Citation: MA Xiaoyi, Jiang Xuefeng. Transportation Planning in National Territory Spatial Planning in Large Metropolitan Areas: A Case Study of Guangzhou [J]. Urban Transport of China, 2019 (04): 11–16.

Transportation Planning in National Territory Spatial Planning in Large Metropolitan Areas: A Case Study of Guangzhou

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Abstract: The new spatial planning system of national territory reveals new opportunities as well as challenges for transportation planning. By reviewing the important role of transportation in the original spatial planning system and referring to the existing practices in Beijing and Shanghai, this paper expounds the urgency of incorporating transportation into the spatial planning of national territory in a more precise and targeted way. Three factors are involved: the critical period to address transportation issues from the source, the lock-in effect of transportation, and the network effect of transportation. With Guangzhou as an example, the paper introduces the exploration of how to establish organization methods, technology ideas, and expression forms of transportation planning as a component of the spatial planning of national territory. Finally, the paper summarizes the experience of synchronously forming the transportation planning and developing a specialized, effective and dynamic maintenance system with an indication of future research areas. **DOI:** 10.13813/j.cn11-5141/u.2019.0403-en

Keywords: spatial planning of national territory; transportation planning; optimization of spatial pattern; Guangzhou

0 Introduction

In the spatial planning process, the transportation system has been consistently playing a significant role. Among the four functions of a city proposed in the *Athens Charter*, the functions of work, residence, and recreation basically correspond to the production space, living space, and ecological space respectively, while the fourth function—transportation—is not only contained in but also connects the above three spaces and provides feedback to the functions of the three spaces through accessibility. The increasingly serious traffic congestion in cities of China require the changes in the spatial planning process with a special attention to transportation. After decades of research and adjustment, multimodal transportation planning (especially in large cities) has become one of few (only two or three) special planning components that is carried out simultaneously and interacts with the overall urban planning, which has made a positive impact on the alleviation of urban traffic congestion.

The general rules and regulations of China's new spatial planning system and its major principles have basically been developed after the publication of *Several Opinions of the Central Committee of the Communist Party of China on the Establishment, Supervision and Implementation of the Land & Space Planning System* (hereinafter referred to as *Several Opinions*) [1]. According to the *Several Opinions*, the spatial planning of national territory will integrate functional area planning, land use planning, urban and rural planning etc., reconcile the conflicts of these plans, and facilitate urban development and transformation. As the new spatial planning system is being established, transportation planning is faced with opportunities and challenges. On one hand, the integration of transportation planning with land and industrial planning is now under a more favorable environment, which will assist in materializing the synergy between transportation and urban development. On the other hand, the national territory spatial planning at or above the level of city and county is scheduled to be basically completed by 2020. The *Several Opinions* only point out that the guidance and constraints of the new spatial planning of national territory on the planning of each subsystem (e.g., functional areas, transportation, etc.) should be strengthened but do not clearly specify the relationship between transportation planning and spatial planning. Therefore, the positioning of transportation planning should be explored.

Received: 2019-06-24

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1 Transportation planning in previous spatial planning system

1.1 Role of transportation in previous spatial planning system

1.1.1 Brief analysis of previous planning system

In the previous spatial planning system, various types of planning played different roles in the process from planning to implementation. Urban master planning determined the nature of the city and the urban spatial pattern and controlled the nature of urban land use through the zoning controls, such as "four areas and four boundaries". The main purpose of general land use planning was to implement the overall land management policies in a practical and planned way, which adopted a "top-down" approach to control indicators, delineate permanent basic farmland, and manage construction land space in "three borders and four areas", etc. Functional area planning was characterized by the allocation and guidance of production factors.

In the past, the above three types of planning constituted a complete spatial planning process. In summary, the urban planning determined the nature of land use; the land use planning provided the scale of land used for various purposes; the functional area planning guided the industrial development. However, these three types of planning were carried out by different departments and they had different technical features and implementation structures, which often resulted in issues such as duplicates and conflicts in plans and complicated review and approval processes, etc.

1.1.2 Application of transportation functions in urban master plans

Transportation planning plays an important role in the urban master planning system, and the synergy of the two types of planning has basically been achieved. In terms of the planning content, transportation hubs are often emphasized as the important components to define the nature of a city; the urban spatial pattern is often developed based on important transportation hubs and corridors; an urban master plan is required to include the land use boundaries for major transportation facilities (defined through yellow lines) and the right-of-way boundaries for major roads (defined through red lines). In terms of the planning system, transportation planning is also integrated with urban planning (Figure 1), which is defined through a series of regulations and specifications. For example, *Development and Approval Process of Urban Master Plan* proposed that the urban master plan should be developed in parallel with the plans of urban multimodal transportation system and the urban rail transit network; *Standard for Urban Comprehensive Transport System Planning* (GB/T51328-2018) put forward that the development, revision, and evaluation of the plan of urban multimodal transportation system should be carried out simultaneously with the urban master plan.

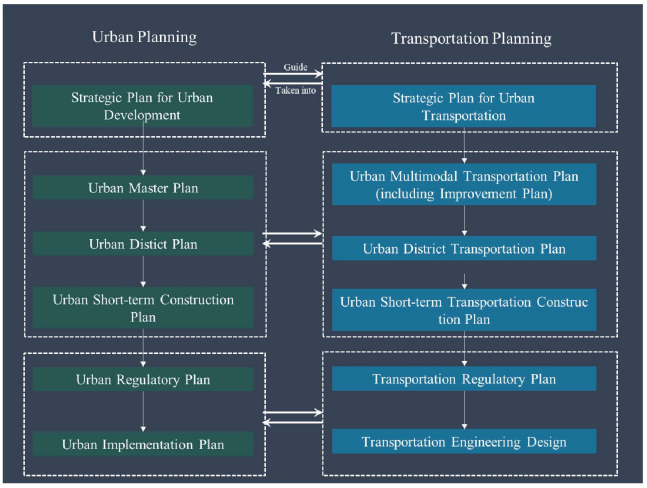

Figure 1 Technology systems of urban planning and transportation planning

In the overall planning of land use, transportation was only represented as a part of the construction land, and in general, there was the lack of research on the interactions between transportation and land use.

Functional area planning was mostly applied at the national and provincial levels with the macroscopic level of land use zoning, and it was limited in the practice at the mesoscopic and microscopic levels such as cities and counties. Although Reference [2] proposed that the development of functional areas should be coordinated with that of the multimodal transportation system, the role of transportation was been clearly defined in the planning system and it was different in different plans. For example, as proposed in the national functional area plan, relevant departments should develop transportation plans separately according to the requirement of the functional area plan. As other examples, the Guangdong functional area plan designated the transportation planning as one of the five strategies, while for Beijing, transportation planning was only specified as one of supporting factors.

1.1.3 Summary

During the "first half" of urbanization in China, urban development was mainly growth-driven, under the condition that there was not much constraint on land resources and not much requirement on the coordination of industries. Transportation worked mainly through coordinating with urban and rural planning. In this process, the technical system serving each stage has been formed. Transportation planning has played its due role in the high-speed development of the economy through the "guidance and introduction" interaction of urban and rural planning. However, as the economy shifts to high-quality development, the urbanization of large cities takes the lead to get into the "second half", which is mainly driven by the development with existing resources. The establishment of a unified spatial planning system of national territory, in turn, requires a more accurate integration of the transportation system.

1.2 Transportation planning in approved urban master plans: cases of Beijing and Shanghai

Although the Urban Master Plans that have been approved by Beijing and Shanghai are not national territory spatial plans, they present some preliminary ideas for the reform of the planning process and have their own significance.

Beijing Urban Master Plan (2016–2035) consists of eight chapters, including 135 clauses. Only five clauses in Section 2 of Chapter 5, titled as "Systematic Measures to Reduce Urban Traffic Congestion", are specific clauses about transportation. However, there are 40 clauses related to transportation in all chapters, accounting for 30% of the whole document. These clauses cover topics such as the development goals, ecological protection, balanced development of urban and rural areas, coordinated land use, and assessment and supervision procedures. In addition, several specific measures are proposed, including the focused development zone along the Second Ring Road, the Tongzhou transportation hub in the subcenter of Beijing, Beijing's new airport targeted for a balanced development of the north and the south, the Beijing–Tianjin–Hebei transportation corridor, etc. These measures clearly reflect the intention to lead urban development through transportation.

Based on the urban master plan for Beijing, *Shanghai Urban Master Plan* (2017–2035) has further improved the style of the master plan and the "connecting" role of transportation planning. It includes a special chapter on transportation and industrial development and discusses the overall transportation layout from the perspectives of international hubs and urban transportation. Throughout the plan, it also highlights the guidance of the transportation system as one of the two principles of spatial layout, along with ecological constraints. The urban and rural areas and public activity centers are all arranged around transportation corridors and hubs. The spatial development strategies of each district set clear development requirements for transportation. In chapters of public service, cultural features, and urban design, enough attention has been paid to the function of transportation in providing service and open space.

2 Urgency of accurately integrating transportation planning into spatial planning of national territory

2.1 Critical period to solve transportation problems at the source

China's economy is in the transition from high-speed development to high-quality development. In large cities, high-quality development is mainly reflected in the following two spatial forms: 1) the "new urbanization" process led by urban agglomeration, with the goal of coordinated development of urban areas, metropolitan areas, rural areas, and large, medium and small cities in the megapolis; 2) the urban development pattern transformed to focusing on the development with existing resources, with the goal of improving the quality and efficiency of urban land use.

In the stage of high-speed economic development, the urban transportation system has been significantly enlarged through large-scale construction to match the urban expansion process. Major transportation corridors and hubs have been built and emerged, which has preliminarily alleviated the issues of large cities, such as traffic congestion. However, in the stage of high-quality economic development, the transformation of urban development pattern will bring more complicated transportation problems. For example, both long-distance travel caused by large-scale movement within an urban, metropolitan or megapolis area and new travel demand caused by the restructuring of industries in central areas could become the source of new transportation problems. Therefore, the transportation system should be accurately planned and integrated with urban space, land use and industrial development to achieve a "smart" development.

2.2 Network effect and development of urban agglomeration

The network effect refers to the phenomenon that the value of a single node and the efficiency of the entire network increase as the number of network nodes or the size of the network increases. The network effect of transportation in the optimization of the national territory spatial pattern is mainly manifested in the following two aspects. 1) Increasing the value of nodes: When cities are integrated into the national and even international transportation networks through external transportation hubs, such as airports, ports and railway stations, the land value around the hubs will grow due to the "stimulating" effect of the transportation system. 2) Network optimization: in the "new urbanization" process represented by metropolitans and megapolises, inter-city travel becomes more frequent and the transportation network integrates large, medium, small cities, and rural areas together, which achieves a more reasonable division of labor and promotes the overall spatial optimization of the urban agglomeration.

In this new era, the development of urban agglomerations has been promoted as a national strategy where the network optimization has a greater impact on urban space and transportation. The newly published *Outline of the Plan for Coordinated Development for the Beijing–Tianjin–Hebei Region* and *Outline Development Plan for the Guangdong–Hong Kong–Macao Greater Bay Area* both take the interconnection of transportation facilities as the most basic and important development strategy, which can be seen as a good and objective understanding of the development rules of urban agglomerations. Guangzhou and Foshan are typical cases of the most developed urban agglomeration in China. With the introduction of the "joint development" of Guangzhou and Foshan, the rail transit between the two cities has evolved from "connecting networks" to "developing one integrated network", which achieved direct connection and high cov-

erage and significantly supported the integration of the two cities.

2.3 Lock-in effect and development with existing resources

The lock-in effect [3] refers to the constraints on infrastructure choices due to the extension of the life of infrastructure investment, and can also refer to the constraints on the overall urban spatial patterns and development models. Transportation facilities have two characteristics. 1) Long service life: The service life of roads and rail tracks can last for decades or hundreds of years. 2) Exclusiveness: Transportation facilities generally occupy a large area, which makes it difficult to build other transportation facilities in the same corridor or zone after structural passages and strategic hubs are built.

Large cities in China have generally entered or are about to enter the era of development with existing (or even reduced) resources. Shanghai has clearly stated that it should "achieve a negative growth of the scale of construction land" [4]. Beijing strives to achieve intensive and efficient land use [5] by improving the quality and reducing the quantity of the land used. The draft of *Spatial Master Plan of Guangzhou's National Territory* (2018–2035) proposes to control the intensity of the land development strictly [6], sets an upper limit on the consumption of land resources, and strictly limits the land development to no more than 30% of urban areas. The lock-in effect of transportation has become increasingly prominent in the development with existing resources. Meanwhile, it has become a crucial and good strategy for large cities to optimize the spatial pattern of national territory by starting from the surrounding areas of transportation facilities. One of the typical cases is the *Guangzhou-Shenzhen Science and Technology Innovation Corridor Plan*. The Guangzhou-Shenzhen expressway shares many common features with the California 101 Highway (Silicon Valley) and the Massachusetts Highway 128 Technology Innovation Corridor, and they are all located in world-famous bay areas. However, the Guangzhou-Shenzhen expressway is not functioning as it is supposed to. Many problems exist along this expressway, such as lack of urban functions, disorder of land use, fragmentation of ecological landscape, and lack of supporting facilities. Through the full understanding of the lock-in effect of the Guangzhou-Shenzhen expressway, the *Guangzhou-Shenzhen Science and Technology Innovation Corridor Plan* integrates the land use type and scale as well as industry development to build a new industrial development zone.

3 Exploration of integrating transportation planning into the draft of *Spatial Master Plan of Guangzhou's National Territory* (2018–2035)

3.1 Take the lead to meet implement the plans of the *Several Opinions*

Guangzhou has always stressed the importance of the coordination of transportation and urban planning. It developed the transportation plan together with and sometimes even in advance of the urban plan to realize the guidance of transportation planning in urban development. The first round of transportation studies in Guangzhou were carried out in 1993, which guided the planning and construction of the inner ring road and alleviated the road congestion problems in the 1990s. The outcomes of significance from those studies were included in the *Guangzhou Urban Master Plan* developed in 2000. The second round of multimodal transportation planning was initiated in 2006. It proposed to use expressways and rail transit as the "skeleton" of the transportation system. This well supported the expansion of urban space, and relevant outcomes were incorporated into the *Guangzhou Urban Master Plan* that was simultaneously developed.

Under the guidance of the Ministry of Natural Resources of the People's Republic of China, Guangzhou took the lead in piloting the spatial master planning of national territory in the country since November 2018. In June 2019, the draft of *Spatial Master Plan of Guangzhou's National Territory* (2018–2035) was published. Guangzhou has fully realized that the transportation system not only takes the largest part of national territory space and connects closely to other land space but is the most powerful driving force of urban development by promoting people mobility. Based on the *Several Opinions*, the transportation planning of Guangzhou imposed strategic, scientific, coordinated, and operational requirements on the master plan and carried out exploratory studies in the areas of organizational methods, technical concepts, and expression forms.

3.2 Follow the tradition to develop the transportation plan simultaneously with the urban master plan

The pilot project to develop the spatial master plan of Guangzhou's national territory followed the tradition of conducting transportation studies simultaneously with the development of the urban master plan. In the form of developing Guangzhou's new transportation strategic plan, 13 well-known research institutions were invited to conduct 11 special studies to support the development of the main report. These special reports were approved by a group of national experts in December 2018, at the beginning of the development of the spatial master plan of national territory.

The special studies selected 11 topics deliberately (see Figure 2), with the following characteristics: 1) integrating the intention of urban development with the development strategies of the national transportation network and inviting design units of specialized departments to participate in the planning of large strategic transportation facilities of air, shipping, and railway; 2) considering the lock-in effect of transportation on national territory space and carrying out studies on the coordination of public transportation and land use, the coordination of transportation with production space, living space and ecological space, etc.; 3) carrying out studies

on transportation big data, new technologies, etc. in order to refresh transportation planning with science and foresight; 4) ensuring the feasibility of transportation projects, carrying out studies on assessment and consultation, and funding sources for construction, investment strategies, etc.

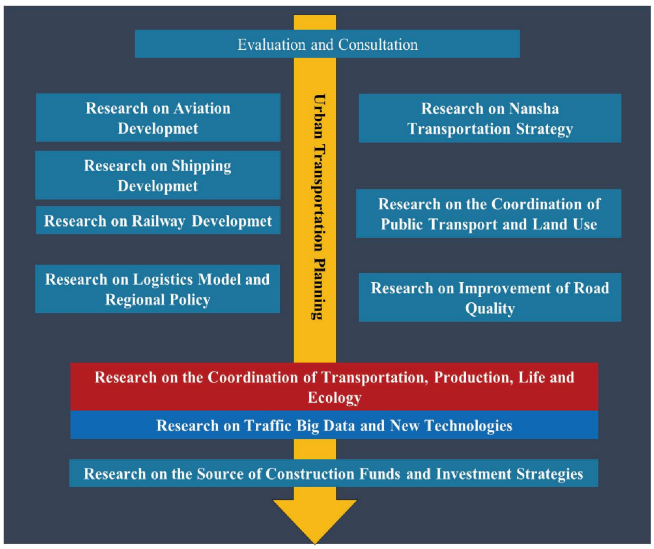

Figure 2 Eleven special research areas in Guangzhou's new-round planning of transportation development strategies

After the completion of the special studies mentioned above, the outcomes of these studies were timely integrated with Guangzhou's situations through a team with abundant local knowledge. Based on Guangzhou's travel demand model that has been well maintained, strategic alternatives were compared and analyzed. A comprehensive planning report of transportation strategies was developed, and relevant outcomes were incorporated in the spatial master plan of national territory.

In Guangzhou, there is a good interaction between the transportation development strategy and the spatial master plan of national territory. With Guangzhou–Zhongshan–Zhuhai–Macao high-speed railway as an example, the transportation strategic plan first identified the issue that the west side of the Greater Bay Area lacked the support of high speed rail. Moreover, it proposed to build the Guangzhou–Zhongshan–Zhuhai–Macao high-speed railway to promote a balanced development between the west and the east sides of the Pearl River. On the other hand, the spatial master plan of national territory immediately included the Guangzhou-Zhongshan-Zhuhai-Macao high-speed railway into the urban space of Guangzhou and reserved the corridor according to the route proposed in the transportation strategic plan—from Knowledge City to Nansha District via the urban center.

3.3 Integrate the development and protection functions of transportation planning

It is crucial to promote the protection of the ecology and civilization through the spatial planning of national territory. The draft of *Spatial Master Plan of Guangzhou's National Territory* (2018–2035) fully recognizes the positive role of transportation in ecology and civilization protection and believes that protection is equally important as development. It puts all development related contents into the chapter dedicated for transportation, and the protection related contents are scattered throughout the entire document.

The protection functions of transportation planning can be classified as passive protection and active protection. The passive protection is materialized as the active yield of transportation. The red lines for ecological protection areas, the red lines for permanent farmland, and the boundary of urban development in the national territory spatial plan are strict control lines. Their original intention is to implement the national security strategies, including those for ecology and food security [7]. In the spatial planning of national territory, the "active yield" of transportation facilities is achieved through spatial coordination and positive list, etc.

The active protection reflects a deeper understanding of transportation's role in optimizing the spatial pattern. Guangzhou is featured with fragmented construction and ecological land. Under the condition of development with existing resources, the optimization of the national territory space is conducted in areas that have been developed, so it is an inevitable choice to concentrate construction land to areas with high transportation accessibility. The draft of *Spatial Master Plan of Guangzhou's National Territory* (2018–2035) explicitly proposed to increase the land supply and the development intensity in areas around rail transit stations in chapters like Urban Renewal, Residential Land Optimization, and Industrial Layout Adjustment, so as to centralize the construction land and change the existing fragmented pattern of land use.

3.4 Explore the way to express transportation planning

In accordance with the requirements of the *Several Opinions* for simplifying the process of planning approval, the draft of *Spatial Master Plan of Guangzhou's National Territory* (2018–2035) classifies the authority over transportation planning into several groups and levels (see Figure 3). It also explores the way to express transportation planning.

The way to express transportation planning was divided into four categories in this master plan. The first two categories reflect the spatial layout and coordinate with spatial structure and control lines determined by the plan. The first category is used for major cross-region and cross-sector linear transportation projects such as railways and highways, which play a crucial role to support and shape the urban space. Structural control should be applied to these projects, and schematics were explored to present them as transportation corridors. The second category is the control of boundaries. The land for major transportation facilities such as airports and ports were reserved within the urban development

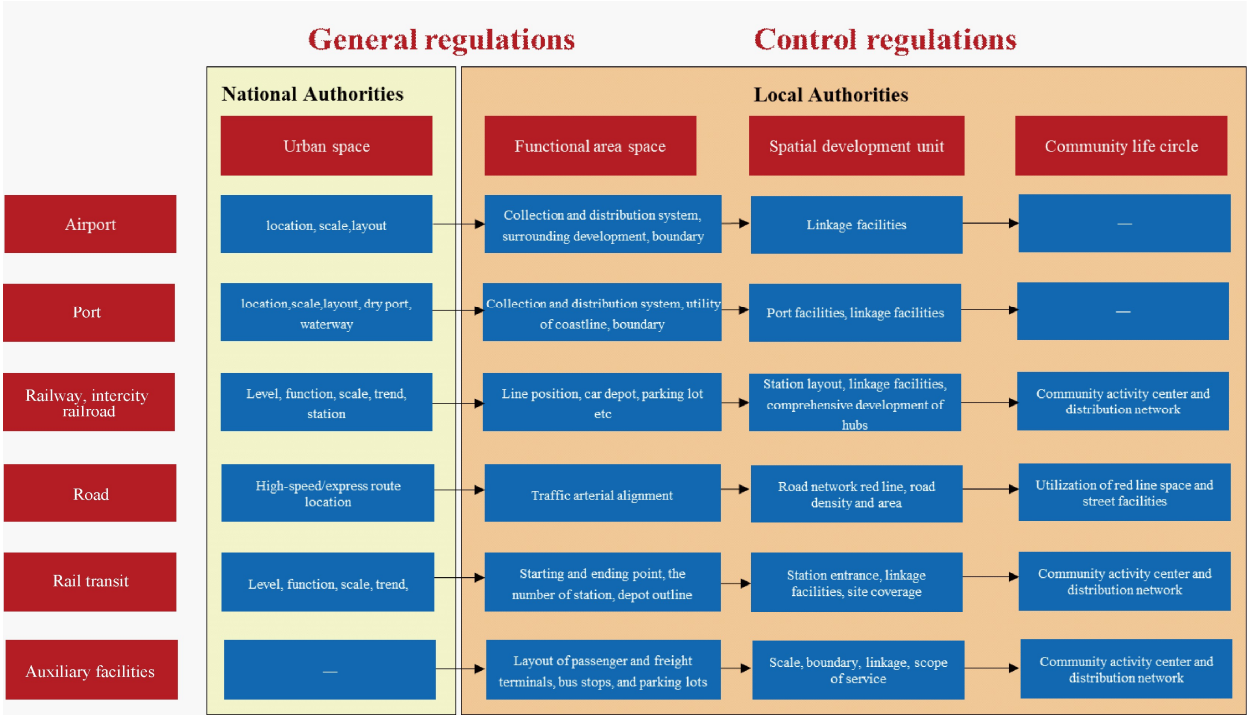

Figure 3 Division of authority over transportation planning

boundary to avoid the conflict with the ecological and agricultural space.

The third category is about space use, which mainly reflects new planning concepts and stresses on establishing relevant institutional mechanisms through text control. For example, the requirements on the refined road design havebeen proposed to reflect the new concepts and technologies obtained through Guangzhou's urban road planning practices in recent years, which include the following: I. A unified management system of streets and municipal roads should be established to protect the road pattern of historic urban areas. II. Travel demand should be studied at the parcel level, and small interchanges and tunnels can be used to efficiently serve short-distance trips. III. Street elements should be designed from the perspective of road users, and road space should be optimized by taking advantage of small-scale transformations.

The fourth category reflects the continuous monitoring and management of space use, which works in the form of index control. These indices are integrated into the monitoring, evaluation, warning and management system of national territory space, which supports the implementation, evaluation, routine management, and monitoring of transportation plans. The transportation indices can be adjusted along with the assessment, which can be divided into three types: assessment indices, monitoring indices, and development objectives.

4 Conclusion

The spatial planning of national territory system has been established preliminarily. For the period from now to 2025, it is the time to explore and improve the regulations, policies, and technical standards of the spatial planning of national territory. To fully utilize the network effect and the lock-in effect of transportation systems and to optimize the national territory spatial layout, we should make sure that transportation takes the initiative and integrate transportation planning into the "new" policy and technical system. The practical experience gained in the development of the draft of *Spatial Master Plan of Guangzhou's National Territory* (2018–2035) can be summarized into the following two aspects: 1) Transportation planning should be conducted simultaneously with spatial planning of national territory, and they should maintain active interactions. 2) A professional, efficient, and dynamic maintenance system should be established to ensure the sustained effectiveness of transportation plans.

In this new situation, effective theoretical support is lacking when transportation planning is integrated with spatial planning of national territory. Therefore, it is suggested to strengthen the following two aspects of research. First, the integrated model of transportation and land use (production space, living space and ecological space) under the constraints of national territory resources should be studied and developed in order that the "guidance" role of the transportation system can be fully played. Second, policy researches for the spatial planning of national territory system should be conducted to ensure that new technologies and methods can receive feedback quickly and to promote the self-renewal of the urban planning system.

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(Translated by Ma XY)