Citation: JING Guosheng, HUANG Rongxin, XIE Zhiming. Innovative Practice of Urban Express Rail Lines in Guangzhou [J]. Urban Transport of China, 2020 (01): 18–23, 11.

Innovative Practice of Urban Express Rail Lines in Guangzhou

JING Guosheng, HUANG Rongxin, XIE Zhiming

Guangzhou Transport Planning Research Institute, Guangzhou 510030, Guangdong Province, China

Abstract: To meet the demand for development from the Greater Bay Area of Guangdong-Hong Kong-Macao in the new era, the rail transit network must adapt to the situation characterized by the travel need of high frequency and high speed between cities and shift the focuses from the maximizing service coverage to high service efficiency in order to optimize the development planning of public land use. By examining the three development stages described as the space extension, urban-rural integration, and hub-type network layout, this paper summarizes the achievements and inadequacies of Guangzhou urban express rail service. The paper then suggests the future key improvement of accelerating the development of the Bay Area railway and urban express rail service (above 60 km) as well as Line A (above 400 km). These developments can promote the innovative service connection among and between the national railway lines, inter-city rail lines and urban rail transit lines and successfully integrate the three networks, which helps to meet the Guangzhou travel demand around the Greater Bay Area and inside the metropolitan area. **DOI:** 10.13813/j.cn11-5141/u.2020.0103-en

Keywords: transportation planning; urban express rail transit; the Bay Area railways; public land use planning; integration of the three networks; Guangdong-Hong Kong-Macao Greater Bay Area; Guangzhou

0 Introduction

With the rapid advancement of urbanization in China, the development of big cities has gradually broken regional limits, transforming these big cities into metropolitan areas and urban clusters with the urban commuting circle being expanded rapidly [1]. The *Guidelineson the Cultivation and Development of Modern Metropolitan Areas* (No. 328 of Development and Reform Plan [2019]) put forward the idea of "building the metropolitan area on the rail". Rail transit plays an important role in strengthening the influence of central cities and guiding the healthy development of industrial economy and land space in metropolitan areas [2]. Under the dual requirements of long-distance travel and large-scale passenger flow, the urban express rail line arises at the historic moment and develops rapidly. In the new round of planning and revision of rail transit network in major cities of China, urban express rail lines have become the key research topic, accounting for 30%–50% of the total mileage of the rail network [3–4].

As one of the cities that planned and constructed the urban rail transit network in advance, Guangzhou started early in the planning, design, and operation of urban express rail lines [5–8]. This paper summarizes the practices and results over the past 20 plus years, analyzes the new development requirements of the Guangdong-Hong Kong-Macao Greater Bay Area, and proposes a new development direction of urban express rail lines, which is to build an urban rail transit network with improved hierarchy. This new development direction will be of great significance to improve Guangzhou's core competency and its influencing and leading role.

1 Practice of urban express rail lines in Guangzhou

From the perspective of the role of urban express rail lines in the rail transit network, Guangzhou has gone through three development stages (see Figure 1), with obvious functional and technical characteristics in each stage.

1.1 Urban space expansion—operation mode of regular lines

In 2000, Panyu and Huadu were merged into Guangzhou as two administrative districts. For the adaptation to the expansion of urban space layout, seven urban rail transit lines with a length of 206 km were planned to implement the spatial development strategy of Guangzhou. The rail transit mode in this period was mainly characterized as "urban rail transit lines + national regular railways".

Received: 2019-06-28

First author: JING Guosheng (1971–), male, from Linyi, Shanxi Province, master's degree, professor-level senior engineer, director, is mainly engaged in the research on comprehensive transportation planning. E-mail: 1049319342@qq.com

In 2005, Guangzhou Metro Line 3 became the first urban express rail line that went into operation in China with the design speed of 120 km·h^{-1}. The planning of this metro line adopts large station spacing to provide fast connection with the four development groups (Baiyun, Huadu, Tianhe, and Panyu) and major external transportation hubs such as Baiyun International Airport and Guangzhou East Railway Station. Its function is to carry daily commuter flow and to collect and distribute passenger flow for external transportation hubs. The total length of Metro Line 3 is about 68 km, with an average daily passenger volume of over 1 million persons·d^{-1}, the peak section passenger flow up to 49,000 persons·h^{-1}, and the passenger load factor over 130% [9].

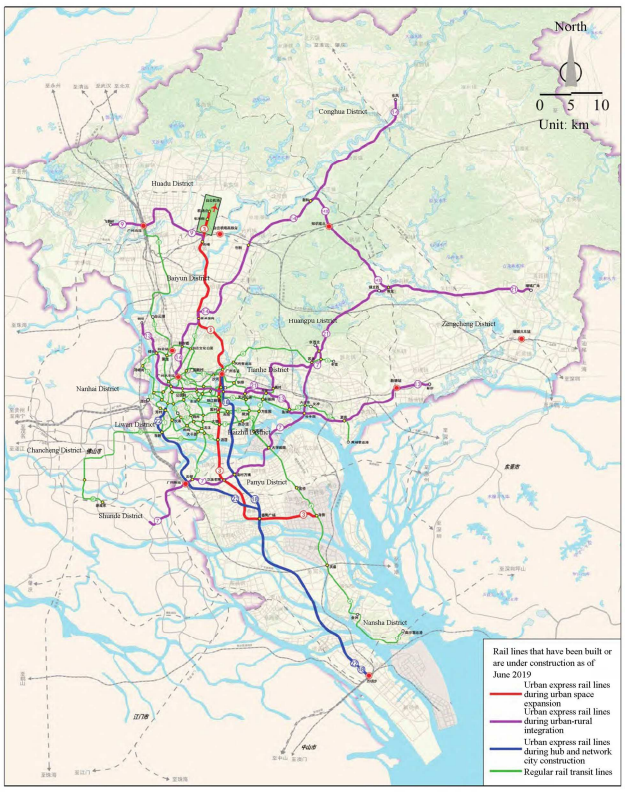


Figure 1 Development of Guangzhou urban rail transit network

Resource: Reference [7].

Due to some historical and objective reasons, Guangzhou Metro Line 3 was not built according to the plan. For example, the station spacing is not large enough. It is only 1.5 km in the central area and about 3 km in the peripheral areas. This metro line adopted the operation mode of stopping at each station, showing little difference from ordinary subways. It failed to give full play to the expected function of the urban express rail line and failed to meet the needs of rapid communication between development groups.

1.2 Urban-rural integration period—operation mode of express and regular lines

In 2010, Guangzhou advanced to the integration of urban and rural areas, and the urban spatial structure was adjusted to "one central area and six sub-centers". In order that the rapid connection between the sub-centers and the central area can be strengthened, a rail transit network with the layout of "loop + radial" was constructed, and 21 rail transit lines with a length of 905 km were planned. The rail transit loop connects important functional nodes and large transportation hubs in the central area and connects with about 70% of the urban rail lines, which effectively reduces the transfer pressure of the downtown transit network. Radial lines are used to strengthen the connection between the central area and various districts. At the same time, the intercity railway network is used to connect with neighboring cities. The rail transit mode in this period was characterized as "urban rail transit lines + intercity railways + national railways".

The urban express rail lines with the design speed of 100–120 km·h^{-1}, such as Metro Lines 14 and 21, constitute the skeleton of the rail transit network in Guangzhou. The operation mode of express and regular lines is adopted to enrich the operation organization, so as to achieve the planning objectives of a denser rail transit network with faster, broader, and better service. With Metro Line 14 as an example, it is a radial line from the central area of Guangzhou to the northeast area with the focus to support the development of peripheral areas such as the Conghua sub-center. The total length is about 93 km. The design speed is 120 km·h^{-1}, and the average station spacing is 4.4 km. In 2018, the first phase of the urban express rail line from Dongfeng Station to Jiahewanggang Station in the peripheral areas was open. It has a total length of about 54 km and adopts the operation mode of express and regular lines, in which the express line stops at five stations with the total travel time of 38 min. From Jiahewanggang Station to Guangzhou central area, passengers need to transfer to Metro Line 2 or 3, and the whole trip takes at least 75 min, namely that the direct and rapid connection between Guangzhou central area and Conghua District has not been realized. At the same time, after Jiahewanggang Station was connected to the first phase of Metro Line 14, the daily transfer volume increased from 160,000 passengers per day to 250,000 passengers per day, with a growth of 56%. In the peak hours, the inbound passengers who transfer to Metro Line 3 account for 35% of the total passenger flow of Line 3, putting the already-saturated Line 3 (the section from Yantang to Guangzhou East Railway Station) on its extreme capacity and making this section the weakest link of the Guangzhou metro network.

1.3 Hub and network city period—high-standard, rapid and direct rail transit

In 2016, Guangzhou defined the development goal of building a hub and network city and started to establish and optimize the multi-center and cluster network space along the rivers. The revision emphasis of rail transit network was to support and lead the construction of three international strategic hubs and sub-centers. At the same time, it paid attention

to the extension and connection to neighboring cities. The urban express rail line is one of the key topics, which is being studied at present.

Nansha, as the only sub-center of Guangzhou, is 60 km away from the central area of Guangzhou. The traditional urban express rail line (the design speed is 100–120 km·h^{-1}) is not competitive with cars in terms of travel time, and it cannot meet the connection requirements. In order to better support the integration of Nansha into the Greater Bay Area, Guangzhou proposed to build a new metro line (Metro Line 18) to connect Tianhe, Haizhu, Panyu, and Nansha districts, which will achieve 30 min travel between Nanshan and Guangzhou East Railway Station. The total length of Metro Line 18 is 60.8 km, with nine stations and an average station spacing of 7.6 km. Metro Line 18 uses 8-car municipal trains with the maximum speed of 160 km·h^{-1}. It adopts the operation mode of express and regular lines: The train stops at five main stations with the travel time of 30 min in the express mode and stops at each station with the travel time of 43 min in the regular mode. The construction of this line has started in 2017, and it is scheduled to open in 2022. At the same time, the possibility to extend to Qingyuan and Zhuhai districts is reserved.

2 Trend of transportation demand in the Greater Bay Area era

In the new era, China and Guangdong Province have put forward new requirements on Guangzhou's urban functional positioning and spatial development pattern. As the core development engine of the Guangdong-Hong Kong-Macao Greater Bay Area, Guangzhou needs to further study the transportation development trend and existing deficiencies at the regional level.

2.1 To meet high-frequency and large-scale intercity travel needs

In the future, the economic scale of the Guangdong-Hong Kong-Macao Greater Bay Area will continue to increase, and an integrated and complementary modern industrial system will gradually take shape. Cities are becoming more and more socially and economically connected, and cross-border business and commuting travel demand will rise dramatically. City centers, adjacent areas, and major transportation hubs such as airports and railway stations will become new growing points of passenger demand. The characteristics of intercity transportation connection and service requirements are approaching those of urban transportation.

For example, the "six cities and two districts" around the Pearl River Estuary in the Guangdong-Hong Kong-Macao Greater Bay Area include Guangzhou, Foshan, Zhongshan, Zhuhai, Dongguan, Shenzhen, Hong Kong, and Macao. It is predicted that in 2025, the total intercity travel demand of this area will be 12.7 million persons·d^{-1} (see Figure 2), which is about 2.2 times that in 2016. The daily one-way passenger flows of the Guangzhou-Dongguan-Shenzhen and Guangzhou-Foshan corridors will be 1 million persons·d^{-1}, and that of the Guangzhou-Zhongshan-Zhuhai corridor will be over 300,000 persons·d^{-1}. Among them, the proportion of commuter passenger flow between Guangzhou and Foshan will grow from 20% in 2016 to 30%–35% in 2025, which will realize the integration of Guangzhou and Foshan at a higher level.

2.2 To meet direct connection between different urban centers

For the integration of the Greater Bay Area, the core functional areas of various cities should first form an organic whole. At present, Guangzhou central area is lacking a fast and direct access to other urban centers in the Greater Bay Area: High-speed railways and intercity railways only connect to Guangzhou South Railway Station, which is located in the periphery of Guangzhou. Forty-five percent of

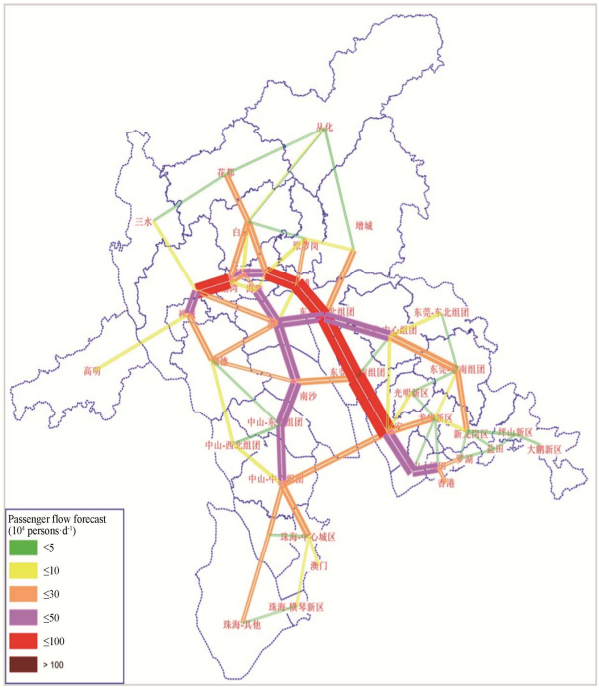
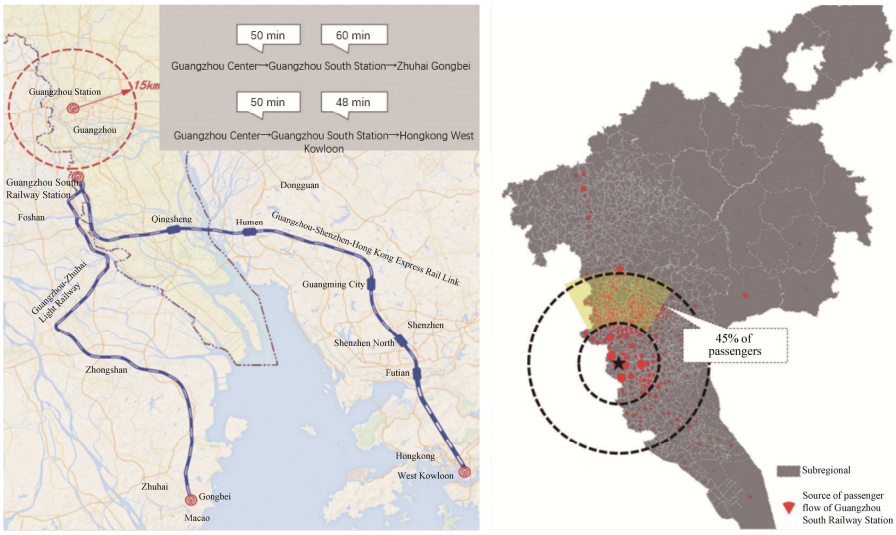


Figure 2 Passenger flow corridor of "six cities and two districts" around the Pearl River Estuary of the Guangdong-Hong Kong-Macao Greater Bay Area in 2025

Resource: 2018 Public Transportation Development Plan of the Metropolitan Area of Pearl River Estuary (2016—2025).



a. Rail transit lines connected to Guangzhou South Railway Station

b. Spatial distribution of passenger sources of Guangzhou South Railway Station

Figure 3 Connection between Guangzhou central area and the major urban centers of the Greater Bay Area

Resource: Reference [8].

passengers at Guangzhou South Railway Station are coming from or going to Guangzhou central area. They travel by the regular urban rail transit, and the travel time is usually more than 50 min, which often exceeds the intercity travel time. Therefore, the travel time between Guangzhou central area and the major urban centers of the Greater Bay Area, such as Shenzhen, Hong Kong, Zhuhai, and Macao, is at least 1.5 h (see Figure 3), which cannot meet the need for the one-hour travel circle in the Greater Bay Area.

2.3 To meet the integration needs of high-speed railway network, intercity railway network and urban rail transit network

The planning and construction of national railways (including high-speed railways), intercity railways, and urban rail transit (including urban express rail lines) are important measures to realize fast and convenient connection at different spatial scales, such as urban agglomerations, metropolitan areas, and city-level spatial organizations. To realize the three-network integration and improve the overall transportation efficiency of the rail network, we should promote the connection and convenient transfer among different rail modes.

However, some deficiencies were discovered in practice. It was found that the three networks failed to merge and they even squeezed each other. The rail planning of the important north-south development corridor in the east of Guangzhou is taken as an example. From the perspective of the development needs of the Greater Bay Area, the ring line of Guangzhou-Foshan intercity railway needs to be constructed in this corridor, with a design speed of 160 km·h^{-1}. This railway line is currently under construction. It will connect various important groups in Guangzhou and Foshan and effectively organize and operate the 2 000 km intercity network in the Greater Bay Area. From the perspective of the urban internal development needs, many key functional areas are distributed along this corridor, such as the business district of Guangzhou South Railway Station, the Zhujiang New Town-Financial Center-Pazhou CBD, and the airport economic zone. It is urgent to plan and build high-capacity and high-speed direct rail transit to support efficient connection in this corridor. Limited by the technical standard, system, and mechanism of the Guangzhou-Foshan intercity railway, it is difficult to add urban express rail lines in this corridor. Therefore, the need for convenient connection between important groups in this corridor cannot be met.

3 Proposals for layout of urban express rail lines in Guangzhou

Urban express rail lines should be taken as the starting point to reconstruct the rapid rail transit network composed of national railways, intercity railways and urban rail transit. They should also be used to establish the deeply integrated network of Guangzhou-Foshan, multiple passages between Guangzhou and Dongguan, as well as the rail transit connection system to access other urban centers.

This paper especially proposes to accelerate the planning and development of the Bay Area railways and the urban express rail line A, improve the hierarchical layout of the rail transit network, and form a multi-mode deep-integrated rail transit system to meet the rail transit travel needs at different levels (see Table 1). Bay Area railways include national railways and intercity railways, and the emphasis is to extend them to downtown Guangzhou. The urban express rail line A is positioned as a fast connection among Guangzhou central area and sub-centers, peripheral areas, and neighboring cities, with a design speed of more than 160 km·h^{-1}.

Table 1 Hierarchical layout of Guangzhou rail transit network

Level	Composition	Functional positioning	Design speed (km·h^{-1})	Travel speed (km·h^{-1})	Service scope (km)
National railway	National high-speed railway	To provide cross-regional high-speed passenger travel services in major and medium-sized cities across the country	200–350	160–280	≥100
Intercity railway	Intercity railway	Located within the urban agglomeration, intercity railways provide rapid rail transit connections between cities. Their key function is to connect	160–200	≥100	≥100
Urban rail transit (urban express rail line + regular line)	Urban express rail line A	To provide high-speed or rapid connection among the central area and sub-centers, peripheral areas, and neighboring cities	≥160	≥80	≤100
	Urban express rail line B	To provide rapid connection among the central area, sub-centers, and peripheral areas	100–140	45–80	≤50
	Regular rail line	To densify the railways inside the central area and its megalopolis or serve as a stand-alone railway network in sub-centers and peripheral areas	80–100	35–45	≤30

Resource: Reference [7].

3.1 Improving high-speed railway and intercity railway networks with Bay Area railways

Based on the stronger cooperation between Guangzhou and other cities in the Guangdong-Hong Kong-Macao Greater Bay Area, the layout of hubs in the Greater Bay Area should be promoted from "a group of hubs" to "an integrated transportation hub" to improve the service capacity of the large-scale transportation hub to a higher level. The Bay Area railway lines should coordinate with national railways and intercity railways (see Figure 4). They mainly include the connection line between Guangzhou South Railway Station and Guangzhou Railway Station on Guangzhou-Shenzhen-Hong Kong High-speed Railway Line, the III and IV lines between Guangzhou Railway Station and Guangzhou East Railway Station, and the V and VI lines between Xintang Station and Guangzhou East Railway Station on Guangzhou-Shantou High-speed Railway. These railway lines are more than 60 km long. They will make it possible for high-speed railways and intercity railways to access to Guangzhou central area and will promote rapid and direct transportation between Guangzhou central area and other major city centers in the Bay Area.

3.2 Organizing key functional areas with urban express rail line A

A new round of Guangzhou spatial structure will be in the form of the urban and rural spatial network system of "central area–sub-centers–peripheral areas–new towns–rural areas" [10]. The focus of transportation is to rely on high-speed or rapid rail transit to realize the interconnection or even direct connection among the central area, sub-centers, and peripheral areas. The goal is that it should take less than 30 min to travel between the central area and sub-centers or between the central area and peripheral areas and take less than 60 min to travel between sub-centers and peripheral areas or between peripheral areas. At the same time, the convenient rail transit connection between Guangzhou and neighboring cities should be strengthened.

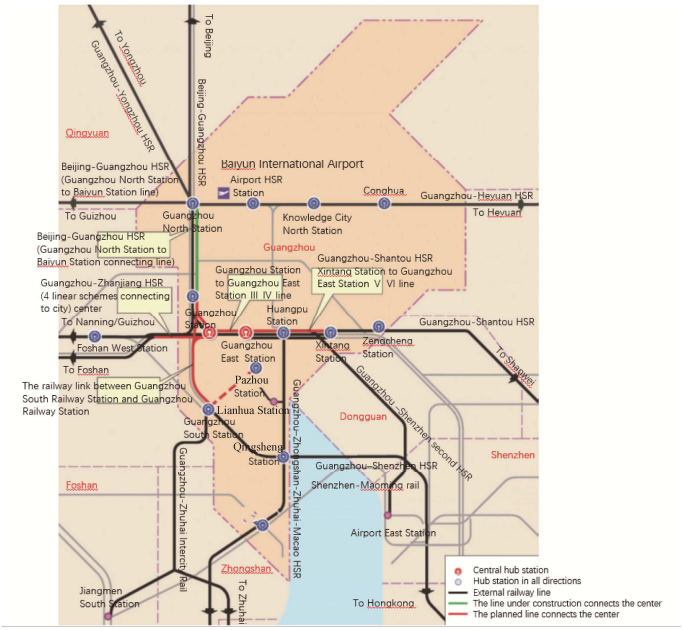


Figure 4 Railway planning in Guangzhou Bay Area

Resource: Reference [8].

The boundary of Guangzhou is as far as 100 km away from Guangzhou central area. Within this boundary, the focus is to build the urban express rail line A to actively coordinate with national railways, intercity railways, and urban regular rail lines. The goal is that the railway lines should be aligned better with the urban spatial corridor, and stations should be highly coupled with urban functional areas. Guangzhou central area is the core of the integrated development of Guangzhou urban space, so the urban express rail line A should be connected to or run throughout Guangzhou central area. The plan proposes five urban express rail lines A, such as Guangzhou-Conghua Express Line and East-West Express Line (see Figure 5). These urban express rail lines are more than 400 km long and will realize the high-speed or rapid connection of Guangzhou central area with important urban groups and neighboring cities.

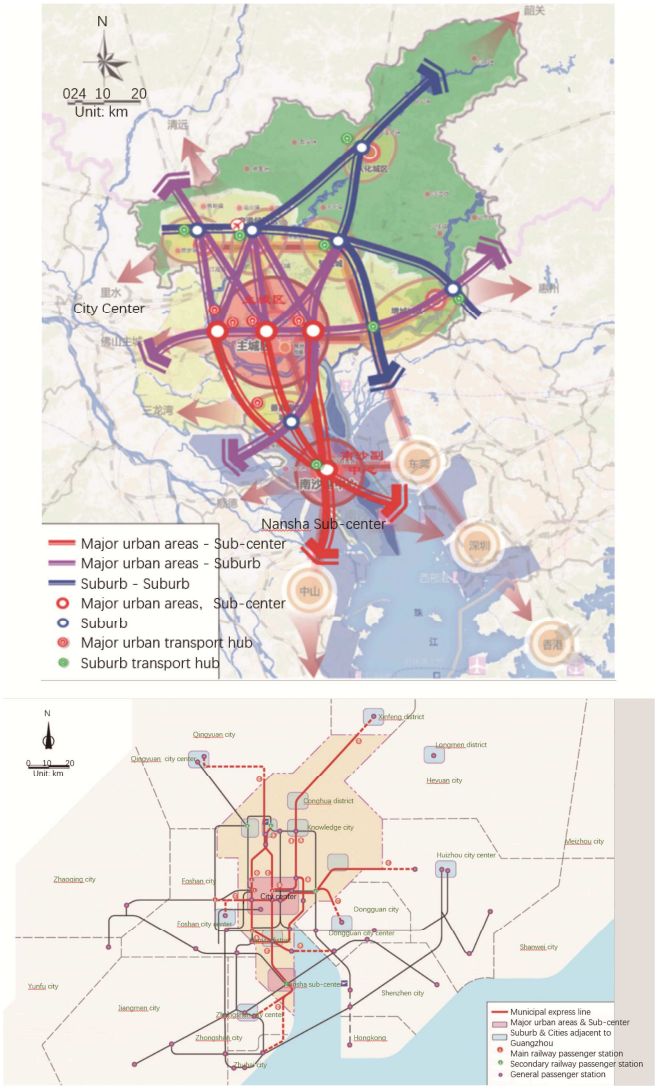


Figure 5 Analysis of express rail transit line A based on Guangzhou urban spatial layout

Resource: Reference [7].

3.3 Strengthening application of "multi-track on one corridor" rail transit mode

The multiple-use of rail transit corridors should be given more emphasis to meet more passenger demands with less transportation land resources. With the planning of the East-West Express Rail Transit Corridor in Guangzhou as an example, this corridor is about 80 km long and connects major passenger hubs such as the Foshan central area, Guangzhou central area, Pazhou Internet Innovation Cluster, Gualv New Town, and Foshan West Railway Station. It is predicted that the cross section passenger flow for the Fangcun-Yuzhu section in both directions can reach 35,000 persons·h^{-1}, and it has obvious morning and evening peaks. Considering multiple functional requirements of the districts along the corridor, such as different functional positioning and rapid regional connection, it is proposed to build the urban express rail line A and the regular rail transit line on the same corridor. In addition, it is proposed to use the rail transit mode of "four parallel tracks" to build the middle section between Fangcun and Yuzhu (see Figure 6, which is only one of the alternatives in the planning of the East-West Express Rail Transit Corridor). The design speeds of the urban express rail line A and the regular rail transit line are 160 km·h^{-1} and 100 km·h^{-1} respectively, which can meet the passenger flow needs with different functions at different levels and can improve the overall rail transit service level along the corridor.

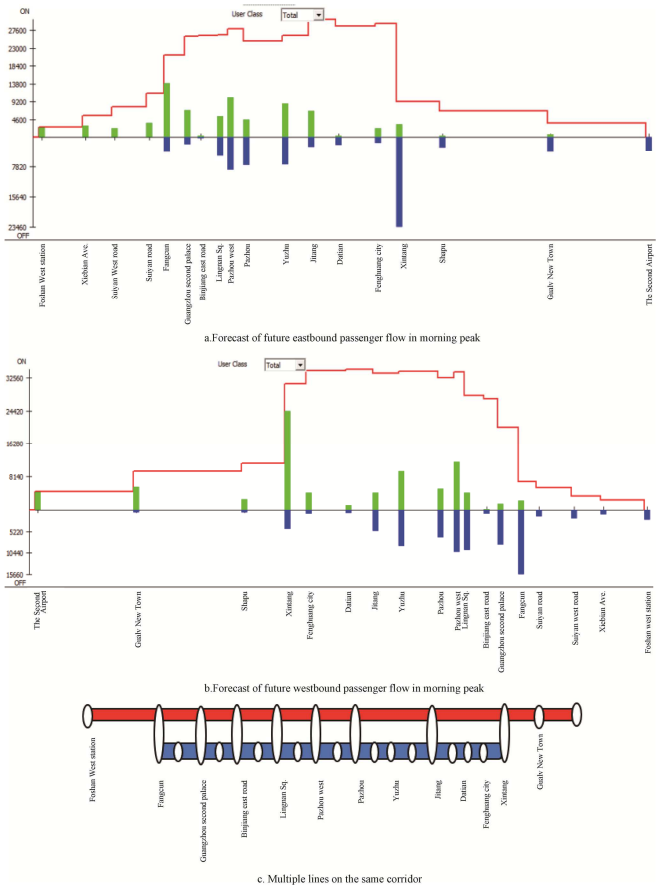


Figure 6 Planning of shared corridor of express rail transit line A and general rail transit lines

Resource: Reference [8].

3.4 Innovating operation and management of rail transit and building urban express rail transit mode suiting Guangzhou

In October 2017, Guangzhou Rail Transit Industry Alliance was established. It regularly organizes annual conference on innovation and development of rail transit and promotes the operation and management of rail transit into a new stage. In the near future, Guangzhou Metro Company will undertake the operation and management of some intercity railways, which will make the coordination and integration of intercity railways and urban rail transit more flexible and will improve the integrated rail transit service to a new level. It is suggested to take this opportunity to further

explore the construction of one rail transit network by integrating national railways, intercity railways, and urban rail transit, to connect Guangzhou central area and the central areas of neighboring cities such as Foshan, Dongguan, Zhongshan and Qingyuan, to promote the unified ticketing system, and to provide one-stop security service for national railways, intercity railways, and urban rail transit.

In addition, the core of public transportation priority is to ensure the diversity of supply and to respond accurately to demand. It requires a city to start from its own needs and capabilities to find a healthy or irreplaceable development model. Generally speaking, the urban express rail line has high technical standard, high cost, low passenger flow, and low unit output, so Guangzhou needs to establish an urban express rail line model that suits its own development needs.

4 Conclusion

Clarifying the functional and technical characteristics of national railways, intercity railways, and urban rail transit (including urban express rail line) and building a rail transit system that integrates these three railway networks would promote Guangzhou's development and meet its needs for efficient service in a broader space. At the Bay Area level, this paper put forward the concept of Bay Area railways and proposed to improve the national railway network and the intercity railway network to address the separation issue between them. At the city level, the paper proposed to strengthen the layout of urban express rail lines A and to strengthen the deep integration of different levels of rail transit. In addition, the paper suggested to pay more attention to the construction mode of one corridor shared by multiple tracks, including national railways, intercity railways and urban rail transit, strengthen the regional integrated operation of the rail transit network, and integrate the policies on the planning, construction, and operation of rail transit.

References

[1] Jing Guosheng, Huang Rongxin, Xu Shiwei, et al. Rail Transit System Development Strategy of Guangdong-Hong Kong-Macao Greater Bay Area [J]. Urban Transport of China, 2019, 17(3): 67–74 (in Chinese).

[2] Zhou Zhihua, Jing Guosheng. Guangzhou Transportation Development Strategies for 2035 [J]. Urban Transport of China, 2019, 17(1): 8–13 (in Chinese).

[3] Chenxiaoli, Zhou Gaoyao, Deng Liangjun, et al. 对杭州城市轨道快线发展的思考[C]//中国城市规划学会. 共享与品质:2018 中国城市规划年会论文集(06 城市交通规划). Beijing: China Architecture & Building Press, 2018: 531–541 (in Chinese).

[4] Zhang Pei, Wang Chaoshen. Causes Analysis to the Development Restriction of Regional Rapid Railways in China's Metropolitan Area [J]. Urban Problems, 2017(11): 25–32 (in Chinese).

[5] Guangzhou Transport Planning Research Institute. 广州市轨道交通线网规划方案 [R]. Guangzhou: Guangzhou Transport Planning Research Institute, 2003 (in Chinese).

[6] Guangzhou Transport Planning Research Institute. 广州市轨道交通线网规划修编 [R]. Guangzhou: Guangzhou Transport Planning Research Institute, 2014 (in Chinese).

[7] Guangzhou Transport Planning Research Institute. 广州市轨道交通线网规划修编 [R]. Guangzhou: Guangzhou Transport Planning Research Institute, 2017 (in Chinese).

[8] Guangzhou Transport Planning Research Institute. 广州市交通发展战略规划(在编稿) [R]. Guangzhou: Guangzhou Transport Planning Research Institute, 2018 (in Chinese).

[9] Jing Guosheng, Ma Xiaoyi, Zhou Zhihua, et al. 2017 广州市交通发展年度报告 [R]. Guangzhou: Guangzhou Transport Planning Research Institute, 2018 (in Chinese).

[10] Guangzhou Municipal Planning and Natural Resources Bureau. 广州市国土空间总体规划(2018–2035)(草案公示) [R]. Guangzhou: Guangzhou Municipal Planning and Natural Resources Bureau, 2019 (in Chinese).

(Translated by JING GS)

