Exploring the Development Trend of Ports in the Guangdong-Hong Kong-Macao Greater Bay Area (GBA) Based on the Intermodal Transport Development of Guangzhou Port

Haoran Xiong*

College of Engineering, Ocean University of China, Qingdao, China

*Corresponding author: xhr2100@stu.ouc.edu.cn

Abstract. Nowadays, multimodal transport is developing rapidly, but the individual ports in the Greater Bay Area (GBA) have been operating separately. In this paper, the development status of multimodal transport in Guangzhou port will be used as an example to discuss the development trend of GBA ports. The study found that the multimodal transport model of the Port of Guangzhou has taken shape. However, there are still many shortcomings with old facilities, difficulties in sharing data, and a lack of unified management, which are common to all ports in the GBA. This paper aims to provide ideas for the direction of port development in GBA, hoping to enhance intermodal transport to connect the ports, improve the efficiency of freight transport and promote the formation of a unified dispatch centre for GBA ports. As a result, it is hoped that the GBA Port Management Committee will be built to achieve more efficient management.

Keywords: Guangzhou port; Guangdong-Hong Kong-Macao Greater Bay Area; Intermodal Transport.

1. Introduction

In 2019, the Chinese Government issued the Outline of the Development Plan for the Greater Bay Area (GBA) of Guangdong, Hong Kong and Macao. According to the Outline, the GBA should be not only a vibrant world-class city cluster, an international center for science and technology innovation, essential support for the construction of "One Belt, One Road", and a demonstration zone for in-depth cooperation between the Mainland, Hong Kong, and Macao, but also a quality living area for living, working and visiting, and a model for high-quality development. The four major cities of Hong Kong, Macau, Guangzhou and Shenzhen will serve as the core engines of regional development[1].

The GBA has formed clusters for the communications and electronics information industry, the new energy automobile industry, the drone industry, the robotics industry and the petrochemical, clothing and footwear, toy processing and food and beverage industries, and is an essential spatial vehicle for China to build a world-class city cluster and participate in global competition. The ports of Guangzhou, Shenzhen and Hong Kong are among the top 10 ports in the world, with a wide range of domestic and international shipping routes and a large cargo throughput. Moreover, multimodal transport is an inevitable trend in the development of ports, which can significantly improve the quality of port transport, reduce transport costs and improve service levels. In GBA, multimodal transport can also enhance communication between ports, strengthen communication between ports and hinterlands, and improve the efficiency of the GBA port cluster as a whole[2].

This paper elaborates on the major ports in GBA and the basis of the multimodal transport situation, then analyses the development policy and multimodal transport development of Guangzhou port, and discusses the port development trend in GBA with the example of Guangzhou port. This paper aims to provide ideas for the direction of port development in GBA, hoping to enhance intermodal transport to connect the ports, improve the efficiency of freight transport and promote the formation of a unified dispatch centre for GBA ports and intermodal transportation.

2. Current situation

2.1 Ports in GBA

The Guangdong-Hong Kong-Macao, Greater Bay Area, abbreviated as the Greater Bay Area (GBA), better known as Pearl River Delta (PRD), includes the Hong Kong Special Administrative Region, the Macau Special Administrative Region, and the cities of Guangzhou, Shenzhen, Zhuhai, Foshan, Huizhou, Dongguan, Zhongshan, Jiangmen, and Zhaoqing in Guangdong Province. The GBA is geographically advantageous, with "three sides surrounded by mountains and three rivers converging", a long coastline, good port clusters, and a vast sea surface. The economic hinterland is vast, with the Pan-PRD (Pearl River Delta) region having about 1/5 of the country's land area, 1/3 of its population, and 1/3 of its economic output. As of December 2020, the resident population of the GBA reached 86,171,900.

The Port of Guangzhou is located at the mouth of the Pearl River and the heart of the Pearl River Delta region, bordering the South China Sea, adjacent to Hong Kong and Macau, where the Dongjiang (East), Xijiang (West), and Beijiang (North) rivers flow into the sea. Guangzhou Port is the largest comprehensive main hub and mainline container port in South China, with 131 international container liner routes in operation and cargo throughput of 636 million tonnes in 2020, ranking fourth in the world.

The Port of Hong Kong is a natural harbor in China and the Far East's shipping center. It is located at 22°30′N, 114°20′E, on the eastern side of the Pearl River estuary, between Hong Kong Island and the Kowloon Peninsula. Hong Kong is strategically located between our country and neighboring Asian countries, at the entrance to the Pearl River Delta, and at the heart of Asia's Pacific rim, which is experiencing impressive economic growth. The Port of Hong Kong is one of the busiest and most efficient international container ports worldwide and a major hub port in the global supply chain. Over 80 international liners provide approximately 500 container liner services per week, connecting the Port of Hong Kong to over 500 destinations worldwide [3].

Shenzhen Port is located in the southern part of the Pearl River Delta in Guangdong Province, the mouth of the Pearl River, the east coast of the Lingding Ocean, adjacent to Hong Kong, and is one of the seaports in the Pearl River Delta region.

According to comprehensive information in 2005, the Port of Shenzhen has eight port areas: Shekou, Chiwan, Mawan, Dongjiaotou, Yantian, Fuyong Airport, Shayuchong, and the river, with a port water area of 106 square kilometers and a land area of 16 square kilometers. As of October 2018, Shenzhen Port has opened 239 international container liner routes, covering 12 major shipping zones worldwide and leading to more than 300 ports in over 100 countries and regions. In 2018, Shenzhen Port's cargo throughput was 251 million tons.

The Dongguan Port is located in the core area of the Pearl River estuary, in the geometric center of the GBA; bordering the Lingding Ocean in the South China Sea, adjacent to Hong Kong, Macau and Guangzhou, where the Pearl River, Dongjiang River and Xijiang River meet; the port area is mainly distributed along the Dongjiang River, the Lion Ocean and the Lingding Ocean basin; it is a national first-class port.

The Zhuhai Port is located on the west side of the mouth of the Pearl River on the south coast of the Pearl River Delta in Guangdong Province, adjacent to the Macau Special Administrative Region. It is one of the major coastal ports in South China.

2.2 Transportation in GBA

The GBA is conveniently located, with Hong Kong's international shipping centre and important ports such as Guangzhou and Shenzhen, which rank among the world's top ports in terms of throughput and aviation hubs with global influence.

By the end of 2017, the highway mileage in the GBA had exceeded 4,000 km, making it one of the regions with the highest density of highway networks in China, and the road network density in the core area has surpassed that of the three major Bay Areas of New York, Tokyo, and London. In

terms of water transport, a high-grade waterway network with direct river and sea access and connections to Hong Kong and Macao has been formed, with the Xijiang River Main Line and the Pearl River Delta "three longitudinal, three horizontal and three horizontal lines" as the backbone[4].

In 2017, the mileage of inland waterways in the GBA exceeded 6,000 kilometers, ranking among the top in China. The coastal ports in the GBA had a container throughput of 80 million TEUs (international standard container units) and civil aviation passenger throughput of over 200 million passengers, both of which ranked first in the global Bay Area.

In April 2018, the Guangdong Provincial Development and Reform Commission launched the preparation of the "GBA Intercity Railway Construction Plan (2020-2030)", which is expected to build a "one-hour urban rail transportation circle" in the GBA in the future.

By the end of 2018, there were seven airports in the GBA, with a passenger throughput of 215 million passengers. The nine cities in the Greater Bay Area have 62,670 km of road access, Hong Kong has 2,123 km of public roads, and Macao has 449 km of road lanes. The data of Guangzhou and Shenzhen ports as shown in Table 1[5].

Table 1. The data of Guangzhou and Shenzhen por

Affiliated cities	Company name	Sea-rail container volume/TEU			Water transfer container volume/TEU			International transshipment container volume/TEU		
		June	January - June	Growth rate %	June	January - June	Growth rate %	June	January - June	Growth rate%
Guangzhou	Guangzhou Container Terminal Ltd.	248	1810	-5.04	52257	291092	-4.67			
	Guangzhou Port Nansha Port Services Co.				428144	2234635	1.18			
	Guangzhou Nansha Seaport Container Terminal Co.				128597.5	781742.75	1.94	41085.25	240673	4.46
	Nansha Container Terminal				188459	1214310	-20.62	13499	62892	137.59
Shenzhen	Shekou Container Terminal	80	2462	-48.32	161471.25	1070928.5	6.22	34795	243810	-12.37
	Chiwan Container Terminal	116	3014	37.69	206289.75	1084152.75	1	90951.75	418299.5	11.74
	Shenzhen Da Chan Bay Modern Port Development Co.				57629	286786	454.62	18764	94706	289.45
	Yantian International Container Terminal	16527	111867	51	194472	1180085	-2.5	173002	1041928	-5

2.3 Status of development of sea-rail intermodal transport in Guangzhou port

2.3.1 Container terminal

Guangzhou Port consists of an inland river port and a seaport. Among them, the seaport includes four major port areas: the inner port, Huangpu (including the old and new port areas), Xinsha, and Nansha port areas. Nansha Port is a new deep-water port and a new engine for container transport in Guangzhou. Guangzhou Port has nine container terminals, including four terminals in Nansha Port: Phase I (four 100,000t berths); Phase II (six 100,000t berths); Phase III (six 10,000t berths); and Phase IV (four fully automated and intelligently equipped deepwater berths). Nansha Port is expected to have an annual container throughput of over 24 million TEU shortly, ranking among the top single port areas in the world. The other five container terminals are Huangpu Old Port Terminal (3 berths of 30,000t class), Huangpu New Port Terminal (3 berths of 50,000-70,000t class), Dongguan Xinsha Port Terminal (3 berths of 70,000t class), Guangjun Terminal and Suihang Terminal (engaged in domestic trade and container barge business for Hong Kong and Macau) [6].

2.3.2 Container railways

All seven major container terminals in Guangzhou Port have a harbor-dredging railway. Among them, the Huangpu old port area has a 2,965m-long railway connecting the Huangpu Station of the Guangzhou-Shenzhen Railway. Huangpu New Port and Xinsha Port have a total length of 60 km, connecting the Huangpu Station of the Guangzhou-Shenzhen Railway. The total size of the railway is 60 km, relating to the Ha Yuan Station of the Guangzhou-Shenzhen Railway. The 88 km-long Nansha Port Area Dredging Railway will be completed and opened to traffic at the end of 2021, and will be a two-line Class I electrified railway, connecting to the Guangzhou-Zhuhai Railway. The 88-km long Nansha Port Port Railway, commissioned at the end of 2021, is a two-line Class I electrified railway connecting with the Guangzhou-Zhuhai Railway. It is an important corridor for integration into the "Belt and Road" initiative. The Guangzhou port is connected to the Guangzhou-Zhuhai railway through the Beijing-Guangzhou, Beijing-Kowloon, Guangzhou-Shenzhen, Guangzhou-Meizhou-Shantou, Guangzhou-Zhuhai and Guangzhou-Sanzhou railways. Guangzhou Port is connected to the national railway network through Beijing-Guangzhou, Beijing-Kowloon, Guangzhou-Shenzhen, Guangmeishan, Guangzhou, and Guangzhou-San railways, covering the Bay Area, The port of Guangzhou is connected to the national railway network through the Beijing-Guangzhou, Beijing-Kowloon, Guangzhou-Shenzhen, Guangzhou-Meishan, Guangzhou-Zhuhai and Guangzhou-San railways, covering the Bay Area, inland and globally. It provides strong support for Guangzhou Port to distribute cargo worldwide and realizes the sea-rail transport of China-Europe and Central Asia trains.

3. Evaluation of Guangzhou Port Development

3.1 Development Benefits

3.1.1. Enhancing the ability to support the hub economy

In September 2019, the "Guangzhou Port-based National Logistics Hub" project, which Guangzhou Port Group operates, was selected as the first batch of national logistics hubs, the only construction project set in Guangdong Province. Under the requirements of implementing the national strategy of Guangdong-Hong Kong-Macao Greater Bay Area and Guangdong Province's regional development pattern of "one core, one belt, and one region", the project promotes the docking of regional port operations and resource sharing. It jointly builds a world-class port cluster with a rational layout, complementary advantages, and efficient synergy, thereby enhancing the ability of the Greater Bay Area and South China to allocate global resource factors. Guangzhou Port plays a leading role in this regard[7].

3.1.2 Attracting more cargo sources and expanding the port's hinterland

The Nansha Port Railway was opened to traffic on 31 December 2021, breaking the last kilometer of sea-rail intermodal transport and promoting Nansha Port as a world-class "sea-rail intermodal" logistics hub; the Nansha International Logistics Centre North Project opened for trial operation and the South Project, the largest single cold storage facility in China, has entered the refrigeration and temperature adjustment stage, with an overall storage capacity of The total storage capacity will be over 700,000 tonnes when the project is put into operation; the construction of Nansha International General Purpose Terminal and the fifth phase of Nansha Port Area will be accelerated. "In 2021, the cargo throughput of Nansha Port will be 321 million tonnes, and the container throughput will be 17.617 million TEUs, of which the foreign trade cargo throughput and container throughput will increase by 13.1% and 16.3%, respectively, year-on-year, making the throughput capacity of a single port at the forefront of the world.

With Nansha Port as the center, Guangzhou Port Group has opened nearly 200 barge feeder routes, including 72 "shuttle bus" barge routes, covering the major inland river terminals in the Pearl River Delta; opened the "Xiang-Guangdong-Africa" international sea-rail intermodal transport corridor, China-Europe class trains, etc. By 2021, Guangzhou Port Group will have completed 15.6 million shipments of sea-rail intermodal transport. In 2021, Guangzhou Port Group will meet the arrival and departure of 156,000 TEUs of intermodal transportation, representing a year-on-year increase of 41.8%, and complete the evacuation of more than 10 million tons of railway transport[8].

3.1.3 Encourage inter-port cooperation

In recent years, the Guangzhou Port Group has accelerated the development of regional port links and synergies. By the end of 2021, the construction and operation projects had covered nine cities in Guangdong, including Dongguan, Foshan, Zhongshan, Chaozhou, Maoming, Yunfu, Jieyang, Shaoguan, and Yangjiang, achieving full coverage of the Pearl River Delta and the eastern, western and northern regions of Guangdong.

At present, the group is accelerating the integration of state-owned port resources belonging to Guangzhou city and district and accelerating the formation of a new pattern of regional port linkage and synergistic development with the Nansha port area as the core ports in the coastal economic zone of western and eastern Guangdong as the two wings, and ports in the Pearl River water system as the linkage. Since the opening of the first phase of Nansha Port in 2004, Guangzhou Port has completed 16 deep-water container berths with an annual throughput capacity of over 20 million TEUs and five ro-ro berths for automobiles with an overall throughput capacity of over 1.8 million vehicles; the near-ocean terminal will form the largest auto terminal cluster in China after its completion. After completing the airport, it will create China's most significant automotive terminal cluster [9].

3.2 Existing problems

3.2.1 Old infrastructure and equipment construction

(1) The collection and distribution system is not perfect. Although the main container terminals of Guangzhou Port have port-diversion railways, the construction of parks and enterprises is lagging, and they are not effectively connected with local logistics parks, factories, and mines. Implementing "bulk to collect" intermodal transport for bulk products is difficult.

(2) The construction of container yards, logistics hubs, and inland ports is lagging. The limited capacity of ports for loading, unloading, and logistics seats has become a bottleneck for the implementation of "public-to-rail"; the continuous tension and ineffectiveness of ports for changing and passing capacity, as well as the poor timeliness of China-Europe and Central Asia trains, have affected the quality of the trains and the growth of their traffic.

(3) The overall technical equipment of sea-rail intermodal transport is backward. In Guangzhou Huangpu Port and Xinsha Port, especially the inland waterless port, the existing railway lines, yard facilities, and equipment are old and need to be expanded and rebuilt; the new port-connected railway in Nansha Port also has many imperfect supporting problems.

3.2.2 Information data is not shared

The railway freight 95306 system and the port EDI, the electronic data exchange system, are not interconnected, and the information exchange is limited to the internal design of each system, which cannot provide document exchange at the same time, with poor timeliness of interaction, many communication links, and difficulties in collaborative operation. The efficiency of production organization, operation planning, scheduling management, statistical analysis, and marketing decision-making is low, and it is challenging to grasp first-hand information on cargo sources.

3.2.3 Lack of large multimodal transport operators

The operation mode is backward, and there is a lack of operators who can fully undertake the whole process of sea-rail intermodal transport. The entire process of sea-rail intermodal transport is jointly completed by the associated parties, without forming a sea-rail intermodal transport community of interests, without a unified operation of the city's main body of responsibility, the management of the process is challenging to put in place. Therefore, sea-rail intermodal transport in Guangzhou port lacks competitiveness in terms of time, efficiency, and cost compared with road and waterways.

3.2.4 Backward mode of intermodal transport organization

The mode of transport organization is backward. The service products of sea-rail intermodal transport are single, the supply structure is unreasonable, and the scope of intermodal transport needs to be expanded. The open-top container collection and distribution system, inland containers, van-type semi-trailers, and other domestic trade intermodal transport systems are imperfect. Implementing the "bulk to collection" of bulk goods, double-decker containers, and railway pack transport is challenging. The intermodal transport products lack comprehensive competitiveness; container sharing, empty container deployment, liner operation scheme, and grouping plan must be studied in depth. Poor railway freight timeliness, punctuality rate is not high, arrival and departure time sometimes can not be guaranteed, resulting in the railway transport period and ship schedule can not be effectively connected, reducing the efficiency of intermodal transport[10].

4. Future trends of ports in the Greater Bay Area

4.1 Port Resource Consolidation

As the GBA develops, more roads, railways, bridges, and tunnels across the sea will be built, and the GBA's transport links will be further upgraded and opened up. Shortly, with the improvement of multimodal transport technologies, including automation and information technology, the transit time between ports in the GBA will be significantly reduced, and the cost of transporting goods over short distances will not be exceptionally high, thus creating a cluster of interconnected ports in the GBA. As a result, it will no longer be essential for cargo owners to arrive at a particular harbor or port area within the GBA. They will no longer need to choose the most suitable time and berth to achieve a certain transport purpose. Still, the cluster of ports in the GBA can work together to improve the overall service level, rationalize the scheduling of incoming cargo and allocate berths for loading and unloading, which will also significantly enhance the efficiency of the various ports in the GBA[11].

4.2 Upgrade of port facilities

The GBA ports were built in different eras; therefore, some of the older ports have problems. For example, the old port area of Huangpu in Guangzhou Port has outdated facilities, is close to the city center, and occupies a small area. The surrounding land plan is almost complete. Therefore, building other railways and expressways around them is very difficult. In the case of old ports, it is important to clarify their use and renovate their infrastructure to accommodate modern multimodal transport better. For example, if transport trucks are often stuck in traffic in front of the old port of Huangpu,

which is less efficient, then we should also improve the dedicated roads in and out of the port to open up the roads for intermodal transport.

4.3 Establishment of the GBA Port Management Committee

The GBA ports are currently operated and managed by local port groups, such as Guangzhou Port Group and Yantian International Container Terminal, competing with each other and not sharing data. Establishing a GBA Port Management Committee (PMC) may be an excellent approach to solving these problems and improving the overall efficiency of the GBA port cluster. It would have a higher level of authority than the local port operators to access data from each port, to achieve overall macro-strategic adjustment of the GBA ports, strengthen cooperation between the ports and achieve intermodal transport and scheduling management of the GBA port cluster.

5. Conclusion

The GBA is an effective development strategy for China, and its port development is substantial. With the upgrading of transportation construction and the development of information technology and automation, the connection between ports will be more convenient and efficient, and multimodal transport is the basis for achieving port interconnection. Take Guangzhou Port as an example, which currently has several multimodal transport routes, including the rail-water intermodal transport of the China-European Liner and the inland water-water intermodal transport of Dongguan, Hong Kong, and Macau. In the coming years, GBA will also continue to develop its transport construction, creating a one-hour commuter city circle in terms of passenger transport, and freight transport will also go to the next level with transport construction. Of course, there are still obstacles to developing a multimodal GBA port. For example, there are problems with old facilities, difficulties in sharing data, and a lack of unified management. In the future, policy and technology obstacles can be broken by renovating and building old facilities, promoting the construction of a GBA port management committee, achieving data sharing, unified scheduling and management, and improving the overall efficiency of GBA ports.

The paper provides ideas for future related research on port cluster management, enhancing communication and coordination and cargo scheduling among ports through multimodal transport, and improving overall efficiency and service levels. In the future, specific traffic routes and information management techniques are yet to be discovered.

There are some limitations in this paper, such as detailed data for the port of Guangzhou is harder to obtain, the data and information are not comprehensive, and some relevant public information for each port in GBA is not consistent in years and cannot be compared well. Due to the impact of the COVID-19 epidemic, the post-2020 data does not reflect the actual development trend under normal circumstances.

References

[1] Huang Rendang. Research on port logistics development of Guangdong-hong Kong-Macau bay area under “the Belt and Road”. Price Theory and Practice, 2020, 12: 148-151.

[2] Comprehensive docking! Guangzhou Port has thus promoted the construction of the Guangdong-Hong Kong-Macao Greater Bay Area. Pearl River Water Transport, 2019, 14: 28.

[3] Shan Li, Hercules Haralambides, Qingcheng Zeng, Economic forces shaping the evolution of integrated port systems - The case of the container port system of China's Pearl River Delta, Research in Transportation Economics, 2022, 94: 101183.

[4] Long Wei, Zhang Xiaofan, Zou Jing Weiqi. Guangzhou Port builds a new pattern of large logistics in South China. China Water Transport News, 2022: 006.

[5] China Hub Port Container Terminal Multimodal Transport Throughput Express (June 2022). Containerization, 2022,33 (07): 30-31.

[6] Wu Jialu. Development pattern outlook of container ports in the Guangdong-Hong Kong-Macao Greater Bay Area. Containerization, 2018,29(10):1-5.

[7] Huang Haiying. Exploring the new pattern of modern logistics development in the Guangdong-Hong Kong-Macao Greater Bay Area. Storage and Transportation in China, 2019 (12): 138-139.

[8] Chen Wei. Research on the Container Business Development Strategy of Guangzhou Port under the Background of the Guangdong-Hong Kong-Macao Greater Bay Area. South China University of Technology, 2018.

[9] Hu Guojie. Study on the Operation Scheme of container Sea Railway at Nansha Port. Beijing Jiaotong University, 2020.

[10] Tang Jianqiao. High-quality Development Countermeasures of Guangzhou Port. China Railway, 2022 (06): 130-136.

[11] Huang Xijin. Proposal on accelerating the high-quality development of multimodal transport in the Guangdong-Hong Kong-Macao Greater Bay Area. China's Technology Industry, 2021 (03): 25.