value is increasingly evident in the digital and intelligent era. In promoting digital economic development, the integration of 3D Real Scene with various types of big data enables seamless interaction between digital and physical spaces. This supports the growth of the low-altitude economy, intelligent driving, smart ports, smart agriculture, digital culture, and tourism, among other aspects of the digital economy. In enhancing the quality of life, 3D Real Scene provides spatial analysis services and high-precision navigation, facilitating more convenient, eco-friendly, and efficient social interactions and travel. For supporting smart social governance, the integration of 3D Real Scene with elements of economic, social, and natural resources allows for more precise and effective spatial matching of resources, promoting finer governance and more efficient services.

2. 3D Real Scene Practice in Qingdao

In July 2020, the Qingdao Municipal Government Office proposed "establishing a 3D spatial benchmark, building a base map of the 3D Real Scene model, and advancing the 3D Real Scene Qingdao." The project was implemented with a focus on high starting points and high standards. In March 2021, the 3D Real Scene Qingdao project was officially launched. After nearly a year of efforts, the project successfully passed the acceptance evaluation by an expert group led by Academician Li Deren from the Chinese Academy of Sciences and the Chinese Academy of Engineering. The project achieved, for the first time, full 3D coverage of Qingdao’s entire land area and seven inhabited islands with high precision, diverse types, and multiple scales. It established an integrated land-sea 2D and 3D spatiotemporal big data platform, serving as Qingdao’s authoritative and unified geographic information public service platform, providing a digital spatial foundation for Digital Qingdao.

2.1 Building a Digital Space Foundation

The results of the 3D Real Scene Qingdao project include "Four Base Maps, One

Platform, and One Set of Standards." The project established the industry's first Spatiotemporal Big Data Computing Center, integrating cloud-native, cloud host, and cloud desktop technologies, designed for spatiotemporal full-service scenarios. In 2024, the first round of updates for terrain-level and city-level 3D Real Scene was completed.

2.1.1 Digital Foundation Solidified by Four Base Maps

The Citywide Terrain 3D Base Map refers to the terrain-level 3D Real Scene model, covering the entire land area of the city and seven inhabited islands, totalling 11,000 square kilometers. It was constructed using 15 cm oblique aerial photography, authentically capturing Qingdao's integrated landscape of mountains, sea, city, islands, and bays. This map enables the digital and spatial representation of the city's terrain, landforms, and current development status, supporting various applications such as territorial spatial planning, urban-rural integrated development, ecological restoration, and major infrastructure construction.

The High-Precision 3D Base Map for Key Areas refers to the city-level 3D Real Scene model, covering approximately 1,800 square kilometers of urban development land, including all city districts, town (street) headquarters, and functional areas. It was constructed using 3 cm oblique aerial photography. For the main urban area, nearly 280,000 key buildings have been modelled in detail, with a structural modelling accuracy of 0.2 meters, meeting the requirements for both the LoD3 level 3D model of the "3D Real Scene China" standard and the CIM4-level City Information Model. This approach enables the "build once, apply many times" strategy.

In addition, 293 graded roads, primary and secondary roads in the main urban area were meticulously refined. Physical models were created for road components such as lamp posts and signboards taller than 0.4 meters, addressing the needs for urban delicacy management. A 2-square-kilometer component-level 3D scene was developed around May Fourth Square, integrating geological bodies, underground facilities, underwater terrain, and indoor building information models, exploring integrated application scenarios for above-ground, underground, above-water, underwater, and indoor-outdoor environments.

Fig 2-1 City-level 3D Real Scene model -St. Michael's Cathedral

Fig 2-2 City-level 3D Real Scene model – Fushan Bay

The Citywide 2D Base Map covers the entire land area of the city and seven inhabited islands, totaling 11,000 square kilometers. It includes three styles: government edition, blue-black edition, and imagery edition, catering to different application scenarios. The digital map achieves a land-sea integrated spatial element representation at a scale better than 1:2000, supporting maritime development strategies.

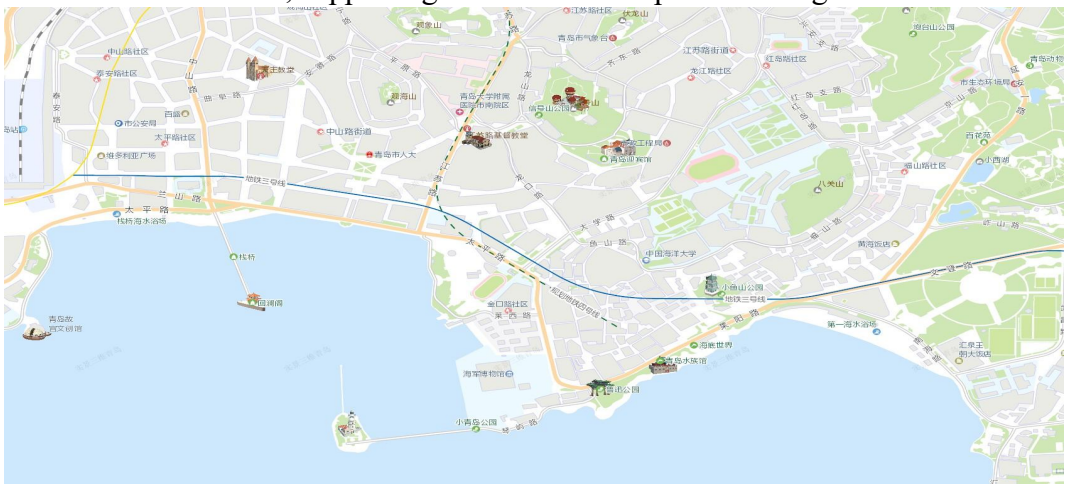

Fig 2-3 2D Digital Map, Administrative Edition

Fig 2-4 2D Digital Map, Black-Blue Edition

Fig 2-5 2D Digital Map, Aerial Imagery Edition

Key Mountain Forest LiDAR Point Cloud Data covers approximately 800 square kilometers within the ecological protection red line areas, including Laoshan Nature Reserve, Dazeshan Nature Reserve, Xiaozhushan, Cangmashan, and Tiejueshan mountain ranges. The data acquisition achieved an average density of 16 points per square meter, resulting in a high-precision digital surface model. This model accurately represents the terrain and vegetation coverage of the mountains, providing scientific data support for forest fire prevention, geological disaster management, forestry resource surveys, and carbon peaking and carbon neutrality accounting.

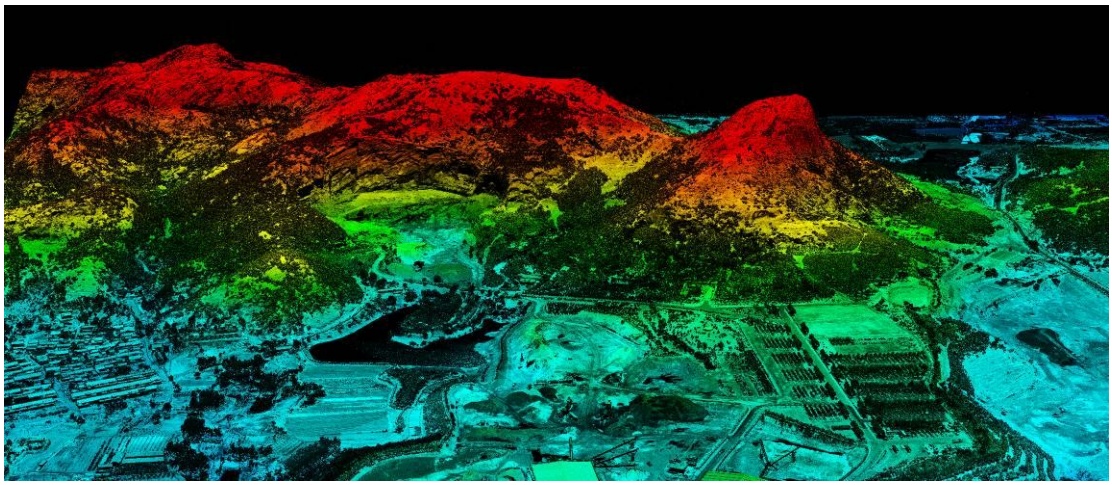

Fig 2-6 Key Mountain Forest LiDAR Point Cloud

2.1.2 Open Data Service on Spatiotemporal Big Data Platform

The Smart Qingdao Spatiotemporal Big Data Platform operates on Qingdao's e-government network, with capabilities for the publication, aggregation, and management of spatiotemporal big data. It has established a unified pool of spatiotemporal information resources and offers users and administrators various services, such as visualization, analysis, application, sharing, distribution, and updates for 2D vector, 3D Real Scene, and geographical name and address data. The platform is capable of rendering in eight dimensions, integrating 2D and 3D, above-ground and underground, above-water, underwater, and indoor-outdoor environments.

The platform adopts a "front-end map, back-end portal" application model, which includes an integrated 2D and 3D map application module, a back-end resource portal, and geographic information spatial data collection tools. The map application module focuses on comprehensive client-side applications, meeting the basic map viewing and querying needs of general users. The back-end resource portal includes data management, service management, and operational maintenance management, primarily handling the storage, management, and sharing of 2D and 3D data and services. The platform also provides tools for the collection of thematic geographic information data. Users can customize data collection tasks, and the collected data can be published as services for use by various business systems.

Fig 2-7 Spatiotemporal Big Data Platform

2.1.3 Technological Development Guided by Standards and Specifications

The local standard called "3D Real Scene Qingdao Construction Technical Specifications", developed by the Qingdao Surveying and Mapping Institute under the guidance of the Qingdao Municipal Bureau of Natural Resources and Planning, gathers the collective expertise of numerous scholars and experts. The standard fully demonstrates professional, scientific, and practical qualities, filling the gap in this field in Qingdao. It is the first set of 3D Real Scene urban construction technical standard to be released nationwide, providing a valuable reference for other cities undertaking 3D Real Scene construction.

By standardizing the city's 3D Real Scene construction technical specifications, Qingdao ensures uniformity in its 3D Real Scene construction and the consistency of its outcomes. This significantly enhances the supply capacity of geographic information resources, offering high-quality data services to support urban governance, digital city construction, and overall economic and social development across the city.

2.1.4 The Computing Center Supports Massive Services

To support the new demands for processing, analyzing, managing, and sharing spatiotemporal big data, with a focus on 3D Real Scene, the first industry-leading

Spatiotemporal Big Data Computing Center was created, integrating cloud-native, cloud host, and cloud desktop technologies, and designed for full-service spatiotemporal scenarios. The center boasts a computing capacity of 3,000 CPU cores and 150 GPUs, and it has established over 250 3D Real Scene modelling units, more than 300 cloud desktops, over 600 cloud hosts, and more than 1,000 cloud-native intelligent processing engines. This infrastructure fully supports the development and updates of 3D Real Scene city construction as well as the operation of online services for municipal governance applications.

Compared to the original graphic workstation approach, the 3-centimeter resolution oblique photography modelling has a daily processing capability of up to 100 square kilometers, achieving more than a tenfold improvement in computational efficiency. The computing capabilities are at the forefront of the industry.

2.1.5 Temporal Construction Maintains Data Freshness

To ensure the timeliness of data, the first round of updates for terrain-level and city-level 3D Real Scene was completed in May 2024. This resulted in the creation of annual temporal sequence data for key areas of change across the city, maintaining the currency and relevance of the data.

Building on the update process, a strategy and mechanism were developed to combine comprehensive and targeted updates of 3D Real Scene data at different levels and scales, ensuring a balance between efficiency and cost. Breakthroughs were made in key technologies, such as wide-area image control networks, tile fusion reconstruction, and automatic detection of 3D model accuracy. These advancements have provided the "Qingdao Experience" for the temporal updates of the 3D Real Scene China project.

Based on the temporal sequence data from 2021 and 2023, changes in various management elements were identified and analyzed, offering objective and precise spatial analysis support for natural resource management and urban decision-making. The updated results have already been shared and applied in areas such as "Three Zones and Three Lines" control, urban renewal construction effectiveness evaluation, monitoring of ecological restoration for historical mining sites, and the rectification of illegal construction issues.

2.2 Advancing the Sharing of Spatiotemporal Elements

Effective data sharing and application are crucial for maximizing the potential of data elements. A 3D Real Scene sharing directory was published on the Qingdao Spatiotemporal Big Data Platform. Government departments at various levels have actively shared and accessed this resource, achieving significant applications and outcomes.

2.2.1 Streamlining Application Sharing Channels

Multiple application channels for different entities have been established. As of September 2024, 25 3D Real Scene sharing directories and 151 secondary development interfaces have been published via the city's integrated big data platform, with 57 departments registered. The total number of online service visits has exceeded 1.7 billion, and offline data retrievals have surpassed 100TB. For socio-economic entities, an innovative 3D Real Scene social sharing and crowdsourced update model has been established. For key projects, the comprehensive application of 3D Real Scene in urban planning and project validation has been promoted.

Various sharing methods are available for different environments. First, online service sharing via the government network, the primary method of 3D Real Scene sharing, has provided online services to over 100 departmental information systems. Second, offline, personalized data sharing meets the needs of departments requiring deep data processing and use in independent environments. Third, dedicated lines support citywide data sharing, offering specialized services to key departments, such as the Municipal Government Duty Office, the Integrated Emergency Command Center, the Urban Renewal and Construction Command Center, the Urban Management Bureau, and the Fire Rescue Brigade, ensuring their access to full-range data for critical applications.

2.2.2 Prominent Impacts of Data Sharing Enablement

Based on the Qingdao Spatiotemporal Big Data Platform, more than 40 departments, including the Municipal Bureau of Justice, the Bureau of Big Data, the Bureau of Emergency Management, the Bureau of Housing and Urban-Rural Development, and the Shinan District Big Data Bureau, have been provided with 2D and 3D foundational geographic information public services. These services support over 100 application scenarios, such as the Integrated Command Platform for the City's Cloud Brain, the CIM Basic Platform, the Comprehensive Safety Risk Monitoring and Early Warning Platform, and the Smart Community Management Service Platform. The service areas span various aspects of urban management and economic and social development, including industrial investment promotion, rural revitalization, and cultural tourism, highlighting its wide application.

The "World's First Practice of Constructing a Port Information Model (PIM) Based on 3D Real Scene" was selected as one of the most representative cases in the first batch of 3D Real Scene data-enabled high-quality development innovation applications organized by the Ministry of Natural Resources and the National Data Bureau. This case was featured in the main event of the 2024 National Mapping Law Publicity Day held by the Ministry of Natural Resources. Additionally, the "Chongqing Elevated Road Digital Chief Engineer Project," based on 3D Real Scene, won the Special Prize at the 5th National BIM Competition in the Engineering Construction Industry and the First Prize (highest award) at the 13th "Longtu Cup" National BIM Competition. These recognitions continually set new records for digital achievements in Qingdao's municipal engineering sector and signify the project’s position at the forefront of digital applications in China.

2.3 Fostering a Thriving Industry Ecosystem

2.3.1 Leading in Standards and Specifications Development

Summarizing the experiences from the 3D Real Scene Qingdao project, Qingdao took the lead in drafting the local standard "3D Real Scene Qingdao Construction Technical Specifications," which provides standardized guidelines for the unified construction, updating, and application of future 3D Real Scene cities. Additionally, Qingdao authored group standards such as "3D Real Scene: Data Requirements for Forest Fire Prevention" and "3D Real Scene: Technical Requirements for Auxiliary Appraisal of Engineering Planning Scheme" and contributed to the development of 10 industry, local, and group standards, including "Quality Inspection and Acceptance of 3D Geographic Information Model Data Products".

2.3.2 Innovation-Driven Development

Commitment to Innovation-Driven Development: Emphasizing the integration of industry, academia, and research, Qingdao collaborates with universities such as Wuhan University, Shenzhen University, and Shandong University of Science and Technology to research key technologies for 3D Real Scene construction. These efforts have resulted in 10 nationally authorized invention patents, 31 software copyright registrations, and the publication of 6 papers in SCI/EI and other core journals.

Open Ecosystem Collaboration: Partnering with over 10 leading domestic companies, Qingdao has established a "project + product" integrated ecosystem to foster mutual benefits and has successfully overcome more than 20 key technological challenges. This collaboration continuously optimizes and enhances the product capabilities of relevant enterprises, offering the “Qingdao Experimental Field” as a testing ground for 3D Real Scene technologies and software systems in China.

Focus on Independent R&D: Following the "multi-system integration" concept, a local team has developed the Q3D proprietary core platform, fully supporting the city's comprehensive digital transformation needs. This platform has been recognized as a major industrial breakthrough under the Shandong Province New and Old Kinetic Energy Conversion project. The Q3D series has applied for trademark registration and has been included in Qingdao's production-oriented service industry resource pool, positioning it as a high-end service brand for cultivation.

Facilitating Transformation and Upgrading: 3D Real Scene is a standardized product of the new basic surveying and mapping system. Leveraging the achievements of the 3D Real Scene Qingdao project, the city is participating in the national pilot work for the new basic surveying and mapping system in Shandong Province. This has led to the development of full-space geographic scenes, underwater (marine) geographic entities, and high-precision geographic entity classification standards with Qingdao's coastal characteristics, driving the transformation and upgrading of the surveying and mapping geographic information

industry.

2.3.3 Open, Exchange and Sharing

The Qingdao Surveying and Mapping Institute took the lead in establishing the 3D Real Scene City Working Committee under the China Association for Geospatial Industry and Sciences. This initiative brings together resources nationwide to build an innovative collaboration ecosystem, strengthen the integration of industry, academia, and research, and lead the development and application of 3D Real Scene city construction. By doing so, it promotes the high-quality development of the 3D Real Scene and the continuous growth of the geographic information industry. As a city that pioneered 3D Real Scene construction with remarkable application results, Qingdao has delivered over 30 invited presentations at national industry exchange conferences. Its construction experiences and successful applications have been featured more than 40 times in authoritative media outlets, such as People's Daily, Natural Resources Daily, and Xuexi Qiangguo.

Qingdao continues to drive innovation in the application, management, technology, and service aspects of 3D Real Scene, employing multiple strategies to unlock the potential of 3D Real Scene data elements. The city established the 3D Real Scene Innovation Application Open Laboratory, which utilizes Qingdao's geographic scenes, geographic entities, and LiDAR data. Supported by the Qingdao Spatiotemporal Big Data Computing Center infrastructure and development environment, the lab explores a new application service model, where "raw data does not leave the domain, and data can be used but not seen," ensuring data security while opening access to enterprises, institutions, universities, and research institutes across society. Additionally, the 3D Real Scene Innovation Application Service Station was established, equipped with professional personnel and equipment. Operating in a "3D Real Scene Internet Cafe" format, it provides comprehensive access to 3D Real Scene data for various bureaus, along with software operation, technical training, and application consulting services, making 3D Real Scene both well-utilized and user-friendly. This initiative supports government-related applications and explores more diverse usage scenarios.

3. Empowering High-Quality Development in Qingdao

Addressing the needs of Qingdao's economic and social development, the 3D Real Scene project provides data elements and platform services across six key areas: empowering government management and decision-making, supporting natural resource management, fostering digital economy development, enhancing the quality of life, promoting digital culture development, and supporting digital ecological civilization. This initiative injects strong momentum into Qingdao's digital transformation and green, sustainable development.

3.1 Empowering Government Management and Decision-making

The 3D Real Scene technology, by providing more intuitive, comprehensive, and

detailed 3D urban data, enables decision-makers to assess the city's current state from a full-scale, 3D perspective. It supports the simulation and evaluation of the actual impacts and potential risks of various policy options, enhancing the government's decision-making capabilities in areas such as urban planning and approvals, urban renewal and management, public safety, emergency response, traffic management, and auditing. This advancement drives government management toward greater scientific precision, refinement, and intelligence.

Application Scenario 1: Urban Renewal and Urban Construction Project Management

Scenario Practice:

Based on the 3D Real Scene, combined with aerial panoramic technology, a 3D project management visualization system has been developed for key urban renewal projects across the city. This system allows for the easy retrieval of information on urban renewal initiatives such as inefficient land use, municipal facilities, subway projects, park greening, old town and village regeneration, and historical district developments. It significantly enhances the level of informatization in urban renewal management.

Project responsibility units can intuitively view and monitor the construction status and progress in real-time, while city-level leadership and command centers can instantly access the overall status of all city projects, including start rates, project progress, and challenges. Through the 3D Real Scene integrated map, project dispatching and coordination can be carried out directly from the command center.

This technology has also been applied to various urban renewal initiatives, such as the Wangtai Old Industrial Area Urban Renewal Information System, the Taishan Park urban renewal project management, and the Laoshan Village renovation project management. These applications improve the efficiency and accuracy of project tracking and decision-making across Qingdao.

Application Effectiveness:

By using high-precision 3D scenes as the foundation and integrating aerial panoramic views, video surveillance, and other data sources, nearly 1,000 projects have been visually displayed and dynamically managed. This approach provides irreplaceable technical support for pre-project evaluation, planning, design, and project management, significantly improving management efficiency. The comprehensive visualization and real-time tracking capabilities ensure that stakeholders can oversee project progress and make informed decisions, leading to more effective execution and coordination across various urban renewal and construction initiatives.

Fig 3-1 Wangtai Old Industrial Area Urban Renewal System

Application Scenario 2: Spatial Foundation for the City Cloud Brain

Scenario Practice:

The Smart Qingdao Spatiotemporal Big Data Platform utilizes 3D Real Scene and 2D maps to create a unique 3D visualization platform for the Licang District. This platform includes key areas such as 15 industrial parks, 7 flood-prone points, 10 critical regions, and 33 communities, providing a comprehensive visual representation of the district's distinct features.

The platform facilitates data co-construction and sharing through an integrated "One Map" system. For instance, the Grid Management 3D Visualization Platform aggregates district-wide data, including demographic information, housing information, and community services. Through data governance, a comprehensive profile of Licang District has been developed. The grid map module integrates data from 870 grids across the district, forming a three-level linkage between streets, communities, and grids. This is visualized on a unified screen alongside panoramic 3D maps and video surveillance points, significantly enhancing urban governance capabilities.

The platform also emphasizes digital connectivity to create typical application scenarios. By leveraging the foundational support of the City Cloud Brain and its central capabilities, the platform enables multi-level, all-encompassing, and multi-perspective work collaboration. This system presents detailed information and introductions for 15 industrial parks in Licang District, optimizing urban design and aiding in scientific decision-making for urban planning, development, and management.

Additionally, the platform integrates citywide IoT sensing into 3D visualization. By connecting various IoT devices, such as security monitoring equipment and energy management systems, it merges IoT data with business and geographic information. This integration creates various application scenarios that provide services such as sensor fusion, monitoring indicators, remote control, and predictive analysis, enhancing the district's management and operational efficiency.

Application Effectiveness:

Through this platform, Licang District has empowered various systems, including the first screen of the City Cloud Brain, the Licang District Smart Community Comprehensive Information Platform, and the Licang District Citywide IoT Sensing Platform. It has expanded business scenarios such as the digital economy and industrial park investment promotion, while also creating typical City Cloud Brain application scenarios such as smart communities, citywide IoT sensing, and digital political advisory systems.

Additionally, the 3D Real Scene Qingdao construction outcomes have provided the foundational support for the development and application of Qingdao's City Cloud Brain and similar platforms in West Coast New Area, Jiaozhou City, Jimo District, and the Chengyang District GIS Spatiotemporal Geographic Information Platform. These platforms enhance the capabilities of urban management and expand their application across various sectors.

Fig 3-2 Licang Smart Community

Application Scenario 3: City Information Model (CIM) Foundation Platform

Scenario Practice:

The platform has integrated the terrain-level and city-level 3D Real Scene results from Qingdao into the City Information Model (CIM) Foundation Platform, upgrading it from a 3D spatiotemporal foundation based on white model building data to a more realistic and immersive 3D model using oblique photography data. This

provides users with a more authentic experience and significantly enhances the CIM platform's capabilities in terms of visualization, spatial analysis, and innovative applications.

By leveraging the 3D Real Scene data, and integrating results from the first National Comprehensive Risk Survey of Natural Disasters for building structures, the platform performs comprehensive analysis and classification of attributes such as building construction year, building type, and height. With a single click, users can analyze historical buildings, old residential communities, and super-high-rise buildings. This provides precise scientific data to support work such as historical district preservation, urban renewal, and the renovation of old residential communities.

Application Effectiveness:

Qingdao was selected as a national pilot city for "New Urban Infrastructure Construction." The City's CIM Foundation Platform, integrated with the Smart Qingdao Spatiotemporal Big Data Platform, enables the seamless sharing of 3D Real Scene data. Recognized by the Provincial Department of Housing and Urban-Rural Development as an exemplary case of informatization and digital transformation in the housing and urban construction sectors, this platform has been promoted throughout the province, delivering significant social benefits.

CIM Foundation Platforms and digital twin systems in key areas such as the SCO Demonstration Area, Laoshan District, Jiaozhou City, the High-Tech Zone, the northern shore of Jiaozhou Bay, the Huanhai Bay Cruise Home Port Zone, and the Jiaozhou Bay Innovation District have also leveraged shared 3D Real Scene Qingdao data. This sharing has resulted in substantial savings in construction costs for these projects.

Fig 3-3 Qingdao’s CIM Foundation Platform

Fig 3-4 SCO Demonstration Area Digital Twin System

Application Scenario 4: Urban Integrated Management Service GIS Middle Platform

Scenario Practice:

The GIS Middle Platform integrates and consolidates various business-specific data across the board, providing spatially unified management of urban management data. By leveraging this platform, it offers centralized GIS data services that support the construction and operation of various business application systems. The platform functions as the unified "central hub" for spatial information services for the Qingdao Urban Management Bureau, utilizing 3D Real Scene data as its foundation. It integrates and consolidates multi-source, massive, heterogeneous spatial big data, offering a spatial data engine that supports the entire lifecycle management of spatiotemporal big data, including data collection, spatialization, storage, result publishing, historical data management, and information retrieval.

The platform connects to city-level data resources and integrates internal information from the Bureau, empowering its digital transformation efforts through a fusion of these data sources. This data-driven approach enhances decision-making and provides precise information services, helping management personnel to address urban issues more efficiently, thereby improving citizen satisfaction.

For example, in an urban environment monitoring task, the staff utilized the advantages of 3D Real Scene—its real, precise, and fully comprehensive coverage without blind spots—to quickly identify over 300 urban environmental issues. A staff member remarked, "By browsing the 3D scenes on the computers, we completed in two days a task that used to take two months of on-site investigation. This significantly improves management efficiency and is a powerful tool for refined urban

governance!"

Application Effectiveness:

The GIS Middle Platform, as a core infrastructure for urban management, enhances the efficiency and quality of city management through data integration, processing, analysis, and application. The platform innovatively applies 3D Real Scene data, enriching the foundational data resources in the urban management domain and serving as a unified 3D data hub for various systems. It enables cross-departmental and cross-system data integration and sharing, effectively breaking down traditional data silos.

With this platform, city managers can comprehensively monitor the city's operations, gaining a complete and up-to-date understanding of the urban environment. This provides strong support for scientific decision-making, allowing for more informed and precise urban management actions that lead to better outcomes in city planning, resource allocation, and public services. The platform's use of 3D Real Scene data not only improves data accuracy but also fosters collaboration across departments, ensuring a more integrated and efficient approach to managing the city.

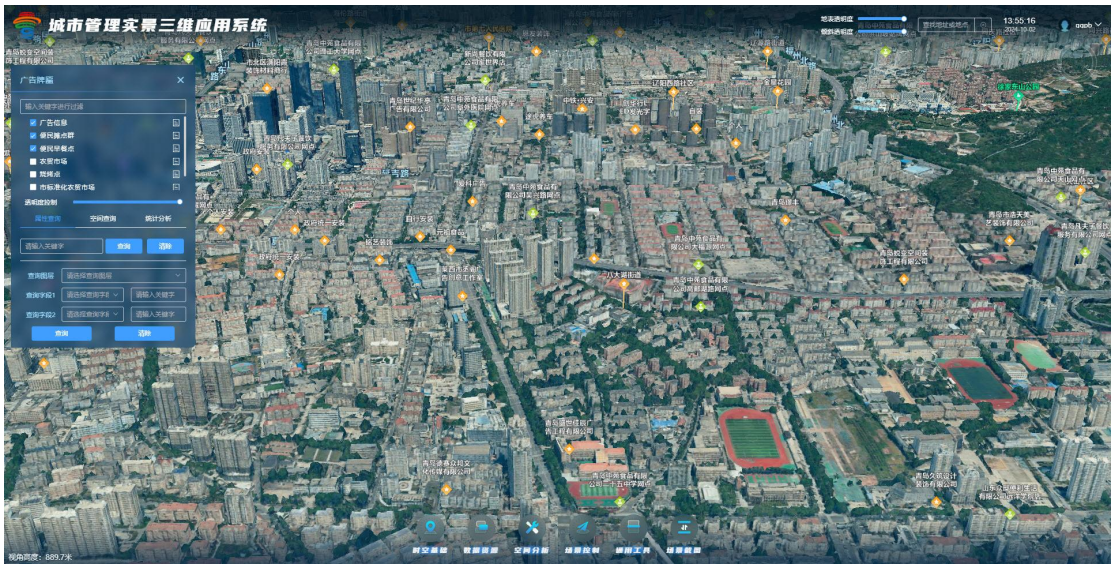

Fig 3-5 Urban Integrated Management Service GIS Middle Platform

Application Scenario 5: Smart Streets (Communities)

Scenario Practice:

To accelerate the development of Smart Streets (Communities) and establish a new model of urban community governance through co-construction, co-governance, and sharing, districts and cities are actively advancing the informatization of smart street (community) infrastructure. By fully leveraging 3D Real Scene data, they are upgrading the digital infrastructure of streets and communities, creating a new hybrid form of community governance and services that integrates online and offline capabilities. This transformation is continuously enhancing residents' sense of

fulfilment, happiness, and security.

For example, platforms like the Shinan District Smart Community Management Service Platform, the Chengyang District Smart Community Integrated Management Service Platform, the Digital Governance of Fuxin Project in the Fushan New Area of Shibei District, and the Liuting Street Smart Street Platform in Chengyang District are utilizing 3D Real Scene data to build street-level 3D work map systems. These platforms use 3D Real Scene to improve efficiency in street-level operations, accelerating processes and enhancing the informatization of street-level business systems. In the Zhangjialou Digital Village Smart Platform in the West Coast New Area, the system integrates 3D Real Scene data of Zhangjialou's local area, along with regulatory planning, land planning, third-party surveys, and specialized data on corporate land use. This assists in urban renewal efforts and supports daily analysis and queries for street-level administration, significantly improving governance and management efficiency.

Application Effectiveness:

The 3D Real Scene provides a unified and authoritative spatiotemporal foundation for Smart Streets (Communities), promoting data sharing and integration, supporting refined management and decision-making, and driving the implementation of smart application scenarios. It facilitates intelligent governance and services, contributing to the high-quality development of urban communities, enhancing efficient governance, and improving the quality of life for residents. This integration enables smarter community operations and better delivery of public services, aligning with the goals of sustainable and inclusive urban growth.

Application Scenario 6: Forest Fire Prevention 3D Real Scene Map

Scenario Practice:

The Forest Fire Prevention 3D Real Scene Data Standard is designed to guide the development of a platform that integrates multi-source data, multi-dimensional spatial analysis, and cross-terminal collaboration for both peacetime and emergency applications. This platform provides robust support for forest fire resource integration, daily management, emergency response, fire monitoring, and decision-making assistance.

The platform enables 3D management of various forest fire prevention resources, displaying key elements such as forests, mountain terrain, surrounding access routes, fire prevention infrastructure, and resource distribution within a 3D scene. This allows for scientific assessment of forest fire conditions and provides comprehensive support for emergency command operations.

The platform also includes a fire risk monitoring model, which aids in the planning and deployment of fire prevention infrastructure and risk-level control. This provides valuable 3D-assisted decision-making services for forest fire emergency drills,

infrastructure planning, and district (city) prevention efforts. Particularly for forest fire planning, the platform leverages integrated fire prevention resources to offer 3D spatial analysis services for selecting and planning essential infrastructure, such as camera installations, watchtowers, and water reservoirs, ensuring scientifically informed deployment of fire prevention facilities.

Application Effectiveness:

The Forest Fire Prevention 3D Real Scene Platform has already been successfully promoted and applied in Pingdu City, Jiaozhou City, and West Coast New Area, providing strong informational support for forest fire prevention efforts. This platform offers significant value in terms of replication and scalability, making it highly applicable for wider use. Additionally, the shared application of 3D Real Scene data has contributed to the construction of Qingdao's forest fire monitoring and early warning system, presenting a clear view of the city’s unique mountain and forest characteristics, as well as the specific deployment of fire prevention strategies. This has provided powerful data support for effective fire prevention measures in the region.

Fig 3-6 3D Real Scene Forest Fire Prevention Digital Sand Table

Application Scenario 7: Urban Flood Control Command and Dispatch

Scenario Practice:

A 3D Digital Sand Table is established to form a unified flood control map, integrating flood-related data into the 3D environment to provide critical intelligence for flood control command and dispatch.

A multi-terminal application system has been developed to assist in flood control dispatch. The system operates on various platforms, including web, mobile, large screens, physical electronic sand tables, and AR. It enables dynamic sensing, resource integration, intelligent analysis, and decision support, making flood control and

disaster mitigation work searchable, analyzable, dispatchable, and capable of simulations and early warnings. This system enhances the digitization, networking, and efficiency of collaborative flood control management in the New Area, improving the government's command and dispatch capabilities during flood seasons. It offers scientific and technological support for safe flood season management and response to sudden flood events.

The system adopts a "Peacetime and Wartime" approach to serve broader objectives. During peacetime, it focuses on water system safety and government needs, providing long-term support for flood control resource planning, site selection, and emergency drill services to various emergency and firefighting management departments. During wartime, when a flood event occurs in the West Coast New Area, the system responds quickly under the unified command of the area's emergency response system, offering data-driven decision support. It rapidly supplies essential baseline and specialized data to ensure efficient emergency command and response.

Application Effectiveness:

During flood seasons, the system provides 3D Real Scene environments and early warning simulation and analysis services. Through scientific simulation and analysis, it offers reliable support for water storage during flood seasons, saving the government approximately tens of millions of yuan annually. The system enhances the flood control and disaster mitigation capabilities in the West Coast New Area by strengthening rainfall and water level monitoring, forecasting, early warning, emergency standby, and analysis. It ensures the timely release of early warning information and the swift activation of emergency responses.

Additionally, the system provides valuable geographic data support for the Comprehensive Urban Safety Risk Monitoring and Early Warning Platform of Qingdao's Emergency Management Bureau, as well as for the city's flood control, drought relief, and typhoon prevention efforts.

Figure 3-7 3D Real Scene-Assisted Flood Control, Drought Relief, and Typhoon Prevention

3.2 Supporting Natural Resource Management

The 3D Real Scene provides detailed and intuitive displays of surface morphology, resource distribution, and dynamic changes, aiding management departments in efficient resource monitoring, precise planning, and scientific evaluation. This technology is widely applied in fields such as the unified registration of natural resources, natural resource surveys and monitoring, territorial spatial planning, transparent city construction, and mine ecological restoration. In these areas, 3D Real Scene enhances the accuracy and effectiveness of resource management and planning, offering a powerful tool for visualizing and analyzing both natural resources and urban spaces in real-time.

Application Scenario 8: Unified Registration of Natural Resources

Scenario Practice:

The unified registration of natural resources requires collaboration across multiple departments, including natural resources, forestry, water conservancy, and ecological environment. During this process, it is essential to accurately determine the nature and spatial boundaries of various natural resources, as well as to clarify water extraction rights, pollutant discharge rights, and their associated attributes and locations, ensuring that all rights information is precise and valid.

By integrating 3D Real Scene data with the results of the unified registration of natural resources, the platform enables a clear and scientific determination of the nature and boundaries of various natural resource areas. This results in a measurable, searchable, and analyzable 3D and intelligent system covering everything from forests and reservoirs to underground mineral deposits.

In Qingdao, due to the redirection of some rivers and the reconstruction of river embankments, river management boundaries need to be redefined. The water conservancy department, referencing the 3D Real Scene results, can precisely delineate river management areas within the digital space. Administrative approval and ecological environment departments can accurately and visually determine the locations and appearances of water intake and discharge points.

Application Effectiveness:

The 3D Real Scene creates a highly realistic digital model that mirrors real-world spatial conditions, providing users with an immersive digital experience. Tasks that traditionally required on-site inspections and measurements can now be completed remotely, leading to more accurate and scientifically informed decision-making. The system allows for various measurement operations within the model, such as distance measurement, area calculation, and volume estimation. These operations are simple to perform, yet yield highly accurate and reliable results, significantly improving work efficiency.

Figure 3-8 Accurate Positioning of Water Intake and Discharge Points Using 3D Real Scene

Application Scenario 9: Natural Resource Survey and Monitoring

Scenario Practice:

By overlaying land survey data and protection boundaries, such as farmland protection lines, ecological redlines, nature reserve boundaries, and water source protection areas, onto the 3D Real Scene, the platform enables a more accurate understanding of the "mountains, rivers, forests, farmlands, lakes, and grasslands" ecosystem's volume and changing trends. This system realizes comprehensive supervision of natural resources and spatial land management. High-precision 3D Real Scene data facilitates surveys and verifications, significantly improving project timelines and data accuracy, ensuring the smooth implementation of various natural resource survey and monitoring tasks.

Application Effectiveness:

The 3D Real Scene serves as a unified spatial base, presenting natural resource elements in a comprehensive and three-dimensional manner. It provides resource managers with intuitive and accurate monitoring information and decision-making support, enhancing oversight and planning capabilities. In the field of farmland protection, the system accurately monitors changes in farmland area and quality, enabling precise management and effective protection of these resources.

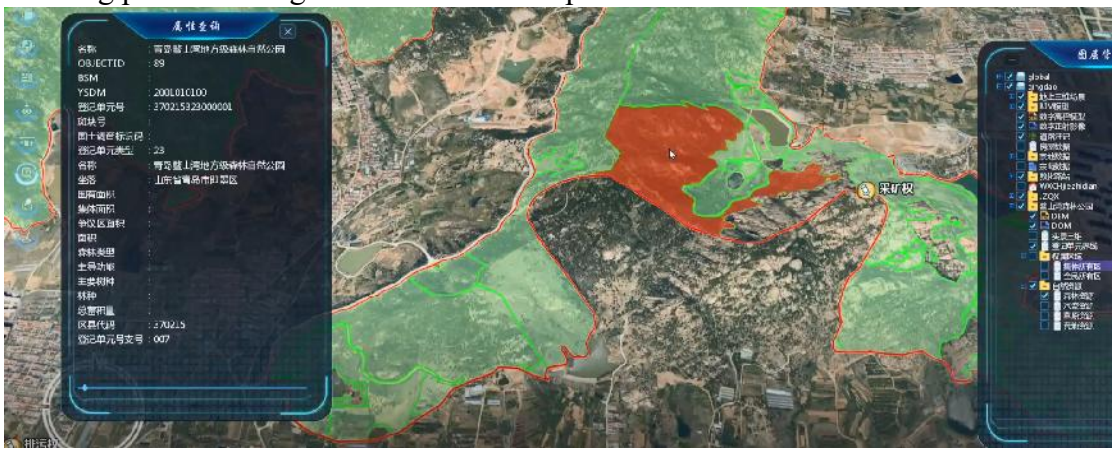

Figure 3-9 3D Real Scene Map of Forest and Mountain Resources

Application Scenario 10: Territorial Spatial Planning Scheme Evaluation

Scenario Practice:

To enhance the use of 3D Real Scene data in planning management, the Qingdao Natural Resources and Planning Bureau has established processes to incorporate 3D Real Scene into the evaluation of planning schemes. This improves the decision-making level and work efficiency in tasks such as regulatory adjustments, site selection, scheme evaluation, and urban design. The 3D Real Scene is used throughout the entire life cycle of urban projects, from design to construction and operations, providing robust support for efficient construction, intelligent management, and sustainable development.

Urban Design: By converting 2D urban design plans (such as building height and form) into 3D models and integrating them into the 3D Real Scene, planners can seamlessly merge the current environment with future plans. This helps planners understand spatial layouts and terrain features, optimizing land use, transportation systems, and green spaces. The measurable aspects of 3D Real Scene allow planners to clearly define setbacks, building distances, and impacts on views and surrounding areas, providing rational advice for scheme evaluations.

Major Transportation Planning: The 3D Real Scene has been instrumental in evaluating major projects, such as the 15th metro line, the Shenhai Expressway's Jiaodong Airport connection, and the second Jiaozhou Bay undersea tunnel. Replacing traditional renderings with 3D scenes, it offers a more intuitive reflection of the project's outcome and helps identify potential issues, allowing experts and decision-makers to objectively select the best solutions.

Industrial Park Layout Planning: For projects like the Qingdao Traditional Chinese Medicine Inheritance and Innovation Industrial Base, the 3D Real Scene resolves integration issues between planning schemes and surrounding environments. It enables quick comparisons and displays how schemes harmonize with their surroundings. For key projects like the microelectronics and GoerTek projects near Binhai Avenue, 3D Real Scene ensures that the building designs meet production requirements while blending seamlessly with the built environment, enhancing the city's image.

Application Effectiveness:

With its intuitive, three-dimensional, measurable, and analyzable advantages, the 3D Real Scene is revolutionizing decision-making for major projects. It provides an immersive platform for planners to test and validate design schemes by merging real-world environments with planning proposals. The system allows for real-time evaluations, dynamic adjustments, and interactions between stakeholders, resulting in scientifically sound and forward-looking urban planning. Major projects in Qingdao are now evaluated using this technology, benefiting all stakeholders by reducing iterative revisions for construction and design teams and enhancing the accuracy and

efficiency of planning approvals.

Fig 3-10 3D Planning Scheme for Qingdao Traditional Chinese Medicine Inheritance and Innovation Base

Fig 3-11 Urban Design Landscape Analysis

Fig 3-12 Pedestrian View in Urban Design

Application Scenario 11: Transparent City

Scenario Practice:

Using the 3D Real Scene as a foundational layer, the Transparent City initiative focuses on multi-source, multi-scale land-sea integrated urban geological 3D modelling and geographic information integration. By leveraging 3D Real Scene data and surveying and mapping geographic information technology, the platform combines invisible geological environment data with accurate and intuitive 3D Real Scene visuals. This integration of aboveground and underground information improves the social service applications of urban geological survey results.

The system integrates multi-source, multi-dimensional data to create a unified aboveground and underground 3D scene. The project has developed multi-level urban geological models, including citywide, demonstration zones, key areas, and showcase zones, integrating and managing large-scale urban geological survey data with surface 3D scenes, remote sensing imagery, and other mapping and geographic data. A geological spatial data warehouse has been established to achieve integrated 2D and 3D land-sea data display, analysis, and mining, helping government departments address key geological environment challenges in urban development.

Application Effectiveness:

The platform plays a significant role in coordinating aboveground and underground urban construction, optimizing urban structure, expanding development space, promoting green and low-carbon city construction, improving urban safety, and addressing "big city" issues. By merging traditional urban geological survey expertise with innovative surveying and geographic information technology, the platform pioneered the "Qingdao Model" of multi-network integration, land-sea coordination, standard-setting, and application-oriented urban geological modelling and 3D Real Scene integration. This model shifts urban geological applications from specialized to generalized use, providing a replicable and scalable example for other coastal cities built on bedrock.

3.3 Fostering Digital Economy Development

As a core component of new infrastructure, 3D Real Scene provides a powerful data foundation for the development of the digital economy, giving rise to a series of innovative platforms such as the Port Information Model (PIM) platform, Park Economy, and Building Economy Integrated Management Service Platforms. These platforms have played critical roles in various fields, collectively driving the growth of the digital economy.

The successful application of these platforms has greatly enhanced the efficiency and accuracy of data processing, promoting the sharing and utilization of information resources. Like bridges between the digital and physical worlds, these platforms

enable deeper integration of the digital and real economies. They offer a more intuitive insight into the intricate details of urban operations and provide a precise understanding of Qingdao's economic development pulse, offering strong support for scientific decision-making.

Through these platforms, decision-makers can monitor and manage urban and economic systems in real-time, improving resource allocation and ensuring that economic growth is both sustainable and well-coordinated with city planning. This integration not only strengthens the digital economy but also drives innovation and efficiency across sectors, reinforcing Qingdao's role as a hub for smart urban management and economic development.

Application Scenario 12: Port Information Model (PIM) Platform

Scenario Practice:

The Port Information Model (PIM) platform, similar to the 3D Real Scene China framework, is composed of three key components: spatial data (geographic scenes and geographic entities), IoT data integration, and system support environments.

First, the platform encompasses multi-scale, full-space, and comprehensive spatial data for Qingdao Port's five major port zones, ranging from global scale to 15 cm and 3 cm resolution 3D models, with the highest precision reaching 1.5 cm. Structured geographic entities represent port assets, such as tanks, silos, and cranes. These are semantically linked to the iEAM Port Asset Management System, creating a digital twin that synchronizes real-world assets with their digital counterparts.

Secondly, the platform integrates IoT data and services, including real-time equipment status, cargo information, environmental monitoring, and millions of Automatic Identification System (AIS) data points for ships. This includes real-time information on ships, cargo, tanks, yards, and mobile equipment, along with dynamic monitoring services like water loss, video surveillance, and pier subsidence monitoring.

Thirdly, the platform also shares the port’s digital infrastructure, integrating aboveground and underground assets. This enables port operators to manage "ten thousand assets across vast areas at their fingertips," supporting the high-quality, digital transformation of the port.

Application Effectiveness:

The PIM platform has revolutionized port management by enabling a digital lifecycle management model covering planning, construction, operations, and services. Experts, including academician Li Huajun, have praised the PIM platform as a digital twin tool that integrates cloud computing, IoT, and big data technologies, positioning Qingdao Port as an industry leader. Media outlets, including Dazhong Daily and China Water Transport News, have reported that Qingdao Port's PIM platform is the world's first of

its kind, digitizing and visualizing all physical resources and filling the gap in port information modelling for the industrial internet era.

Application Scenario 13: Digital Construction and Management Platform for Major Transportation Infrastructure

Scenario Practice:

The Chongqing Elevated Road is a critical transportation infrastructure project for the East Coast Industrial Park in Qingdao, forming an essential north-south artery in the "Three Horizontal and Four Vertical" main urban road network. This large-scale project faces several challenges: it involves the construction of the longest and most complex three-dimensional transportation corridor in the province, the need to coordinate nearly 20 municipal pipelines, and the requirement to maintain safe metro operations while accelerating construction.

To overcome these challenges, the project makes full use of digital twin technology, with the 3D Real Scene as the digital foundation. By integrating BIM models, current pipeline models, geological data, and video surveillance into a unified "one map" visual sand table, the project has created a BIM+GIS digital construction management platform. This platform supports the entire lifecycle of the project, providing 3D visualization for critical scenarios such as land use, building demolition, and pipeline relocation.

The BIM models allow for a clear presentation of the overall design, enabling effective evaluation of key design nodes. Over 30 different design schemes across multiple categories have been optimized and compared through this process. Using the 3D Real Scene for volumetric measurements of buildings, structures, and vegetation involved in demolition has drastically reduced the time and costs for field surveys and assessments, while also improving estimation accuracy.

By integrating 3D Real Scene data with BIM design schemes for roads, bridges, sound barriers, and pipelines, the platform provides visual support for expert evaluations, allowing for precise design improvements and risk avoidance. The centimeter-level precision of the 3D Real Scene data, combined with BIM models, enables accurate measurement of distances between project areas and nearby buildings or underground pipelines. This level of detail supports planning and coordination for building demolitions, relocations, and communication with nearby residential communities and property owners, significantly enhancing the efficiency of project management and collaboration.

Application Effectiveness:

The Chongqing Elevated Road project, built on the foundation of 3D Real Scene, BIM, and digital twin technologies, has created a digital construction and management platform that integrates national policies, standards, and regulations.

This innovative approach led to the development of China's first "Digital Chief Engineer" system. Throughout the construction process, over 30 participating units and more than 1,000 management personnel collaborated on the digital platform, leveraging the visual capabilities of 3D Real Scene technology to continuously optimize design and construction organization plans.

The platform enabled the digital transformation of key project management processes, including progress tracking, quality control, safety management, and measurement. It also facilitated intelligent applications of on-site construction data related to personnel, machinery, materials, methods, and environmental factors. This digitalization significantly enhanced project management efficiency, coordination, and effectiveness, allowing for real-time adjustments and improved collaboration among stakeholders. By utilizing the digital twin platform, the project achieved optimized design iterations, better resource allocation, and more precise management, all while ensuring compliance with national standards and enhancing the overall quality and safety of the project.

Application Scenario 14: Industrial Park Operation and Management

Scenario Practice:

Land Resource Activation: By utilizing 3D Real Scene technology, the platform provides a highly realistic view of public spaces, infrastructure, and buildings within the park. This aids decision-makers in understanding current conditions and devising scientifically sound planning schemes. The platform supports project siting and efficient land use by integrating elements such as land ownership, planning controls, and project proposals.

Investment Promotion: Combining 3D Real Scene with BIM technology, the platform supports both indoor and outdoor presentations of buildings, aiding in investment promotion. The system allows potential investors to visualize the building's surroundings, facilities, and location advantages while analyzing available space, infrastructure, and economic parameters.

Asset Operation and Management: The platform transforms asset management from traditional record-keeping into a 3D spatial visualization approach. 3D Real Scene data provides building exteriors and layouts, while BIM models deliver detailed floor-level and unit-level information, facilitating digital archiving and management. It allows for a clear overview of the park's assets, helping to analyze leasing conditions, view historical information, and assess the commercial value of resources.

Application Effectiveness:

The platform plays a crucial role in promoting efficient and intensive land resource utilization, accelerating project siting and implementation, and improving the business environment. By transitioning project design from 2D to 3D space, it provides strong support for investment promotion and construction projects. The platform effectively

integrates urban information models with data, technology, and business operations, offering foundational support for the digitalization and intelligent management of companies and the Port Area Management Bureau. It empowers the entire lifecycle of projects, from planning and construction to operations and management.

In addition, the Fuchunjiang Road Smart Park Project, utilizing 3D Real Scene data, supports industrial operation analysis, building economy analysis, and smart party-building management within the park; the Huanhai Economic Development Zone Industry Map Project builds a comprehensive dataset of enterprise land use, operational income, upstream and downstream industrial chains, tax per unit area, and industry concentration. This supports investment promotion, industry planning, and decision-making for the Huanhai Economic Development Zone; the SCO Demonstration Zone Digital Twin Visualization Platform uses 3D Real Scene data for the entire zone, with a digital twin U-shaped screen visualization platform at the Jiaodong Airport Economic Zone Investment Promotion Center. This aids in inspection, external promotion, and investment attraction for the Jiaodong Airport Economic Demonstration Zone.

Fig 3-13 Qingdao Huanhaiwan CIM Foundation Platform

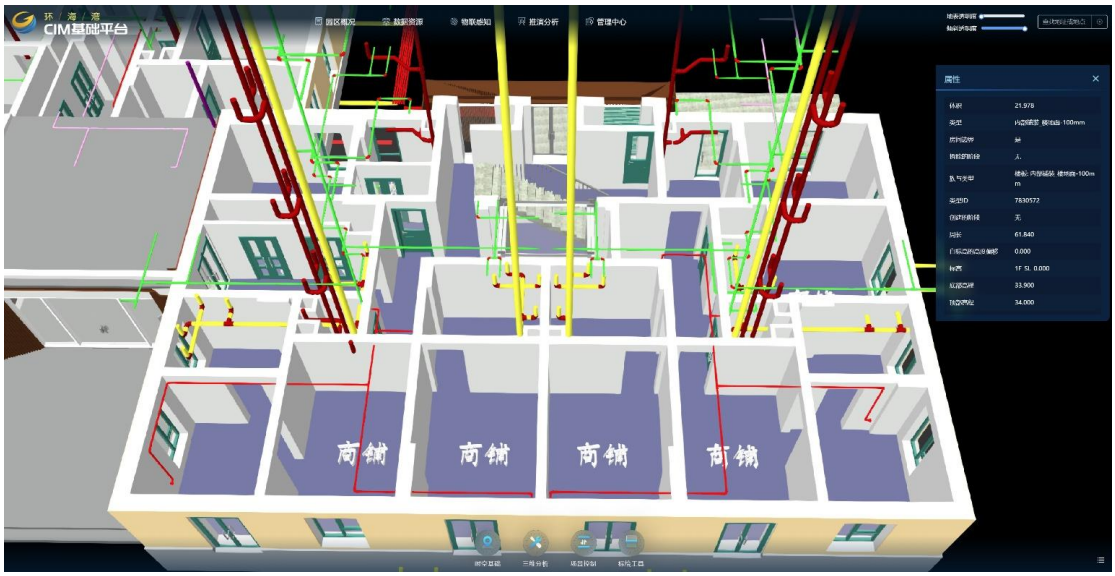

Fig 3-14 BIM Management

Application Scenario 15: Low-Altitude Safety Inspection in Metro Protection Zones

Scenario Practice:

Qingdao Metro Group Co., Ltd. has taken a leading role in leveraging the low-altitude economy by introducing drone nests for intelligent inspections in metro protection zones. In collaboration with the Qingdao Institute of Surveying and Mapping, they have deployed unmanned airports to conduct research on automated dispatch, line inspection, and management, utilizing 3D Real Scene data to optimize low-altitude flight inspection routes.

Drone Nest Site Selection: The 3D Real Scene allows for intuitive visualization of the relationship between potential nest locations and surrounding features. This aids in line-of-sight analysis and visibility studies, improving signal stability and operational coverage during the airport's operational phase.

Flight Path Planning: The platform enables automatic collision monitoring and analysis through 3D Real Scene technology, enhancing the safety of drone flights. This reduces unnecessary detours and wait times, improving efficiency and lowering operational costs.

Inspection Process: The drones are scheduled for automated takeoffs, precise route-based inspections, and real-time video transmission. With AI-based automatic recognition and AR scene integration, the system provides continuous, full-coverage, real-time monitoring of metro protection zones. It can automatically detect and alert on high-risk machinery or unauthorized construction activities, increasing the inspection efficiency and coverage area, reducing manpower costs, and facilitating real-time information sharing and monitoring.

Application Effectiveness:

The integration of 3D Real Scene data with drone-based inspections has demonstrated significant benefits in the inspection of metro protection zones. The intelligent flight route planning, combined with real-time video transmission and AI-based recognition, allows for timely detection and warning of hazardous equipment or illegal activities within the protection zones. This enhances coverage, reduces labour costs, and improves the overall inspection efficiency, ensuring metro safety.

The combination of 3D Real Scene with automated drone inspections has optimized flight paths, significantly boosting operational capabilities. This innovative approach supports smart and efficient management of metro protection zones, contributing to the development and advancement of inspection technologies, and providing robust support for the intelligent management of metro protection areas.

Fig 3-15 AI Automatic Recognition of Construction Vehicles from Video feeds

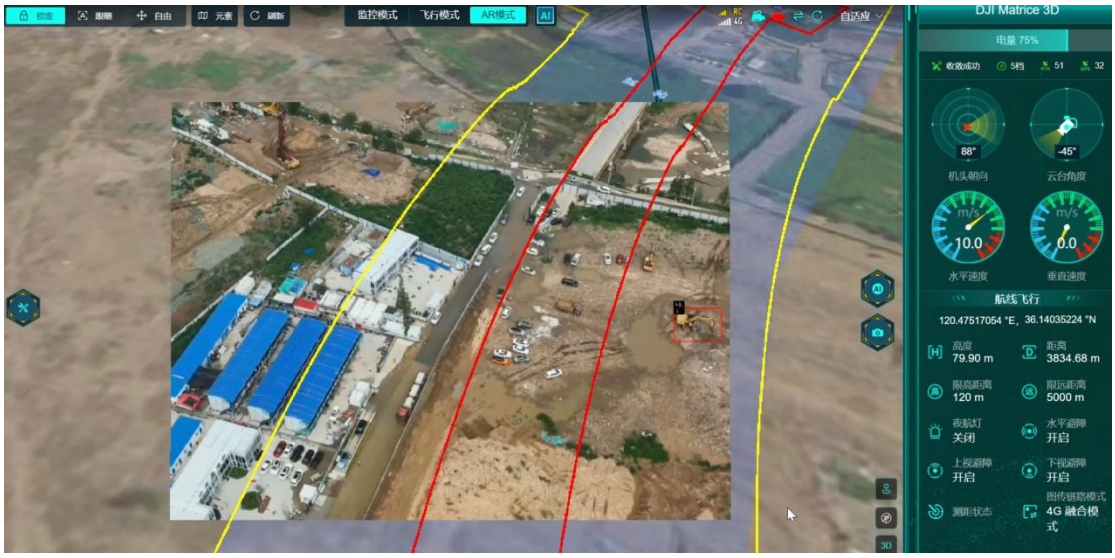

Fig 3-16 Drone Automated Inspection Route Setup

3.4 Enhancing the Quality of Life

With the rapid advancement of technology, 3D Real Scene applications have transcended specialized fields and have quietly integrated into the daily lives of Qingdao residents, becoming a significant driver for enhancing quality of life and enriching cultural experiences. By deeply integrating 3D Real Scene digital spaces with convenient living, it becomes possible to achieve fine management and analytical simulations of both indoor and outdoor environments and various objects.

This integration facilitates the establishment of more spatiotemporal social service information platforms, offering services such as property management, fitness, elderly care, employment, and housekeeping based on 3D Real Scene data. These services provide residents with a more convenient and intelligent living experience, allowing for better access to information and resources in their daily lives.

Application Scenario 16: Smart Property Management Service Platform

Scenario Practice:

Current property management services primarily rely on 2D point data for location information, which can lead to a lack of spatial management thinking and various limitations during service delivery. The Smart Property Management Service Platform utilizes the 3D Real Scene data from Qingdao's construction achievements, enabling a realistic, three-dimensional, accurate, and objective representation of the real world.

Within residential communities, users can explore scenes in 3D, perform viewpoint positioning, and conduct four-dimensional queries linking buildings, units, floors, and apartments. This effectively addresses issues related to inaccurate positioning in 2D views, lack of intuitive perspectives on buildings, and incomplete detail representation. The platform facilitates interactive data exchange between 2D and 3D, maximizing the advantages of 3D Real Scene applications.

In the 3D scene, the platform integrates various IoT devices, including video surveillance, access control for individuals and vehicles, fire alarm information etc.. Users can conduct real-time queries on video feeds from various points within the community, monitor entry and exit locations, and track key vehicle movements. This timely access to fire alarms and breach alerts enables management personnel to promptly address fire hazards and security breaches within the area.

Application Effectiveness:

The innovative application of 3D Real Scene data has constructed a smart property management platform that enhances the intelligent management model. By integrating new infrastructure into the 3D base map and conducting citywide property data collection, aggregation, and sharing, the platform effectively addresses gaps in residential community services. Leveraging data as a core driver, it promotes the online and offline integration of property services, assisting property management companies in achieving smart community management while providing regulatory personnel with a robust oversight platform.

Fig 3-17 Smart Property Management Service Platform

Application Scenario 17: Urban-Rural Element Circulation Platform

Scenario Practice:

The “Huameidani Rural Revitalization Demonstration Area” is one of the first provincial demonstration zones for rural revitalization in Shandong. In response to the rural revitalization strategy, a reliable Urban-Rural Element Circulation Platform is being established in this demonstration area to integrate local idle housing and land resources, facilitating the flow of urban-rural elements in Zhangjialou Street and addressing issues of resource idleness caused by urbanization and an aging population.

Leveraging the 3D Real Scene data from Qingdao, the platform is designed for a unified experience of “Viewing Houses in the Cloud” and “Viewing Land in the Cloud,” accessible via mobile, management, and visual display screens.

The platform integrates high-precision, high-resolution 3D data as a spatial digital foundation. It collects information on idle houses, shops, land, and factories in the area, establishing a database of urban and rural economic elements. Additionally, it gathers 720-degree indoor panoramic views of key locations, laying the groundwork for remote viewing of properties and land. The platform consists of three main modules:

- Resource Management Module: This provides rural administrators with tools for managing resources, orders, and other administrative functions.
- Cloud Information Display Module: Utilizing a WeChat mini-program as a medium, this module offers online options for selecting houses and land based on 3D Real Scene data, electronic maps, indoor panoramas, and on-site photos.
- Portal Display Module: Area managers can use this module to query the current status, distribution, and leasing conditions of idle elements in the area, facilitating investment attraction.

Application Effectiveness:

Since its launch in November 2023, the platform has successfully processed 72 various orders, effectively revitalizing idle land and housing resources in the area. Its innovative features include optimized mobile presentation of 3D Real Scene data, employing efficient 3D data compression algorithms that allow for rapid loading and browsing in mobile network environments. The platform has been optimized for different hardware platforms and operating systems, ensuring stable performance of 3D applications across diverse mobile devices.

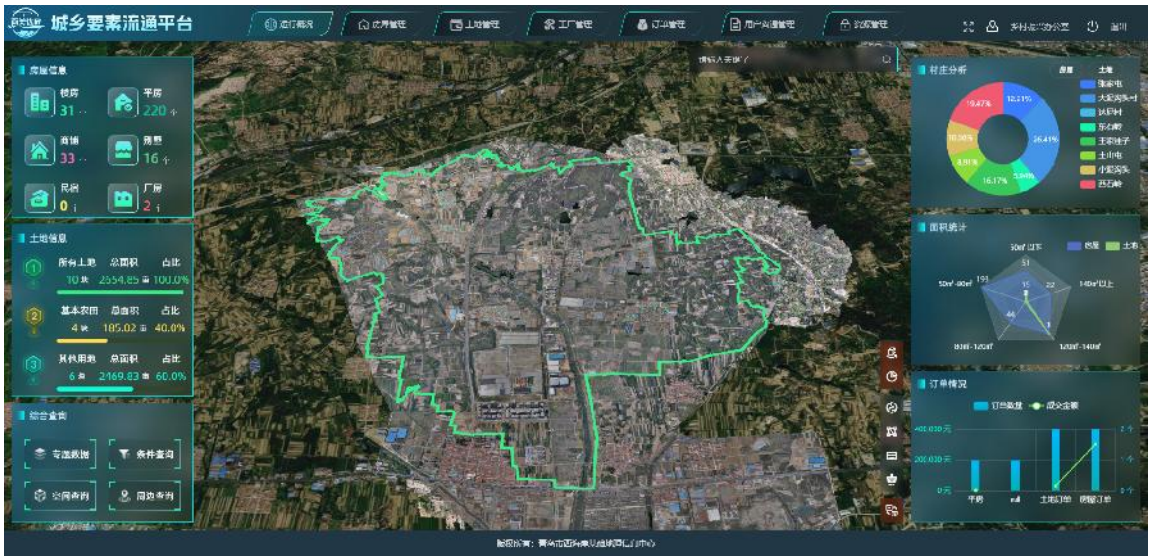

Fig 3-18 Urban-Rural Element Circulation Platform

3.5 Promoting Digital Culture Development

With the support of 3D Real Scene technology, Qingdao is leveraging its rich cultural resources and valuable cultural heritage to create a comprehensive, three-dimensional, and interactive new model for the cultural services industry. This initiative promotes the integration of culture and tourism while revitalizing cultural heritage resources.

The integration of 3D Real Scene facilitates innovative platforms for the protection of historical and cultural heritage, cultural dissemination, and the creative industry. By creating immersive experiences, the project not only enhances cultural engagement for residents and visitors but also provides new ideas and tools for the sustainable utilization of cultural resources and the transmission of cultural heritage.

Application Scenario 18: Smart Cultural Tourism

Scenario Practice:

Seizing the opportunity of the 2023 Shandong Province Tourism Development Conference held in Qingdao, the Qingdao Cultural and Tourism Bureau proposed a strategy to enhance the existing "Cloud Tour Qingdao" platform by innovatively integrating 3D Real Scene technology to deepen digital cultural tourism applications. This initiative aims to promote distinctive innovations in the cultural tourism sector using digital twin technology and 3D Real Scene.

The Smart Cultural Tourism Platform fully utilizes the 3D Real Scene data from Qingdao, integrating multi-scale scenes that range from terrain-level to city-level and component-level. The platform focuses on application scenarios and facilitates the fusion of data elements at different scales, presenting them in three formats: web, desktop, and mobile.

Web Version: The 3D big data visualization and analysis decision-making system for the cultural tourism industry primarily targets government managers. It provides a comprehensive, three-dimensional display of tourist areas and their surrounding environments, supporting features, and advantages. The platform facilitates the integration of monitoring data related to visitor flow, security, environmental conditions, and energy consumption, enabling a comprehensive oversight of tourism resources. It also performs real-time monitoring and analysis of key tourist spots, highway entrances, and airports regarding foot traffic and visitor trends, thus supporting the development of the cultural tourism industry.

Desktop Version: A digital twin system is deployed in urban reception halls, allowing tourism professionals and visitors to view macro-scale integrated displays and associative analyses of tourism topics, such as regional visitor rankings and historical reception trends. This provides macro-level decision-making support for tourism promotion and operational management.

Mobile Version: The Cloud Tour Qingdao mini-program offers 3D cloud tour services for over 20 key attractions, providing immersive visualizations that transport visitors to scenic locations.

Application Effectiveness:
Upon its debut at the 2023 Shandong Province Tourism Development Conference, the platform captured attendees' attention. Guests could intuitively experience Qingdao's unique integration of "mountains, sea, and city," achieving a real-time interactive view of the area through 3D Real Scene technology. This blend of virtual and real elements enhances the immersive experience for tourists, facilitating a new development in the integration of digital cultural tourism.

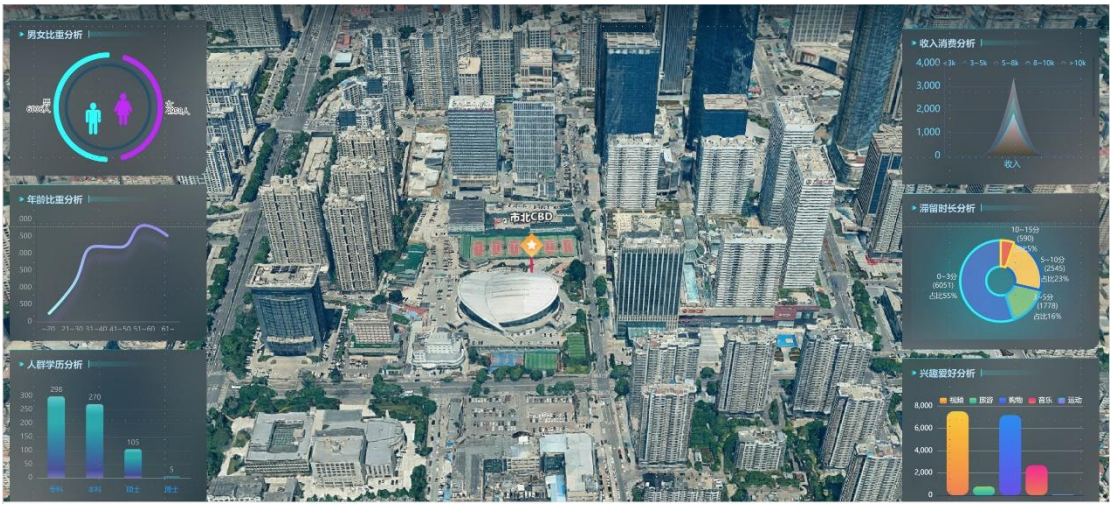

Fig 3-19 Smart Cultural Tourism Platform

Application Scenario 19: Protection of Historical Districts

Scenario Practice:

Leveraging 3D Real Scene technology, efforts to enhance the quality and effectiveness of protection and renewal in historical districts have been significantly improved. By establishing a digital spatial foundation characterized by being "comprehensive, precise, accurate, and practical," a digital twin framework is created to provide digital support for applications in cultural tourism, popular science education, archival research, emergency security, and disaster prevention and reduction. This allows for refined management and revitalization of historical districts, using digital tools to promote high-quality development in cultural heritage protection and transmission.

Utilizing various digital technologies, including 3D Real Scene, the precise mapping of historical buildings and districts from "physical space" to "digital space" has been achieved. The historical district protection and renewal digital management platform, built on 3D Real Scene data, has established a "cloud-based online and interconnected sharing" management model. This enables informationization and intelligent multi-terminal collaborative management of historical districts, ensuring efficient operations for business departments and providing application services for the public.

To address challenges such as a lack of digital support for historical districts and insufficient community involvement, "digital empowerment" has enabled functionalities such as data entry, storage management, maintenance updates, query and retrieval, statistical analysis, and visual representation. This integration covers the entire lifecycle management, including planning, construction, and restoration, while connecting daily management, business processing, terminal applications, public participation, and external promotion. It embodies a "people-centered" new concept in historical and cultural protection, providing application support for the renewal and revitalization of historical districts.

Application Effectiveness:

The digital twin technology based on 3D Real Scene accurately records the status of cultural heritage, providing intuitive and reliable evidence for restoration and protective measures. This innovative approach leads to new methods in cultural heritage protection, guiding the new development of historical cultural transmission, advancing the application of information technology in the industry, and facilitating the revitalization and utilization of historical buildings in the context of the digital economy.

Fig 3-20 Integration of Monitoring Sensors with 3D Real Scene Geographic Scenes

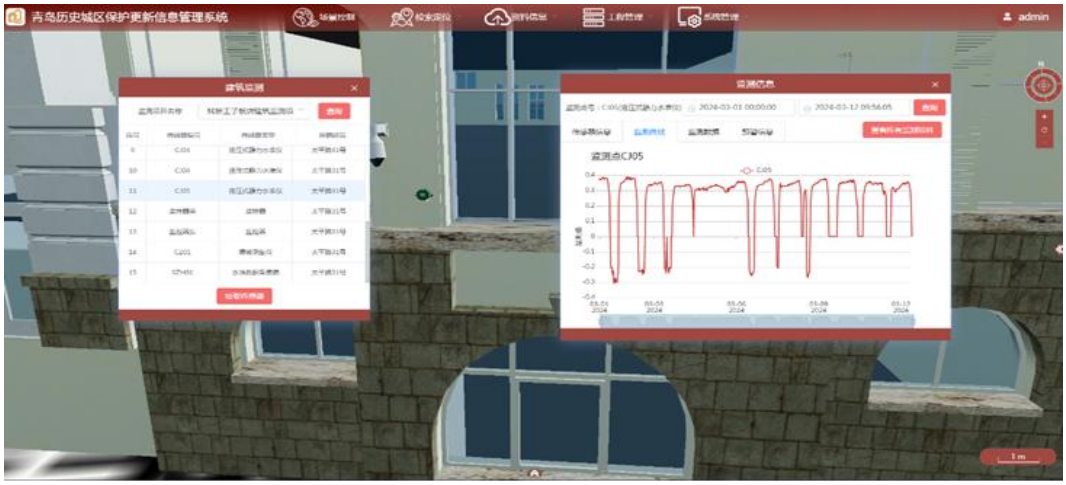

Fig 3-21 Historical Building Health Monitoring Change Analysis

3.6 Supporting Digital Ecological Civilization

Currently, China's economic and social development has entered a stage of accelerating green and low-carbon high-quality development. Building a digital ecological civilization and promoting green low-carbon development have become inevitable trends. In the face of the urgent tasks of ecological environment protection, 3D Real Scene technology, with its unique advantages, injects new vitality and momentum into Qingdao's digital ecological civilization construction. For example, it provides scientific evidence for the creation of green ecological cities and carbon accounting, assisting Qingdao in achieving green development, circular development, and low-carbon development.

Application Scenario 20: Carbon Peaking and Carbon Neutrality Accounting

Scenario Practice:

The "Action Plan for Carbon Peak Before 2030" proposes the establishment of a comprehensive carbon emissions measurement system, accelerating the application of

emerging technologies such as remote sensing, big data, and cloud computing in carbon emissions measurement. It aims to establish a monitoring and accounting system for ecosystem carbon sinks and to conduct baseline investigations, carbon stock assessments, and potential analyses for carbon sinks such as forests, grasslands, wetlands, oceans, soils, permafrost, and karst areas. The Qingdao Sino-German Ecological Park Management Committee utilizes 3D Real Scene, remote sensing, and Geographic Information Systems (GIS) technologies to carry out carbon accounting for the park, supporting green, low-carbon, high-quality development.

Conducting Baseline Investigations and Analyses of Carbon Sinks: By categorizing ecosystem types based on 3D Real Scene data, the accounting objects for carbon sinks are identified. Carbon accounting for the Sino-German Ecological Park is conducted, analyzing the spatial volume and distribution characteristics of carbon sinks through 3D Real Scene analysis.

Conducting Carbon Emission Accounting: Utilizing the characteristics of 3D Real Scene—current, three-dimensional, and measurable—carbon emission sources are identified, accounting boundaries are determined, and data required for carbon emission accounting is collected. This is combined with socioeconomic statistical data to calculate the carbon emissions of the Sino-German Ecological Park.

Conducting GEP Accounting and Change Analysis: A GEP (Gross Ecosystem Product) accounting indicator system is established, using the measurement functions of 3D Real Scene to acquire necessary data for GEP accounting. This data is also combined with socioeconomic statistical information to calculate the GEP of the Sino-German Ecological Park.

Application Effectiveness:

Based on the carbon accounting results of the Sino-German Ecological Park, a carbon neutrality strategy has been proposed, providing a basis for the formulation of carbon peak and carbon neutrality policies. At the First Sino-German Green Development Promotion Conference, the carbon accounting white paper for the Sino-German Ecological Park was released, attracting significant attention from attendees. The results garnered widespread interest at the 17th China Smart City Conference, highlighting the application of 3D Real Scene technology in carbon accounting.

Application Scenario 21: Green Ecological Area Operation Monitoring

Scenario Practice:

Based on 3D Real Scene technology, an analysis of the green low-carbon baseline, carbon emissions accounting, and the preparation of special green ecological planning have been conducted in Qingdao High-tech Zone. A Green Ecological Urban Implementation and Monitoring Evaluation Platform has been developed to support the creation of a green ecological urban area in Qingdao High-tech Zone.

Green Low-Carbon Baseline Investigation and Analysis: By categorizing ecosystem types based on 3D Real Scene data, the spatial volume and distribution characteristics of carbon sinks are analyzed. This provides essential data support for green low-carbon planning, implementation, and dynamic monitoring of green development.

Carbon Emission Accounting: Using 3D Real Scene, the spatial footprints of carbon emissions from buildings, industries, transportation, waste, road facilities, and renewable energy are mapped. This helps to understand the spatial distribution of carbon emissions and systematically develop phased and regional reduction measures and strategies, along with corresponding reduction plans.

Preparation of Green Ecological Planning: Based on 3D Real Scene analysis of ecological conditions and existing construction, development goals are established, an indicator system is constructed, special planning is drafted, implementation plans are formulated, and supervision indicators are clarified. A comprehensive indicator system for the green ecological urban area is created, with overall planning, regulatory planning, and specialized planning for buildings, municipal facilities, and energy being developed according to green, ecological, and low-carbon principles.

Development of the Green Ecological Urban Implementation Monitoring Evaluation Platform: A database for carbon accounting and special planning results is established, and dynamic monitoring functions for planning implementation are developed. This enables integrated 2D and 3D display and management of carbon accounting and special planning results, ensuring the realization of green construction goals. Regulatory and service mechanisms are established throughout project initiation, land transfer, planning design, construction, and operation management.

Application Effectiveness:

By leveraging 3D Real Scene technology to empower the construction of green ecological urban areas, Qingdao High-tech Zone is making significant strides in promoting green, low-carbon, and circular development. This initiative achieves breakthroughs in sustainable development, harmonious regional relationships, and green smart growth, creating an ecologically led and environmentally harmonious green ecological urban area. In August 2024, Qingdao High-tech Zone received a three-star green ecological urban area certification organized by the China Urban Science Research Association.

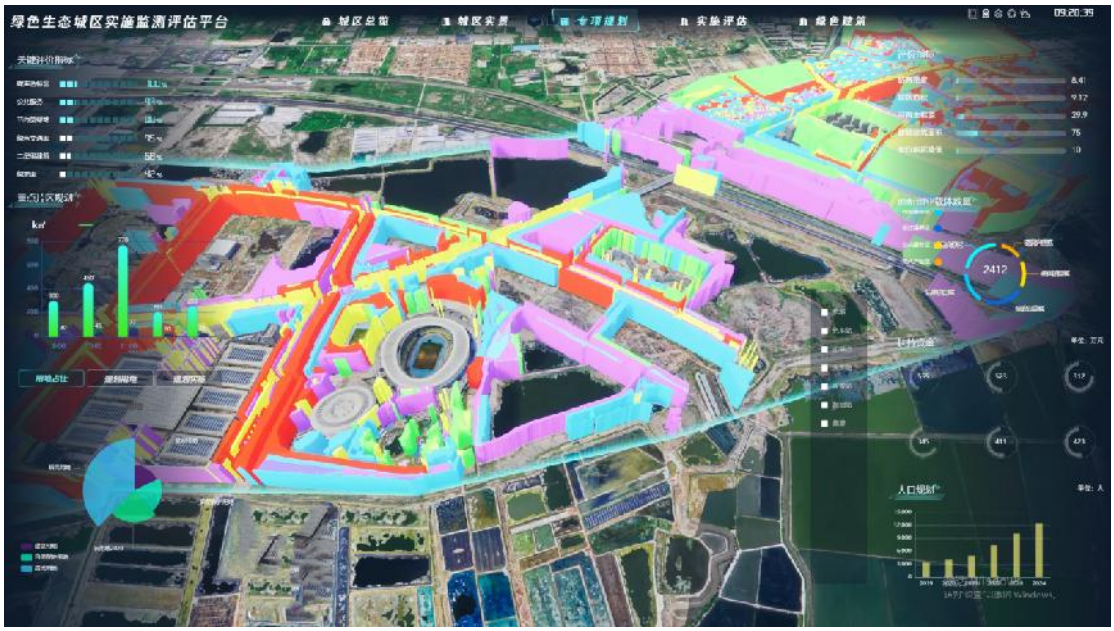

Fig 3-22 3D Spatial Distribution of Carbon Sinks

Fig 3-23 Green Ecological Urban Implementation Monitoring Evaluation Platform

4. Development Prospects

The Ministry of Natural Resources is accelerating the construction of the 3D Real Scene China project, expanding the application areas and depth of 3D Real Scene technology. First, it aims to strengthen the supply of 3D Real Scene data, consolidating the foundation of the national spatial geographic data infrastructure. This involves building an integrated spatial geographic data resource system that encompasses land, sea, and air, as well as both two-dimensional and three-dimensional elements, while continuously improving coverage, precision,

timeliness, and richness. Second, it focuses on cultivating an application ecosystem and unlocking the value of spatial geographic data elements. This will stimulate demand for applications, create multidimensional digital application scenarios, and facilitate the efficient and intelligent matching and circulation of various production elements across time and space.

For Qingdao's local requirements, the relevant work will focus on the following key areas:

4.1 Continuous Technological Breakthroughs

Actively explore the application of cutting-edge technologies such as artificial intelligence, big data, and the Internet of Things in the construction of 3D Real Scene China, optimizing and innovating technical routes and methods to continuously enhance the capabilities and levels of data acquisition, processing, and application services.

Strengthen technical breakthroughs by conducting in-depth research on key technologies such as rapid construction of 3D Real Scene, lightweight processing, and application of 3D Real Scene. Additionally, increase the application of domestic high-resolution satellite remote sensing in 3D Real Scene development to maintain data "freshness" while reducing data production costs. Make technological advances in integrating 3D Real Scene with digital twin technology, enhancing the intelligent analysis and decision-support applications of 3D Real Scene.

Collaborate with the Chinese Academy of Surveying and Mapping, Wuhan University, and the National Geomatics Center of China to jointly apply for the “Earth Observation and Navigation” key project under the “14th Five-Year Plan” National Key Research and Development Program. The project, titled “Key Technologies for Efficient Modeling of 3D Real Scene Geographic Entities and Application Demonstration,” will further expand Qingdao's leading role in 3D Real Scene development, promote technological innovation in this field, and enhance the city's core competitiveness. This initiative will also drive the transformation and upgrading of Qingdao’s surveying and geographic information industry, foster cooperation with more advanced scientific and technological institutions, and elevate Qingdao’s influence and status in the realm of digital transformation.

4.2 Building a Digital Twin City

A digital twin city serves as the foundation for the development of smart cities. It not only replicates the physical structure of the city but also accurately reflects its operational state through real-time data collection and analysis. By leveraging the high-precision positioning of the BeiDou Satellite Navigation System, the high-speed data transmission of 5G technology, and audio-based high-precision positioning technology, dynamic elements such as water, electricity, and gas supply, as well as the movement of people, vehicles, and logistics within the city, can be captured. This enables the creation of a city model that mirrors the real city in terms of population

flow, transportation, environment, weather, and other aspects.

Through the comprehensive application of advanced technologies such as artificial intelligence and cloud computing, the value of city model data elements, based on 3D Real Scene, can be unlocked. This data is further analyzed to generate insights and predictions, providing intelligent decision-making support for urban management.

4.3 Strengthening International Cooperation

Based on 3D Real Scene technology, international cooperation and exchanges will be carried out to promote the innovative development and application of geoinformation technology. A key focus is advancing the "Sino-Australian 3D Real Scene Innovation Technology Cooperation Project," led by the Chinese Academy of Surveying and Mapping. By leveraging the strengths of both parties, the goal is to create a global demonstration of geographical information knowledge and innovation collaboration.

At the 2024 United Nations Geospatial Information Week (UN GEONOW), the project unveiled a comprehensive course on the entire process of 3D aerial data acquisition, high-precision modelling, and result-sharing applications. This course validates with real-world case studies to demonstrate its scalability and re-usability, providing technical support and a model effect for the development of smart cities and digital earth initiatives. Additionally, the course will be adopted as part of the global geographical information leadership training program under the United Nations Global Geospatial Knowledge and Innovation Centre (UN-GGKIC), and it is planned to be launched at the 2025 International Federation of Surveyors (FIG) Geospatial Week.

Moreover, in collaboration with research institutions and universities such as Tongji University and Ruhr University Bochum, joint research will be conducted on the IMECOGIP (Implementation of the Ecosystem Service Concept in Green Infrastructure Planning) project. The project will capitalize on the advantages of 3D Real Scene technology—such as its intuitive visualization, accuracy, measurability, and immersive experience—to carry out technical research in ecological mapping, ecosystem service indicator calculation, and assessment. This will strengthen international cooperation on 3D Real Scene technology, expand its application areas, and contribute China's expertise to global efforts in ecosystem assessment, restoration, and sustainable development.

4.4 Deepening Application Empowerment

Expand industry exchanges and stimulate user demand. Continuously conduct industry exchanges and training, as well as cross-sector discussions and collaborations. Further promote data openness and sharing, exploring pathways for data element transactions. Through public outreach activities, introduce 3D Real Scene technology to more industries, empowering a wide range of sectors.

Strengthen the real-time integration, fusion, and computation of 3D Real Scene data products with ubiquitous information such as social, economic, and demographic data, as well as natural resource management information. By leveraging spatiotemporal connections, spatiotemporal computation, and spatiotemporal intelligence, provide high-quality spatiotemporal information, advanced spatiotemporal analysis, and high-level spatiotemporal empowerment for economic and social development as well as natural resource management.

Unlock the value of data and empower the "low-altitude economy." Relying on the Low-Altitude Flight Intelligent Service Support Shandong Provincial Engineering Research Center, standards for the classification and construction of 3D geographic entities in low-altitude digital airspace will be developed based on 3D Real Scene technology. Research will be conducted on the efficient modelling and integrated representation of structured and semantically rich 3D geographic entities in low-altitude digital airspace, such as terrain, buildings, obstacles, and no-fly zones. This will lead to the creation of the "Qingdao Low-Altitude Airspace Navigation Map," which will serve as a 3D digital foundation for low-altitude airspace, providing safe and orderly routes for low-altitude aircraft. This service will support low-altitude airspace utilization, route coordination, facility management, and safety control, creating a new business model for 3D Real Scene applications and opening up a new track for 3D Real Scene innovations.

Conclusion

With the ongoing advancement of the global digitalization wave, the 3D Real Scene, as a core component of new infrastructure, is transforming our production and lifestyle at an unprecedented pace. It has become a critical driving force in promoting the comprehensive green transition of the economy and society and in building a digital China. As a pioneer, the city of Qingdao, through the successful implementation and continuous innovation of the 3D Real Scene Qingdao project, has not only set a benchmark domestically but also provided a valuable "Qingdao Model" and "Qingdao Experience" for the construction of 3D Real Scene systems in megacities worldwide.

Looking ahead, the 3D Real Scene will further deepen its integration and application across various industries, expanding from single-domain usage to multi-domain and cross-industry penetration. In the development of smart cities, the 3D Real Scene will serve as the core platform for urban digital twins, providing more accurate and efficient data support for urban planning, management, and decision-making, thereby facilitating the modernization of urban governance systems and capacities. Meanwhile, with the continuous iteration and upgrading of technology, the collection, processing, and updating of 3D Real Scene data will become more intelligent and automated, enabling real-time dynamic data updates. This will offer strong support for urban operations monitoring, emergency response, disaster prevention, and more.

In addition, the 3D Real Scene will play an increasingly important role in the digital economy sector, driving the deep integration of the digital economy with the real economy, empowering the transformation and upgrading of traditional industries, and fostering new business formats and models, injecting new momentum into high-quality economic development. We believe that in the near future, the 3D Real Scene will become a key force in promoting social progress and fostering sustainable development, contributing more wisdom and strength to the building of a community with a shared future for mankind. As a pioneering city in 3D Real Scene applications, Qingdao, under the guidance of the Ministry of Natural Resources and Department of Natural Resources of Shandong Province, will continue to explore innovations, tackle challenges, and strive to write a new chapter in the development of 3D Real Scene technology.