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Approach Evolution and Technical Features of Shanghai's Comprehensive Transportation Development Planning

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Abstract: Since the beginning of the 21st century, Shanghai has carried out four rounds of comprehensive transportation development planning practices, providing strong support for the construction of an international shipping center and the improvement of a comprehensive megacity's transportation system. Reviewing the development history of nearly 40 years, Shanghai's comprehensive transportation development planning has always been closely aligned with the urban development phases, spatial expansion needs, and functional upgrade goals, ensuring both the implementability and the continuity of planning tasks. In the process of the Shanghai 14th Five-Year Plan for Comprehensive Transportation Development, multiple innovative technologies and methods have been adopted, including multidimensional quantitative assessments, updates of transportation modeling and demand forecasting techniques, the establishment of a framework with integrated transportation objectives and indicators, and the formulation of system-specific transportation planning strategies and key initiatives. Meanwhile, a complete guarantee mechanism has been established to ensure the implementation of all tasks. Finally, new directions for Shanghai's comprehensive transportation development planning are proposed with focuses on serving as an international comprehensive transportation hub, fostering metropolitan area coordination, enhancing transportation functions to adapt to the evolving spatial structure of the city, refining transportation governance, strengthening transportation infrastructure resilience, and advancing green and intelligent mobility services. **DOI:** 10.13813/j.cn11-5141/u.2025.0015-en

Keywords: comprehensive transportation; development planning; megacity; Yangtze River Delta; 14th Five-Year Plan; Shanghai

1 Evolution of comprehensive transportation development in Shanghai

1.1 Initial development stage (1986–1999)

During the 1980s and 1990s, Shanghai's urbanization and motorization were in their early stages. The primary objective in this stage was to address the shortage of transportation infrastructure and alleviate difficulties in daily travel for residents.

In 1986, Shanghai's permanent population was approximately 12 million, with a daily travel volume of about 20 million trips. Urban functions were highly concentrated in the central city [①], which housed 37% of the total population with a density of 50,000 people per square kilometer and accounted for 41% of the city's total travel volume. Public buses and trolleybuses were the dominant motorized transportation modes, with a modal share of 35% in the central area. However, constrained by limited socio-economic development, the transport supply lagged significantly. The per capita road area in the central city was merely 2 m².

Beginning with the 7th Five-Year Plan (1986–1990), Shanghai made substantial investments in urban road infrastructure, achieving preliminary improvements. Nonetheless, the central area's road network remained saturated, and the mixed traffic of motorized and non-motorized vehicles caused serious issues related to traffic order and safety.

In the 1990s, with the implementation of the Pudong Development and Opening-up strategy, new residential communities proliferated in suburban districts [②] and Pudong New Area. The urban spatial structure exhibited a layered expansion from the central city [③], accompanied by suburban urbanization. Notable progress was made in road and transportation infrastructure: the radial "Shen"(申)-shaped expressway system, the Three Horizontal and Three Vertical arterial road network, cross-river bridges and tunnels, and major rail transit lines (Lines 1, 2, and 3) significantly transformed the urban transportation landscape. However, with the rapid growth of private car ownership, major arterials in the central city remained congested during peak hours. Due to increasing road traffic congestion and strained public bus capacity, the modal share of public buses in the central area dropped to 23% by 1995, while the share of non-motorized transport rose to 34%.

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1.2 Rapid growth stage (2000–2015)

Since 2000, Shanghai has placed a greater emphasis on enhancing urban functions and striving to build a modern, international metropolis. During this stage, the focus was on optimizing the transportation structure, expanding the scale of transportation infrastructure, and improving the quality of transportation services.

In 2005, the official opening of the Yangshan Deep Water Port marked a major breakthrough in the development of Shanghai as an international shipping center. Leveraging the opportunity presented by the 2010 Shanghai World Expo, the city maintained a high level of investment in transportation and comprehensively advanced the development of its comprehensive transportation system. Urban population and industries were systematically guided toward suburban areas, with urban development increasingly oriented toward the entire municipal area and the Yangtze River Delta region. In 2010, Shanghai Port handled 29.07 million TEUs, ranking first in the world for the first time. With the commissioning of the second runway [1] at Pudong International Airport in 2005 and the third runway in 2008, and Terminal 2 entering operation, the airport's passenger throughput exceeded 40 million in 2010, marking its entry into the category of mega-hub airports. Its cargo and mail throughput ranked third globally. In the same year, the total passenger throughput of Shanghai's airports reached 71.88 million, and cargo and mail throughput reached 3.71 million tons [2].

Following the policy of Encouraging Private Vehicle Ownership outlined in the Tenth Five-Year Plan for National Economic and Social Development of the People's Republic of China, the city experienced a rapid rise in motorization. By 2015, Shanghai's permanent resident population reached 24.15 million, with total daily travel volume rising to 52.16 million trips. The number of registered motor vehicles surged to 3.34 million [3].

The layout of external transportation infrastructure was progressively improved, and the capacity of the city's backbone transportation network was significantly enhanced. Urban rail transit, comprehensive passenger transportation hubs, high-grade highways, and railways all experienced leapfrog development, forming a comprehensive transportation system with expressways and urban rail transit as the backbone in the central city, and high-grade highways as the framework in suburban areas. In 2009, the Shanghai Yangtze River Tunnel and Bridge—the world's largest combined bridge-and-tunnel project—was completed and opened to traffic, ending the historical absence of direct transportation links between Chongming Island and mainland Shanghai. In July 2010, the Hongqiao High-Speed Railway Station and the Shanghai-Nanjing Intercity Railway were completed and put into operation simultaneously, establishing a "three main, three auxiliary" ④ passenger railway station system. To meet the extraordinary travel demand generated by the 2010 World Expo, the operating length of urban rail transit increased by 304 kilometers between 2006 and 2010, reaching 452 kilometers in 2010 [1]. Shanghai thus became the first city in China to exceed 400 kilometers in urban rail transit operating length, providing strong transportation support for the successful delivery of the Expo. By 2015, the city had 15 operating urban rail transit lines (including the maglev line), with a total length of 617.5 kilometers, nearly a tenfold increase compared to 2000, and a daily passenger volume reaching 8.405 million trips.

1.3 Stable development stage (from 2016 onwards)

Since the 13th Five-Year Plan period, Shanghai's comprehensive transportation system, characterized by being hub-oriented, functional, and networked, has been continuously improved and upgraded. Key tasks and major projects have progressed in an orderly manner, and the international shipping center has been completed. This stage focuses on the coordination between infrastructure functions and management, and aims to build an integrated, multidimensional transportation system.

In terms of external transportation, first, port handling capacity has been continuously enhanced, and the Phase IV automated terminal of Yangshan Deep Water Port has been put into operation. In 2024, Shanghai Port's container throughput reached 51.506 million TEUs [4], ranking first in the world for 15 consecutive years. According to the Xinhua-Baltic International Shipping Centre Development Index Report (2024), Shanghai ranked third in comprehensive strength among global shipping center cities. Second, a preliminary Asia-Pacific air hub has been established. In 2024, the passenger throughput of Shanghai airports reached 125 million, and cargo and mail throughput reached 4.206 million tons, ranking third and second globally among cities, respectively. Third, regional transportation infrastructure construction has been steadily advancing. In 2020, the first stage of the Shanghai–Suzhou–Nantong Railway was completed and opened to traffic; in 2022, the second stage began construction; and in 2024, the Shanghai–Suzhou–Huzhou Railway was completed and opened [5].

In terms of urban transportation, first, the dominant role of urban rail transit in public passenger transport has become increasingly prominent, and the network has been continuously improved. In 2023, Shanghai's permanent resident population reached 24.87 million, with a total travel volume of 56.45 million person-times per day [6]. In 2024, the public transport passenger volume reached 13.37 million person-times per day, among which urban rail transit accounted for 10.28 million person-times per day. In 2024, the total operating mileage of urban rail transit reached 896 km, and station coverage continued to expand. Within the city center, 55% of the population can now access a rail transit station within a 10-minute walk. Second, public bus and trolleybus services have gradually transformed, with service

levels steadily enriched. In 2023, there were 1,589 public bus and trolleybus lines and 17,351 operating vehicles. Third, the road network has been increasingly improved, and supporting infrastructure in key areas has been strengthened. In 2023, the total road length in the city exceeded 19,000 km, including 13,000 km of highways and about 5,500 km of urban roads. In 2024, the number of registered motor vehicles in the city reached 5.796 million, and the actual number of small passenger cars reached 6.13 million. Despite the continued increase in the total number of small passenger vehicles, with the continuous advancement of special congestion management projects, traffic conditions during peak hours in the central city remain generally controllable.

In terms of comprehensive traffic management, first, the capability of traffic safety assurance and emergency management services has been continuously enhanced. A multi-party collaborative comprehensive traffic safety assurance system has been established, accomplishing traffic safety assurance tasks for major events such as the 7th China International Import Expo and the 10th China Flower Expo. Second, significant results have been achieved in green and low-carbon transportation development. New energy transportation tools have been vigorously promoted, the proportion of new energy vehicles in public bus and trolleybus fleets has continued to increase, and the deployment of charging facilities has been accelerated. Third, a friendly travel environment has been continuously cultivated. Efforts have been made to actively build "slow-traffic demonstration zones," strengthen barrier-free and elderly-friendly renovations in urban rail and public bus systems, and enhance the quality of existing transportation facilities. Fourth, the digital and intelligent transformation of the transportation sector has been fully promoted. The intelligent upgrading of transportation infrastructure has been accelerated, with the construction of smart expressways and smart waterways being advanced. Smart travel services have been improved, and new digital-intelligent management platforms have been built.

2 Evolution of the planning approach for comprehensive transportation development in Shanghai

Over the past two decades, Shanghai has successively formulated four major rounds of comprehensive transportation development plans: the Shanghai 11th Five-Year Urban Transportation Development Plan (hereinafter referred to as the 11th Five-Year Plan), the Shanghai 12th Five-Year Comprehensive Transportation Development Plan (12th Five-Year Plan), the Shanghai 13th Five-Year Comprehensive Transportation Plan (13th Five-Year Plan), and the Shanghai 14th Five-Year Comprehensive Transportation Development Plan (14th Five-Year Plan). These plans were generally developed in alignment with the corresponding Five-Year Plans for Shanghai's national economic and social development, ensuring both adaptability and continuity, while retaining the phased characteristics inherent to five-year planning cycles.

2.1 Planning themes reflecting urban development stages

Each planning cycle reflects the primary development theme of its respective era. The 11th Five-Year Plan centered around preparations for the 2010 Shanghai World Expo and proposed accelerating the construction of a hub-oriented, functional, and networked comprehensive transportation system. The 12th Five-Year Plan leveraged the post-Expo momentum, emphasizing principles such as transportation-led development, management-first approaches, service enhancement, and urban-rural integration, with the dual focus of infrastructure improvement and enhanced integrated management [7]. The 13th Five-Year Plan shifted toward a governance-oriented strategy with an emphasis on system-building and addressing deficiencies. It focused on identifying and resolving critical issues within the comprehensive transportation system to enhance overall capacity and competitiveness [8]. The 14th Five-Year Plan further evolved to align with the national dual circulation strategy and the high-quality integrated development of the Yangtze River Delta, with a stronger emphasis on the characteristics of smart, green, and resilient transportation systems [9].

2.2 Planning scope reflecting urban spatial expansion

The spatial perspective of the plans has gradually expanded from the central city and municipal area to the broader metropolitan region and the Yangtze River Delta urban agglomeration. The 12th Five-Year Plan focused on addressing travel challenges in suburban new towns. The 13th Five-Year Plan emphasized coordinated development with surrounding cities in the Yangtze River Delta. Following the elevation of Yangtze River Delta integration to a national strategy in 2018, the 14th Five-Year Plan outlined new initiatives such as the joint development of a "Yangtze River Delta on Rails" and the creation of a world-class airport cluster. It also prioritized the construction of integrated transportation hubs and networks in new towns to support their roles as comprehensive node cities.

2.3 Planning objectives reflecting functional upgrade goals

Since the 11th Five-Year Plan, the overarching goal of Shanghai's comprehensive transportation planning has been to build a hub-oriented, functional, and networked integrated transportation system. In alignment with China's strategy to boost the strength in transportation, the planning objectives have progressively emphasized breakthroughs in smart, safe, green, and shared transportation. Aligning with the

requirements for the transformation and upgrading, organic renewal, refined management, and risk management of urban functions, recent plans also focus on effectively embodying the concept of a "people-oriented city." The 14th Five-Year Plan introduced new targets and tasks aimed at improving service quality, enhancing the modernization of transportation governance, and creating more comfortable and accessible travel environments for residents (Table 1).

2.4 Planning tasks reflecting implementability and continuity

The focus of key planning tasks lies in projects and measures that are feasible in the short term, while also demonstrating continuity across successive plans. The 11th Five-Year Plan proposed major tasks, including the establishment of Shanghai as an international shipping center and the construction of a basic urban rail transit network. The 12th Five-Year Plan and the 13th Five-Year Plan clarified core objectives such as enhancing the radiative capacity of the international shipping center, advancing Yangtze River Delta integration, and developing a "transit-oriented city." The 14th Five-Year Plan emphasized both the reinforcement of strategic facilities, new types of infrastructure, and key regional investments, and the optimization of existing assets and sustainable development. It further stressed improving the quality of life and service experiences, and enhancing the modernization level of megacity governance. Specifically, 225 major tasks were defined across six dimensions: improving the layout of the comprehensive transportation infrastructure system, enhancing the quality of transportation services, strengthening the capacity for refining transportation governance, accelerating the construction of new infrastructure, promoting green and low-carbon transformation, and improving the comprehensive transportation guarantee mechanism.

Over four rounds of planning, Shanghai has continuously identified and addressed key bottlenecks for comprehensive transportation development, demonstrating a dynamic process of optimization and balance. (1) Coordination among different plans has been emphasized, particularly in aligning infrastructure functions, construction timelines, and governance mechanisms across regional, municipal, and district levels, while also strengthening integration with territorial spatial planning and industrial development planning. (2) Continuity of transportation objectives has been maintained throughout implementation by scientifically analyzing existing bottlenecks and development trends, and making necessary adjustments based on objective assessments. Major revisions are subject to deliberation by the municipal government and the People's Congress. (3) Continuous tracking and dynamic optimization of planning content are essential due to evolving macro-strategies, policies, emerging technologies, and new business models at both national and municipal levels.

3 Content and technical characteristics of the 14th Five-Year Plan

3.1 Technical roadmap

The comprehensive transportation development planning is a specialized transportation plan formulated in coordination with the urban national economic and social development planning, and is revised every five years. Its core task is to identify a series of major projects and initiatives that are forward-looking, catalytic, and innovative, serving as critical instruments for realizing broader economic and social development goals, and guiding the planning, construction, and management of comprehensive transportation systems over the next five years and beyond.

Table 1 Comparison of goals across the four rounds of Shanghai's comprehensive transportation development plans

Comprehensive transportation development plan	Overall goal	Sub-goals
11th Five-Year Plan	Strengthen the construction of hub-oriented, functional, and networked major transportation infrastructure to build an integrated transportation system featuring urban-suburban integration, internal-external connectivity, and convenient efficiency	1) Initially establish the status of an international shipping center and the status of an Asia-Pacific air hub port 2) Further enhance the function of passenger railway hubs and improve the hierarchical highway network within the city 3) Improve the central city road network and cross-river passages, and enhance the overall service level of urban public transportation 4) Form a framework for an integrated transportation information system and improve the energy-saving and environmental performance of the transportation system
12th Five-Year Plan	Strive to build an integrated transportation system that is well-equipped, intelligent, and efficient, public transport-oriented, safe and orderly, and low-carbon and energy-saving	1) Establish the basic pattern of a transportation network integrating urban and rural areas and connecting internal and external systems 2) Improve the service level of transportation across the entire city and ensure smooth operation 3) Form an intensive transportation model with public transport as the mainstay 4) Create a safe and green integrated transportation environment
13th Five-Year Plan	Improve and enhance a hub-oriented, functional, and networked integrated transportation system for an international metropolis, and further highlight the concepts of smart, low-carbon, and shared development	1) Build transportation hubs with global reach and national service capability 2) Ensure that transportation operations are safe and reliable 3) Make passenger travel and cargo transport more convenient and efficient, with organically integrated and efficiently operated transportation systems 4) Create a green and civilized transportation environment
14th Five-Year Plan	Continuously improve the comprehensive transportation system of a megacity featuring hubs, functions, networks, intelligence, and greenness, and build a high-quality, modern integrated transportation system that is three-dimensional, human-centered, ecological, smart, and efficient	1) Achieve world-class status as an international shipping center 2) Attain nationally leading levels of regional integrated transportation connectivity 3) Deliver first-class quality in comprehensive transportation services 4) Fully enhance the modernization level of transportation governance capabilities

Comprehensive transportation development planning must integrate the key components of comprehensive transportation system planning, which emphasizes the spatial layout of transportation infrastructure, and system-specific transportation planning, which focuses on the planning of individual subsystems, thus highlighting the characteristics of systemic coordination and dynamic development. It requires not only a longitudinal evaluation across different urban development stages but also top-level strategic guidance that ensures the coherence of transportation objectives across all subsystems. The planning content includes both specific spatial layout proposals aligned with territorial spatial planning and development tasks related to transportation, management, and service provision under new conceptual frameworks.

The technical roadmap for the 14th Five-Year Plan follows four major procedures (Fig. 1): (1) Transportation development assessment: a comprehensive evaluation of the current transportation system to identify existing problems and weaknesses; (2) Strategic analysis of transportation development: determination of the future strategic direction of transportation development based on assessment outcomes; (3) Formulation of transportation schemes and tasks: development of specific transportation development plans and implementation tasks; and (4) Establishment of transportation guarantee mechanism: design of institutional mechanisms and policy measures to ensure effective implementation of the plan.

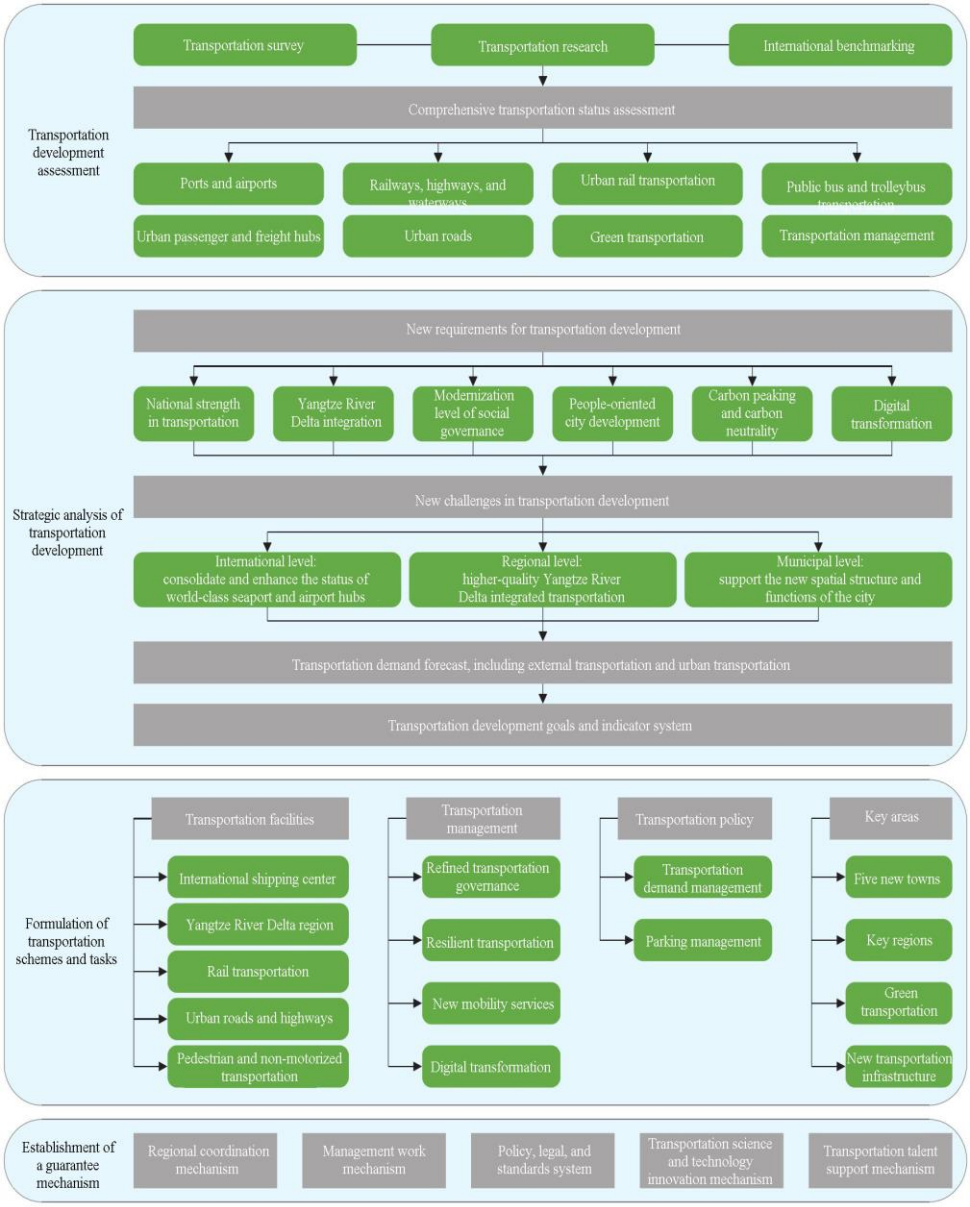

Fig. 1 Technical roadmap for the Shanghai 14th Five-Year Comprehensive Transportation Development Plan

Source: Reference [10].

3.2 Transportation development assessment

3.2.1 Phased and multidimensional evaluation

Transportation development assessment is typically carried out in two stages: a mid-term evaluation, conducted two and a half years after the implementation of the plan, and a final evaluation, conducted at the end of the five-year plan period. The assessment focuses on the current state of development, the degree of goal attainment, the progress of task implementation, problems encountered during execution, and future trends and challenges. It aligns with and provides feedback to Shanghai's territorial spatial planning evaluation system, which follows a "annual checkup, five-year evaluation" mechanism. The methodology emphasizes a combination of quantitative and qualitative approaches, integrates both process and outcome evaluations, and incorporates both overall and component-level assessments.

3.2.2 Quantitative evaluation of indicators

Quantitative assessment serves as the most fundamental and objective technical method within transportation development evaluation. On the one hand, it relies on Shanghai's long-term accumulation of comprehensive transportation statistics and historical survey data to conduct in-depth analyses of development trends. On the other hand, in light of the higher timeliness requirements of five-year planning, the assessment employs a wide array of modern data collection technologies, including manual surveys, mobile phone signaling, GPS-based continuous trajectory data, and layered expansion sampling of multi-source datasets. Additionally, big data mining techniques using GPS and IC card data from public buses and trolleybuses are utilized. These technologies enable the timely acquisition of relevant indicators and datasets, supporting the analysis of operational characteristics across dimensions such as passenger mobility, vehicle flows, roadway traffic, public transit, freight transportation, and external connectivity, thereby providing robust and up-to-date data support for the evaluation process.

3.3 Strategic analysis of transportation development

3.3.1 Analysis of transportation development trends

(1) Incorporating internal and external factors to analyze new requirements for comprehensive transportation development in Shanghai

In assessing transportation development trends, it is essential to comprehensively consider the macro-level guidance and short-term policy requirements at the national, regional, and municipal levels concerning the evolution of the comprehensive transportation system. Attention must also be given to the interactions between internal and external elements of the system, including the integration of transportation with urban spatial development, coordination among different transportation subsystems, and the alignment between intra-city and external transportation. In addition, the assessment must take into account the influence of broader urban factors such as economic structure, industrial development, land use, population dynamics, and fiscal capacity.

(2) Focusing on the relationship between transportation development and urban spatial planning under the new spatial structure

Based on the city's master plan and in light of recent changes in regional coordination, urban spatial configuration, and the development of key areas, emphasis is placed on the spatially coordinated development of the Yangtze River Delta urban agglomeration and the Shanghai metropolitan area. For different zones, such as the central city, new towns, emerging urban areas, and key development districts, new directions for comprehensive transportation development are identified and prioritized for strategic planning.

3.3.2 Updates to transportation models and travel demand forecasting techniques

(1) Development of an intercity transportation model

The intercity transportation model is used to forecast and analyze short- and medium-to-long-term trends in Shanghai's intercity passenger demand. The forecasting content includes the total volume and structure of intercity passenger flows, as well as the total volume and structural characteristics of passenger flows between Shanghai and the Yangtze River Delta region. Major technical approaches include time-series forecasting, elasticity coefficient analysis, and mode-specific forecasting methods, integrated through ensemble forecasting techniques (Fig. 2). For example, by taking into account the spatial distribution of regional transportation network infrastructure, the Yangtze River Delta regional transportation model can simulate and assess the accessibility of the Yangtze River Delta urban agglomeration to Shanghai (Fig. 3), thereby promoting the continuous enhancement of accessibility within the Shanghai Metropolitan Area during the 14th Five-Year Plan period.

(2) Optimization of the municipal transportation model

In line with the latest requirements of the Yangtze River Delta regional plans, the city master plan, and key area development plans, the municipal transportation model is refined. Within the four-step model framework, specific improvements are made to the municipal skim matrix, cross-classification tables of population and employment, private vehicle ownership models, trip generation models, walk trip pre-segmentation models, trip distribution models, mode choice models, and traffic assignment models. Based on the spatial distribution of population, employment, and transportation facilities during the 14th Five-Year Plan period, the model forecasts and analyzes the spatial characteristics of urban travel corridors. The analysis shows that demand remains significant along key corridors (Fig. 4).

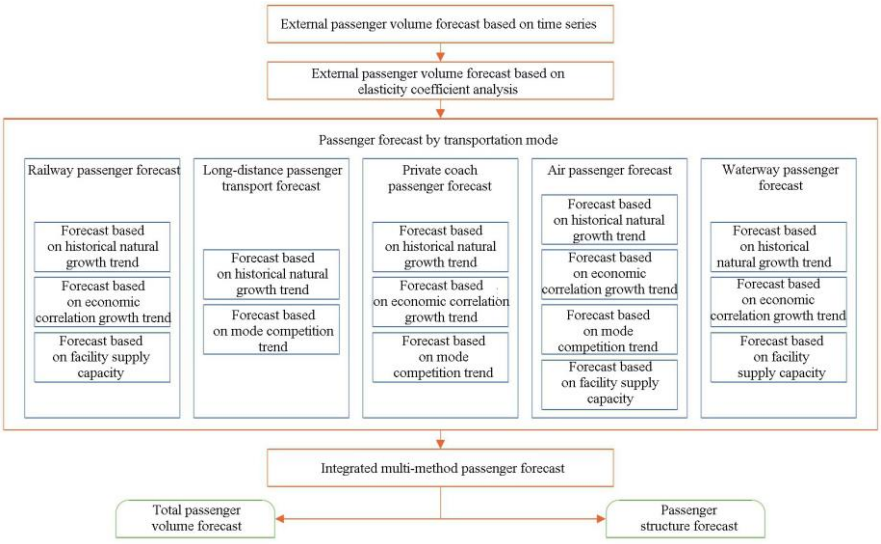

Fig. 2 Framework for building Shanghai's external transportation model

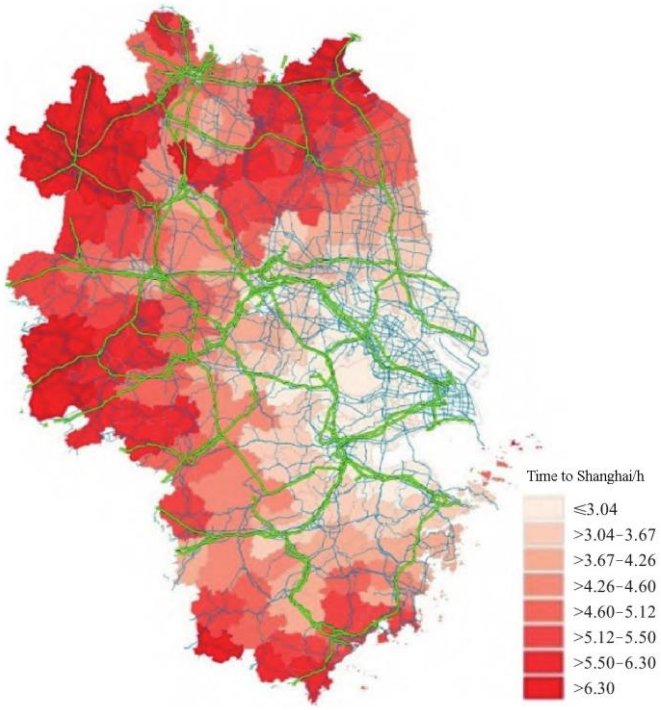

Fig. 3 Distribution of transportation accessibility in Shanghai and the Yangtze River Delta urban agglomeration

(3) Construction of new town transportation models

Job-housing relationship analysis forms the foundation for assessing current and future transportation conditions in new towns. By integrating multi-source data such as mobile signaling, resident travel surveys, and remote sensing land-use data, a comprehensive analysis of job-housing relationships in new towns is conducted to provide quantitative support for their transportation planning. The new town transportation model analyzes differences in daytime and nighttime population, residential population's workplace choices, employment population's residential locations, and commuting patterns between new towns and the Yangtze River Delta region. This enables forecasts of commuting distance, travel time, transportation structure, and travel distribution in new towns.

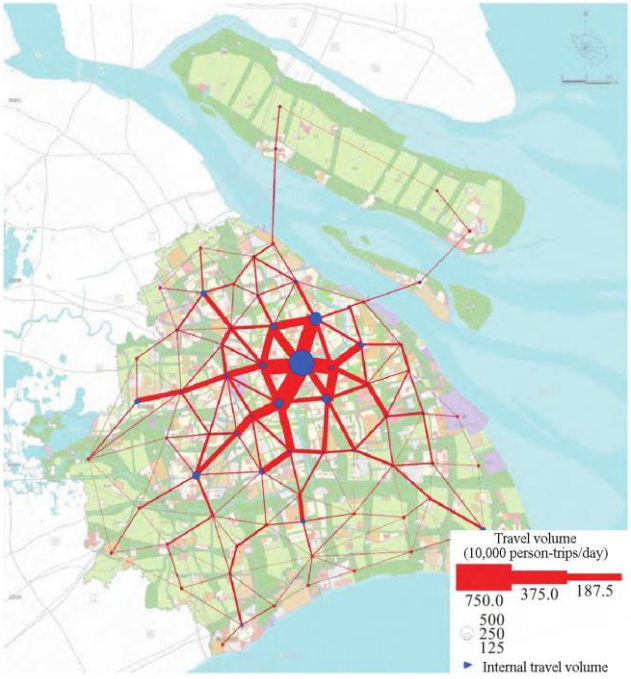

Fig. 4 Forecast of urban travel volumes in Shanghai

By using remote sensing image interpretation techniques, the land-use characteristics of Shanghai's five new towns are analyzed (Fig. 5), which reveals key patterns in job-housing distribution. Meanwhile, mobile signaling data are used to analyze the workplace distribution of new town residents (Fig. 6), which provides scientific support for evaluating job-housing patterns and commuting characteristics.

Fig. 5 Current land use classification of Shanghai's five new towns

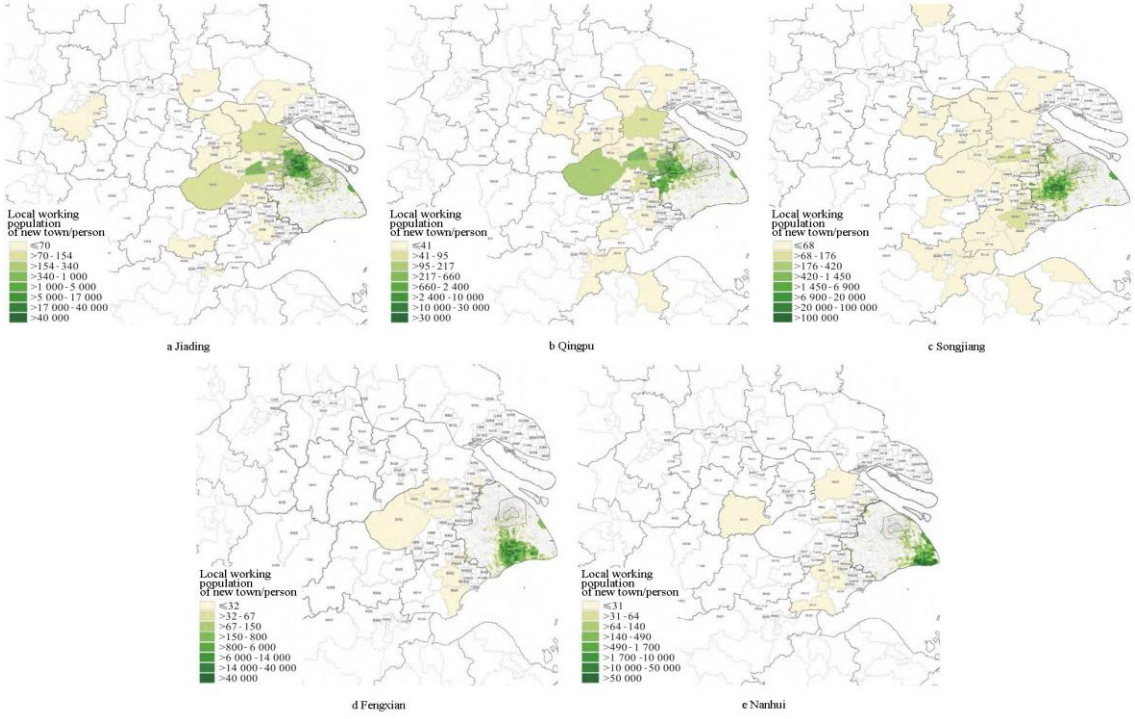

Fig. 6 Workplace distribution of residents in Shanghai's five new towns

(4) Construction of the freight transportation model

Taking into account economic development indicators, total industrial output, total retail sales of consumer goods, total import and export volume, and the supply of intercity freight infrastructure, a freight transportation model is developed using integrated forecasting techniques (Fig. 7). Data sources include GPS data from information-based sampling and operational data from reservation systems, among others. The main technical methods consist of time-series and elasticity coefficient-based forecasts. These are supplemented by projections from the city master plan and specialized transportation agencies to form integrated forecasts of both short- and long-term freight volumes and structural distribution.

3.3.3 Formulation of integrated transportation development goals

(1) Drawing on the experience of typical international cities in integrated transportation development

The integrated transportation development and planning practices of typical international cities are characterized by three key features. (1) A well-structured functional hierarchy

is maintained, with multi-tiered transportation systems spanning intercontinental, intercity, metropolitan area, and central city levels, which serve as the foundation for global competitiveness. (2) A green and low-carbon orientation is emphasized, with sustainable transportation development prioritized, transportation demand managed to reduce private car dependency, walking and cycling networks revitalized, and modern public transit systems established. (3) Transportation transformation is facilitated through the application of advanced technologies, which are leveraged to improve service quality and operational efficiency. As shown in Table 2, by referencing international experience and reasonably comparing common characteristics from the perspectives of development trajectories, system features, and plans, benchmarking analysis is carried out to inform the formulation of development goals for the 14th Five-Year Plan.

(2) Analyzing the development stages of Shanghai's integrated transportation

By focusing on key factors such as economic and social development, urban spatial expansion, transportation infrastructure supply, service level, and investment intensity, the development patterns of Shanghai's integrated transportation over time are systematically reviewed. Over

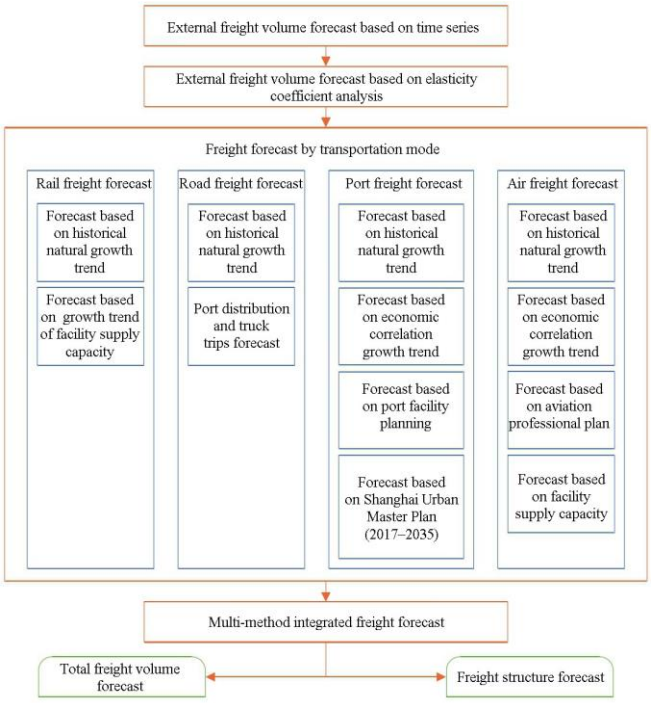

Fig. 7 Framework for building Shanghai's freight transportation model

Table 2 Comparison of comprehensive transportation development indicators between Shanghai and typical international cities

	Key indicators	Shanghai	International cities
External transportation	Port container throughput /(10,000 TEUs/year)	5 150.6(in 2024)	4112 (Singapore in 2024) 2 440(Busan in 2024)
	Water-to-water transshipment ratio for containers/%	60(in 2024)	>80(Singapore in 2022) >50(Rotterdam in 2022)
	Airport passenger throughput/ (100 million passengers/year)	1.25(in 2024)	1.78(London in 2024) 1.46(New York in 2024) 1.25(Tokyo in 2024)
	Airport cargo and mail throughput /(10,000 tons/year)	420.6(in 2024)	490.0(Hong Kong International Airport in 2024) 388.2(Memphis International Airport in 2023)
	Air passenger transfer ratio/%	15.7(Shanghai Pudong International Airport in 2024)	34.0(London Heathrow Airport in 2019) 29.6(Hong Kong International Airport in 2019)
Urban transportation	Proportion of public transport in total travel modes/%	30.8 (Central city in 2019)	54 (Tokyo urban wards in 2018) 36(Greater London in 2019)
	Share of green transportation (public transport, walking, cycling)/%	74.8 (Central city in 2023)	91.0(Tokyo urban wards in 2018)
	Urban rail transit network density/(km/km^{-2})	0.76 (Central city in 2022)	1.24(Tokyo urban wards in 2018)
	Minimum train headway in urban rail transit/s	110(in 2022)	120(London in 2016) 90(Tokyo in 2016) 139(Singapore in 2016)
	Urban rail passenger intensity/10,000 trips·km^{-1}	1.27(in 2024)	2.75(Tokyo Metro in 2018) 1.15 (New York Subway in 2016) 0.94 (London Underground in 2016)
	Road network density/ (km/km^{-2})	5.5 (Central city arterial roads in 2022)	19.2 (Tokyo urban wards in 2002) 9.3 (Greater London in 2001) 12.5 (New York in 2005)
	Average main road speed during morning peak (km/h^{-1})	15–19 (Within Inner Ring in 2022)	14 (London in 2023) 19 (New York in 2023)
	Average commuting time/min	42 (Central city in 2019)	37(Greater London in 2020) 56 (Tokyo urban wards in 1998)

Source: Reference [11].

the past three decades, Shanghai's transportation development has progressed through distinct stages: from addressing historical infrastructure deficits and capacity shortages, to optimizing transportation structure and improving development quality, and more recently, to coordinating infrastructure function and management to build a comprehensive multi-level transportation network. Looking ahead, Shanghai is entering a new stage focused on enhancing regional transportation functions, optimizing existing infrastructure, and improving service quality.

(3) Establishing integrated transportation development goals and an indicator system

First, the principles for defining integrated transportation development goals and selecting indicators are clarified. These include the following aspects: (1) reflecting the concept of integrated transportation through adequate scope, depth, and intensity; (2) ensuring accessibility and ease of processing to minimize subjective interference; (3) maintaining relative independence among indicators to reduce correlation effects; and (4) achieving a balance between macro-level composite indicators and sector-specific indicators within the transportation system. Next, a performance evaluation framework for integrated transportation is established, composed of goal-oriented indicators (including core and major indicators) and action-oriented indicators. The goal-oriented indicators reflect the focus of the government and public attention, while the action-oriented indicators support these goals and measure departmental performance. The indicators are categorized as anticipated and binding indicators, where the fulfillment, especially of binding indicators, directly reflects the effectiveness of plan implementation.

(4) Shifting the focus of goals and indicators from quantity to quality

The integrated transportation indicator system increasingly emphasizes operational efficiency, service quality, and the intrinsic values of development. The 14th Five-Year Plan highlights the goals of "strengthening hubs, weaving networks, improving quality, enhancing governance, and promoting transformation." Accordingly, four categories of eleven core indicators are outlined, including four international-level, high-capacity indicators related to the global status of Shanghai's international shipping center, two integration and efficiency indicators for the Yangtze River Delta, three intensification and convenience indicators for municipal transportation, and two green and low-carbon indicators for the transportation environment.

3.4 Formulation of transportation plans and tasks

Focusing on the overarching goal of high-quality integrated development, planning proposals and key tasks are put forward by the subsystem, which cover transportation infrastructure, operations, management, and institutional mechanisms. (1) Strategic infrastructure deployment: From the international, national, and regional levels, "hardware" proposals are clarified for transportation hubs (incorporating ports, airports, and integrated transportation hubs) and corridors (including railways, highways, and inland waterways), to build a comprehensive multi-level transportation network. (2) Optimization of the municipal transportation network: Planning proposals and near-term plans are formulated for urban rail transit, road systems, parking systems, and pedestrian and non-motorized transportation systems. (3) Enhancement of "software" quality: Coordinated and actionable tasks are proposed in areas such as passenger and freight transportation management, green and low-carbon transformation, refined governance, resilience and safety, and coordination mechanisms.

3.5 Transportation guarantee mechanisms

To ensure efficient coordination across all stages of integrated transportation, such as planning, construction, operation, and services, a comprehensive guarantee system encompassing policies, regulations, institutions, and mechanisms is established. (1) A regional coordination mechanism is designed to support strategic alignment, integrated planning, complementary strengths, and market-based cooperation across regions. (2) A management mechanism enhances the coordination capacity of integrated transportation through policy alignment and multi-stakeholder collaboration. (3) A policy, legal, and standard framework is improved to refine the system of standards and elevate the international alignment of industry norms. (4) A technological innovation mechanism is emphasized to support pilot projects driven by innovation and to develop performance-based incentive systems for scientific and technological innovation. (5) A talent support mechanism is reinforced to promote the cultivation and attraction of high-level professionals and urgently needed technical personnel.

4 Reflection and prospect

In the new stage of development, the integrated transportation system in Shanghai must support the construction of the "Five Centers" and "Four Core Functions." However, it continues to face new challenges. Firstly, persistent external uncertainties continue to affect development, and the capacity and reach of the international shipping center still need to be enhanced. Secondly, the Yangtze River Delta transportation system is evolving toward higher-quality integration, yet regional transportation systems and coordinated management mechanisms remain to be improved. Thirdly, imbalances and inadequacies still exist in transportation system development, and functional performance needs further enhancement. Fourthly, there remains a gap between the current level of modern

transportation governance and the development needs of a people-oriented city, with governance models and management technologies still requiring improvement. Fifthly, urban transportation infrastructure has entered a stock-oriented era, leading to greater pressure on full life-cycle management, and resilient transportation infrastructure construction needs to be accelerated. Sixthly, new requirements for green, digital, and intelligent transformation of transportation development are emerging, with increasing constraints from financing, land, and environmental factors. Therefore, the future development of Shanghai's comprehensive transportation planning should focus on the following new directions.

4.1 Enhancing the status as an international integrated transportation hub

To support the central node function in the domestic circulation and the strategic link in the dual circulation, both domestically and internationally, Shanghai must build a new structure for upgraded hub services and improved resource allocation capacity.

To further elevate Shanghai's status as an international shipping center, efforts should be directed toward enhancing port infrastructure capacity and promoting the high-quality development of port facilities. An efficient and seamless collection-distribution system is to be established, while multimodal transportation models are to be optimized through the active promotion of river-sea intermodal and direct transportation services. The development of container sea-rail intermodal transportation is expected to be accelerated. Shipping service functions are to be improved by fostering high-end services such as shipping finance, information systems, trading platforms, and maritime arbitration, to enhance the global capacity for shipping resource allocation.

Simultaneously, the leading role of the international air hub is to be reinforced. The development of a globally connected multi-airport system covering cross-regional networks is to be advanced to support the formation of a world-class "super carrier" and an intercontinental transfer center. A modern air traffic management system is to be constructed, with reforms to terminal airspace structures expedited and the allocation capacity for air cargo time slots improved. A deeply integrated and efficiently interconnected collection-distribution network is to be established, and the airport collection-distribution system is to be completed based on urban rail transit, to enable the integration of land, sea, air, and rail modes.

4.2 Coordinated development of the Shanghai metropolitan area

In alignment with the strategic positioning of the Yangtze River Delta and to support the rapidly growing demand for regional connectivity, coordinated development will be driven by world-class city cluster transportation infrastructure, efficient and convenient integrated transportation services, and leadership in transportation technology innovation.

The integrated development of comprehensive transportation within the Shanghai metropolitan area and the adjacent demonstration cooperation zone is to be promoted. The construction of transportation corridors, with urban rail transit serving as the structural backbone, is to be continuously advanced. Emphasis is to be placed on the improvement of cross-river and bay corridors, while the development of multi-directional, high-capacity rapid transit corridors with robust internal and external connectivity is to be accelerated. The coordination and optimization of expressway systems and high-grade inland waterway networks are to be undertaken to enhance the quality and efficiency of regional passenger and freight transportation services and their management. A coordinated approach to development across the metropolitan area is to be promoted, with strengthened regional linkages and integrated planning, construction, operation, and management of transportation systems to be systematically advanced.

4.3 Improving transportation functions under the new metropolitan spatial structure

Based on the new round of the master plan, Shanghai will accelerate the formation of a new metropolitan spatial structure characterized by a "central hub with radial reach, dual wings driving synergy, new towns gaining momentum, and north-south transformation." Following the direction of spatial functional adjustment, development will focus on expanding from the central city to surrounding areas, new towns, urban clusters, and key regions. Strategic objectives and development tasks will be differentiated and targeted according to each region's development stage and characteristics, including systematic functions of the transportation network, infrastructure capacity, transportation management, and coordination mechanisms.

In conjunction with urban renewal and functional upgrading, the central city will improve transportation services in terms of convenience, reliability, and quality. Having transitioned from large-scale infrastructure construction to the optimization of existing assets, the central city must adhere to the dual approach of prioritizing green transportation and managing transportation demand. Private car usage will be guided toward more intensive and greener transportation modes. At the same time, the city will actively promote "complete streets" and the creation of "15-minute community life circles" to foster vibrant public urban spaces. The areas surrounding the central city, as both extensions of central functions and relatively independent urban zones, must improve their connectivity with the central city transportation network while addressing deficiencies in their own internal transportation infrastructure.

Relatively independent integrated transportation systems are to be developed for the five new towns, with full

consideration given to industry-city integration and the balance between employment and housing. Regional-scale integrated transportation hubs are to be planned and constructed to support the nodal functions of these towns within the Yangtze River Delta. Public transportation networks are to be optimized through the provision of backbone routes, feeder services, and on-demand buses, thereby enhancing the attractiveness of bus and trolleybus systems. Improvements to internal road networks are to be accelerated by completing primary, secondary, and tertiary street grids to increase network density. Walking and cycling infrastructure is to be actively developed to support the creation of environments conducive to living, business, and tourism. More diversified transportation services are to be provided to the urban clusters surrounding the new towns, and the development of new, multi-modal shared mobility systems is to be explored.

Key regions should be positioned at a high strategic level and play a leading and radiating role in transportation for the Yangtze River Delta and even the whole country. Developments in the Yangtze River Delta Integrated Development Demonstration Zone, the Lin-gang Special Area of China (Shanghai) Pilot Free Trade Zone, the Hongqiao International Open Hub, and the Dongfang Hub will have a major influence on Shanghai and its metropolitan spatial system. Transportation must take the lead and serve as a foundation, while aligning with requirements related to industrial development, land use, and population in these strategic areas.

4.4 Refining the model of transportation governance

Adhering to the "people-oriented city" development concept and aiming to enhance the "soft power" of Shanghai as a megacity, efforts will focus on improving modern transportation governance capabilities. Given new dynamics such as urban functional transformation and upgrading, environmental resource constraints, operational uncertainties, and deepening marketization and digitalization, the refinement and legal development of urban transportation management must be accelerated.

The refinement of the transportation governance model requires four key transitions. (1) From "speed" to "warmth": Transition from focusing on the pace of transportation infrastructure development to people-centered management with empathy should be emphasized. The core of urban transportation development should prioritize serving public needs, to ensure more equitable distribution of resources, address the needs of vulnerable groups, and accommodate personalized mobility demands. (2) From "rectification" to "governance": Transportation governance must become more legal, scientific, and democratic to foster a fair and orderly development environment. It requires a shift from an all-powerful government model to diversified co-governance involving government, market, and society. (3) From "efficiency" to "effectiveness": Shift from focusing on scale indicators such as infrastructure capacity and transportation volume to comprehensive effectiveness indicators such as congestion indices, travel costs, accessibility, comfort, and user perceptions, including satisfaction and happiness, should be emphasized. There should be a greater emphasis on the integration between city and transportation, transportation and the environment, transportation and safety, and transportation and urban civility. (4) From "traditional" to "modern": Reflecting the requirements of Chinese modernization, this transition should leverage digital transformation to innovate the transportation governance model, to make city operations more orderly, management more efficient, and services more precise, ultimately forming a replicable and scalable governance model suitable for megacities.

4.5 Enhancing the safety and resilience of transportation infrastructure across the entire lifecycle

Many of Shanghai's urban transportation infrastructure assets have been in service for nearly 30 years. As aging becomes more apparent and potential risks increase, it is essential to strengthen the serviceability of existing infrastructure, improve operations and maintenance, enhance risk prevention and recovery capabilities, and ensure the safe operation of the transportation system.

Therefore, to enhance the lifecycle safety and resilience of transportation infrastructure, several strategies are to be adopted. First, full-lifecycle management of transportation infrastructure is to be strengthened through the establishment of an efficient and precise maintenance and supervision system, alongside the standardization of maintenance operations. Second, the implementation of "rejuvenation projects" for elevated roads, such as the Inner Ring Expressway, is to be explored to extend service lifespans. Third, the level of safety protection across the transportation system is to be improved by increasing investment in safety measures, refining routine inspection and maintenance mechanisms, and upgrading safety technologies for vehicles and equipment. Lastly, capabilities for disaster prevention, emergency response, and rapid recovery in the event of natural disasters or accidents are to be enhanced. A comprehensive emergency management system and operational mechanism will be established, an integrated, multi-level emergency rescue network constructed, and coordination in emergency management and response efforts strengthened.

4.6 Enhancing green and smart service experience

Comprehensive transportation development is subject to new demands arising from technological innovation and green and low-carbon transformation. In response to trends in technological progress and industrial transformation, the digital and intelligent transformation of transportation

infrastructure, travel services, and governance in Shanghai will be advanced. A fundamental shift in development models and transportation modes is to be promoted, to accelerate the low-carbon transition and minimize ecological impacts.

In alignment with the city's broader digital transformation strategy, efforts will be made to develop smart transportation systems and next-generation infrastructure within the transportation sector. This includes the promotion of the low-altitude economy through the establishment of service support systems and management mechanisms for low-altitude flights; the advancement and accelerated deployment of intelligent connected vehicle (ICV) technologies; and the construction of smart expressways and smart ports through the application of Internet of Things (IoT), 5G, and other advanced technologies. These measures are intended to enhance travel information integration and facilitate the development of a transportation technology innovation platform.

To support green transportation development and contribute to carbon peaking and carbon neutrality objectives, the sustainable growth of transportation and the ecological environment will be pursued alongside increasing transportation demand. The transportation structure will be optimized, and a transition toward clean energy will be encouraged. Improvements will be made in energy conservation and pollution control capabilities, a governance system for transportation-related carbon emissions will be established, and efforts will be strengthened to protect and restore ecosystems affected by transportation infrastructure.

5 Conclusions

This paper reviews nearly four decades of comprehensive transportation development in Shanghai, summarizes the evolution across four rounds of integrated transportation planning, and systematically explains the content and technical features of the 14th Five-Year Plan. It also offers preliminary reflections on future directions. Facing new challenges such as new quality productive forces, digital transformation, reducing costs and improving quality in logistics, and urban renewal, Shanghai must plan the 15th Five-Year Comprehensive Transportation Development Plan from a higher starting point, with a forward-looking, innovative, and people-centered approach.

Notes:

① In the 1980s, Shanghai's urban spatial structure was divided into four zones: the central area, the peripheral area, Pudong, and suburban counties. The central area referred to the old urban core of Shanghai, including Huangpu District, Nanshi District, Luwan District, Jing'an District, and the southern part of Hongkou District, covering approximately 93 km^2.

② In the 1990s, the peripheral area of Shanghai referred to the zone between the city center within the Inner Ring Road and the Outer Ring Expressway S20.

③ In the 1990s, the central city of Shanghai included both the central area within the Inner Ring Road and the peripheral area between the Inner and Outer Ring Roads.

④ The "Three Main" railway stations refer to Hongqiao Railway Station, Shanghai Railway Station, and Shanghai South Railway Station. The "Three Auxiliary" stations refer to Shanghai West Railway Station, Anting North Railway Station, and Shanghai Songjiang Railway Station (formerly Songjiang South Railway Station).

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