

Research on the Guangdong-Hong Kong-Macao Airport Group: International Experience and China's Path

Zini Chen
Jinan University
Guangzhou, China

Abstract—Constructing the Guangdong-Hong Kong-Macao Greater Bay Area into a world-class Greater Bay Area is a significant strategy for China. In this context, how to rationally allocate air traffic resources in the Bay Area has become an important issue. Based on the analysis of the significance of constructing a world-class airport group in the Guangdong-Hong Kong-Macao Greater Bay Area, this paper selects three famous world-class airport groups to analyze their development processes and application patterns. Based on the experience of these cases and combined with the development status of the Guangdong-Hong Kong-Macao Airport Group, the suggestions and countermeasures for further development are proposed. This paper attempts to provide references for the construction of the world-class airport group in Guangdong-Hong Kong-Macao Greater Bay Area.

Keywords: *airport group, Guangdong-Hong Kong-Macao Greater Bay Area, urban agglomerations*

I. INTRODUCTION

The Guangdong-Hong Kong-Macao, Greater Bay Area, has industrial, technological, and geographic advantages, signing of the hub in the Belt and Road Initiative, and plays a crucial role in foreign exchange and economic development. To build a world-class Greater Bay Area, it must pay attention to the role of airport group in regional economic development. Combined with regional industrial advantages, a world-class airport group will be established in the Guangdong-Hong Kong-Macao Greater Bay Area.

In 2018, the total passenger volume of the airport group in the Guangdong-Hong Kong-Macao Greater Bay Area was nearly 213 million, the total cargo volume exceeded 8.15 million tons, and the flight takeoffs and landings was about 1.41 million, which has exceeded the other three major bay areas in the world. However, judging from the current status, the airports in the Bay Area still faces many problems, resulting in the failure of the airport group to maximize its effect. Therefore, the development of the airport group is an essential part of the construction of the Guangdong-Hong Kong-Macao Greater Bay Area.

A. The connotation of airport group

Neufville (1995) proposed the concept of the Multi-Airport System, which is defined as a group of airports serving the air transport in the metropolitan area. All the airports that belong to different cities or jurisdictions but are related can be part of the airport group [1]. Nayak (2012) defines the simultaneous operation and interdependence of multiple airports serving a metropolitan area as the Multi-Airport System of the region [2]. Hassanein (2019) newly defined the Multi-Airport System as a system that can achieve self-sufficiency in transporting passengers and cargo by combining multiple airports [3].

In China, the article Hong Kong and Macao Lookout (1995) first proposed the concept of Airport Groups [4]. Zhang Ning (2007) first defined the Airport Group based on some common points of view. That is, the airport group aims at optimizing resource allocation, according to route and flight deployment, airspace and airport management, industrial and logistics strategies, geographical conditions and ecological environmental constraints and the strategic requirements for regional, optimize the allocation of space areas and form airport synergy within this area [5]. In short, most current domestic definitions of Airport Group are similar to foreign definitions of Multi-Airport Systems.

B. Research of the airport group

Neufville (1984) studied and proposed a dynamic strategic planning strategy for the construction of multi-airport systems [1]. He concluded that the competitiveness of airports differed in different markets and that airports in the airport group can develop better in their respective advantageous markets. [6]. Atkins (2008) analyzed the airport group in the San Francisco Bay Area and found that the interdependence between neighboring airports will lead to a reduction in airport capacity and operational efficiency [7]. Bonnefoy, Neufville, and Hansman (2010) conducted research on 59 airport groups around the world. The research shows that the evolution of regional airport systems involves the generation of second airports, and the development of airports has a strong correlation with urban development.

Sun Xiaoqian and Wandelt (2017) studied the multi-airport system from the time distance between airports [9].

Domestic research on airport groups is still in the preliminary stage. Zhou Xing and Hu Zhiyong (2002) analyzed the relationship between the aviation network structure and the Chinese urban system, and found that the aviation network is highly related to the size of the city [10]. Zhu Yingming (2003) studied the relationship between urban agglomerations and air transport. They believed that close air transport links could strengthen the economic and social relations of urban clusters [11]. Wang Jiao'e, Mo Huihui, and Jin Fengjun (2008) studied the distribution pattern of airports in the world and put forward suggestions for the construction of Chinese airports from the aspects of airport construction and national strategic support [12]. Hao Yuan and Quan Bo (2016) combined with the development experience of airport groups in world-class urban agglomerations to make constructive suggestions for the development of Beijing-Tianjin-Hebei Airport Group [13]. Fan Yuan & Jiang Xinchun (2019) studied the spatial layout of California's world-class airport groups, explored the joint development of airport groups and urban agglomerations. They put forward constructive suggestions from the aspects of airport infrastructure, industrial layout and overall planning of the urban agglomeration. [14].

II. SIGNIFICANCE OF GUANGDONG-HONG KONG-MACAU AIRPORT CLUSTER

An advanced aviation system is an important measure for building an international urban agglomeration, and a good aviation network is a competitive advantage for regional economic development. According to existing research, urban aviation construction is highly related to the scale of urban.

A. *Improving international competitiveness*

Aviation is a crucial channel for introducing talent, materials, capital, and technology in a region. A complete aviation network can not only enhance the close exchanges between the Guangdong-Hong Kong-Macao Greater Bay Area and other regions but also use efficient aviation logistics to drive regional industrial-economic progress. Establishing a coordinated development of the airport group can enable each airport to cover more routes networks worldwide through the division of labor and cooperation, thereby expanding the extent to which the entire Greater Bay Area utilizes domestic and foreign resources. By enhancing the ability of the Guangdong-Hong Kong-Macao Greater Bay Area to participate in the international division of labor in aviation, the international competitiveness of the entire Bay Area will be enhanced.

B. *Optimizing industrial structure and accelerating economic development*

The Guangdong-Hong Kong-Macao, Greater Bay Area, is an important gathering place for manufacturing, high-tech industries, and the financial industry. Judging from the

economic and social needs of each city in the Bay Area, there is a need to build a developed air transportation system. Aviation construction promotes the development of logistics and often stimulates the emergence of urban airspace industries. The airport will bring together the city's high-tech and high-quality industries to optimize the industrial space layout and industrial structure. Domestic and foreign cities related to these industries will become important communication targets for the world-class airport group in the Guangdong-Hong Kong-Macao Greater Bay Area, thereby accelerating the economic development of the urban agglomerations. The industrial development of the Greater Bay Area will rely more on the free flow of high-quality talents, which will inevitably bring about personnel mobility and stimulate the demand for civil aviation. Therefore, it is imperative to develop the aviation industry in the Bay Area vigorously.

C. *Optimizing regional traffic layout*

The uneven distribution of transportation facilities is a shortcoming of the Guangdong-Hong Kong-Macao Greater Bay Area. The transportation functions in the Bay Area cannot support the economic needs of world-class Bay Areas. Airports are often the hubs of urban integrated transportation systems, and they support the construction of ground transportation networks in urban agglomerations. In addition to air transportation, airports often integrate many modes of transportation such as expressways and rail transit. With the combination of multiple airports in the urban agglomeration, it will make more cooperation between cities in the Guangdong-Hong Kong-Macao Greater Bay Area and promote overall development.

III. OVERVIEW OF AIRPORT CLUSTER IN GUANGDONG-HONG KONG-MACAO GREATER BAY AREA

At present, Guangdong-Hong Kong-Macao Greater Bay Area airport group is mainly dominated by five major airports, including Hong Kong International Airport, Guangzhou Baiyun International Airport, Shenzhen Baoan International Airport, Macao International Airport and Zhuhai Jinwan Airport. The surrounding Huizhou Pingtan Airport and the Pearl River Delta Shinkansen Airport are also under construction within the airport group.

The Guangdong-Hong Kong-Macao Greater Bay Area covers an area of 56,000 square kilometers and has a total population of approximately 67 million people. In 2017, the GDP of the Guangdong-Hong Kong-Macao Greater Bay Area was approximately 1.6 trillion US dollars, and the total value of imports and exports of the Bay Area between 2012 and 2016 was approximately 8-9 trillion US dollars, accounting for 40% of the country's total imports and exports. In 2018, the total passenger volume of the Guangdong-Hong Kong-Macao Airport Group was approximately 213 million, the total cargo volume was approximately 8.15 million tons, and the flight takeoffs and landings was 1.41 million. It has surpassed the well-known London Airport Group and the airport groups of Three Great Bay Areas of the World.

“Tables I” and “Table II” are relevant information of the five major airports in the Guangdong-Hong Kong-Macao Greater Bay Area: (1) The airports in Hong Kong, Guangzhou and Shenzhen are the three major airports in the Guangdong-Hong Kong-Macao Airport Group, having better airport facilities and more international destinations. In contrast, Zhuhai and Macao airports are smaller. (2) Hong Kong Airport is one of the leading forces in the airport group of the Guangdong-Hong Kong-Macao Greater Bay Area. Its passenger volume accounts for about 35% of the Guangdong-Hong Kong-Macao Airport Group, and the cargo volume is about 60%. (3) Guangzhou Airport is another core airport in the Greater Bay Area. In 2018, it ranked at No. 3 in the country and No. 13 in the world. It is

approaching Hong Kong, and cargo volume continues to grow. (4)The growth rate of the passenger volume of Shenzhen Airport in 2018 ranked first among the top ten domestic airports. In the same year, the airport opened many international routes and officially approved the construction of a third runway in 2019 to expand its scale.(5) The shortcoming of the Macao airport is that the runway is short, and international passenger planes cannot take off and land in Macao, which limits the expansion of the international routes. (6) Zhuhai Airport has a long runway that can meet all international aircraft, but there are no international routes. (7) In recent years, the passenger volume of Macao Airport and Zhuhai Airport has reached record highs, and the growth rate of cargo volume has also increased by leaps and bounds.

TABLE I. OVERVIEW OF THE FIVE MAJOR AIRPORTS IN GUANGDONG-HONG KONG-MACAU GREATER BAY AREA

Airport	Airport Level	Runways	Terminal Area(×10 ⁴ m ²)	Departure gate	Air Route
Hongkong International Airport	4F	2	71	182	>220
Guangzhou Baiyun Airport	4F	3	140	245	>220
Shenzhen Baoan Airport	4F	2	45	199	188
Zhuhai Jinwan Airport	4E	1	9	26	127
Macao International Airport	4E	1	6	24	56

^a. Data source: Civil Aviation Administration of China, official websites of airports

TABLE II. OPERATION OF THE FIVE MAJOR AIRPORTS IN THE GUANGDONG-HONG KONG-MACAU GREATER BAY AREA IN 2018

Airport	Total Passenger Volume(×10 ⁴)		Total Cargo Volume(×10 ⁴)		Take-off and Landing	
	Current amount	Rate of change (%)	Current amount	Rate of change (%)	Current amount	Rate of change (%)
Hongkong International Airport	7482.2	2.1	495.7	-0.5	42.9	1.3
Guangzhou Baiyun Airport	6972.0	5.9	189.1	6.2	47.7	2.6
Shenzhen Baoan Airport	4934.9	8.2	121.9	5.1	35.6	4.6
Zhuhai Jinwan Airport	1122.1	21.7	4.6	24.1	8.5	14.3
Macao International Airport	826.3	15.3	4.0	7	6.6	12.6

^a. Data source: Civil Aviation Administration of China, official websites of airportCase study and experience summary of world-class airport clusters

IV. CASE STUDY AND EXPERIENCE SUMMARY OF WORLD-CLASS AIRPORT CLUSTERS

Compared with domestic countries, aviation construction in developed countries is relatively mature, so analyzing the models and experience of thriving airport group will play an essential role in advancing the construction of world-class Airport Group in the Guangdong-Hong Kong-Macao Greater Bay Area. This section will take famous world-class airport groups as examples, including New York Bay Area Airport Group, Chicago Airport Group, and London Airport Group as cases, study their operating modes and summarize experiences.

A. New York Bay Area airport group

The New York Bay Area airport group is one of the world's most influential airport groups, consisting of five airports, including JFK International Airport, Newark International Airport, LaGuardia International Airport, Stuart International Airport, and Teterboro Airport. The airports in JFK, Wacker and LaGuardia are the three major airports in the New York Airport Group. Stuart Airport is a small airport. Teterboro Airport is a business airport and also a regional adjustment airport. Among them, JFK Airport ranks

first in the New York Airport Group, with robust airport facilities and the most international destinations. Newark Airport routes are evenly distributed internationally and domestically, ranking second in the airport group. LaGuardia Airport ranks last among the three largest airports with few international routes. From the perspective of a single airport, each airport in the New York Airport Group has a relatively limited influence in American airports. However, in general, it is one of the most influential airport groups in the world.

1) *The positioning of a single airport:* JFK Airport is positioned as the international hub of the New York Airport Group, with a dominant position in the Airport Group. Newark Airport is the domestic gateway and is responsible for most of the major domestic routes. LaGuardia Airport is positioned as a small regional airport. The airport group is also supported by the world's most influential business jet airport, Teterboro Airport, and other small airports that assist in the diversion.

2) *The positioning of a single airport:* From the perspective of the New York Airport Group as a whole, its management mode is the unified management of all airports by the New York and New Jersey Port Authority(PANYNJ). It uses this management mode to systematically allocate

markets based on the characteristics of the airport. Such a management mode makes each airport differentiated and misplaced to compete, and maximizes the overall profitability of the New York Airport Group.

3) *The air routes and aviation business:* American Airlines and Delta Air Lines jointly operate JFK Airport, whose international routes focus on Europe and parts of Central America. United Airlines has contracted the international business of Newark Airport and is the sole air carrier of the New York Airport Group to the Asian market. Such route deployment is specially approved by the government. Although it does not fully comply with the market's rules for free competition, it can bring the most significant benefits to the New York Airport Group.

4) *The regional traffic of the airport group:* JFK Airport and Newark Airport jointly developed a joint transportation system around the beginning of the 21st century. The airport terminals, road transportation and rail transportation are all connected to provide a joint between the airport terminal, the New York subway and the rail system. The service dramatically facilitates the travel of passengers.

B. Chicago Airport Group

In 2017, Chicago Airport Group became the eighth airport group in the world with a passenger throughput of over 100 million. The Chicago Airport Group is mainly composed of four airports: including passenger airport O'Hare International Airport and Midway Airport, cargo airport Rockford Airport and business jet dedicated airport PWK Airport. Here we mainly study the two major civil airports O'Hare Airport and Midway Airport.

Midway Airport was built in the 1930s and has become one of the world's largest airports for decades in a row. It was the only core airport in Chicago at the time. For the same reason that most of the second airports appear, because the halfway airport is too saturated, Chicago established O'Hare International Airport in the late 1950s to divert the halfway airport. At first, O'Hare Airport had less passenger flow as a second airport. Later, a series of far-reaching effects brought by the entry of Low-Cost Airlines (Southwest Airlines Effect) made the new airport grouping effect even more prominent. Later, due to the emergence of jet aircraft, the short runway at Midway Airport could not accommodate new aircraft, and the main airport of Chicago gradually moved from Midway Airport to O'Hare Airport.

In the division of labor between the two airports, O'Hare Airport undertakes most of the international routes and a small part of domestic routes, while Midway Airport is mainly operated by Low-Cost Airlines, which undertakes most of the domestic routes. It is worth mentioning that O'Hare Airport is a dual main aviation airport. United Airlines and American Airlines each occupy one terminal in O'Hare Airport. The dual main aviation airport brings double economic benefits. Along with the diversification of passenger travel, inter-transit division transit will become a trend in the aviation field in the future. If airlines can

effectively cooperate, it will also generate new economic benefits.

C. London Airport Group

As an international financial center, London's busy economic business requires a developed air transportation system. The London Airport Group is composed of six major civil airports including Heathrow Airport, Gatwick Airport, Stansted Airport, Luton Airport, London City Airport and Southend Airport, and the business airport Farnborough Airport. In 2017, the London Airport Group had a passenger volume of over 160 million, of which Heathrow Airport ranked first, the throughput was close to 50% of the London Airport Group, and the second ranked single-runway Airport Gatwick. The following studies the London Airport Group from two aspects.

1) *The airport division of labor and business market:* Heathrow Airport is mainly responsible for international long-distance business and transit business. International routes cover all regions except some of the Americas. As Heathrow Airport has become saturated in recent years, Gatwick Airport has since moved up. Gatwick Airport is mainly responsible for long-haul routes, mainly in the United States, Canada, and the Caribbean. It is considered to be the busiest single-runway airport in the world. Stansted Airport is a hub for Low-Cost Aviation in the London area. It also has many international routes, but most of its destinations are within Europe. Luton Airport is responsible for part of the Low-Cost Aviation business and the leading leisure and vacation charter business. Due to its short runway, London City Airport is mainly used for the takeoff and landing of the propeller and small jet aircraft. Southend Airport is currently small and is mainly operated by two Low-Cost Airlines. Farnborough Airport: Farnborough Airport is responsible for the business jet business in the London area, with about 25,000 business jets taking off and landing each year.

2) *The characteristics of the airport group:* The most important feature is that each airport combines its own characteristics and market demand to operate in a dislocated manner under the conditions of overlapping markets, avoiding excessive competition, and cooperating. The second point is the development of Low-Cost Aviation. Based on EasyJet Airline, which has the largest low-cost market share in the London Airport Group, it develops aviation transit projects at Gatwick Airport, operates international routes at Stansted Airport, and operates secondary routes at Southend Airport. While nurturing the business market, it also meets the needs of low-cost passenger travel. Finally, a sound public transport system is also key to the construction of the London Airport Group. The major airports of the London Airport Group have opened express trains and light rail traffic to and from the city center, achieving rapid communication between airports and the airport and the city.

D. International experience and summary

1) *Differentiated positioning of each airport and clear division of labor:* The most prominent commonality of the three cases is that each airport in the airport group has a different division of labor and focuses on the development of different markets. In the New York Airport Group, JFK International Airport is mainly for developing international routes, Newark Airport is the main domestic gateway, and LaGuardia Airport is a small regional airport. The Chicago Airport Group is dominated by O'Hare Airport, which has a comprehensive full route, supplemented by mid-way airports that mainly operate Low-Cost Airlines. Heathrow Airport and Gatwick Airports operate different international routes in the London Airport Group. Other airports mainly use Low-Cost Airlines to perform different functions of the London Airport Group. Differentiated positioning of each airport in the region and dislocation development are the key to avoid disorderly competition.

2) *Centralized planning and unified management:* How to effectively make each airport in the airport group perform its role is the most critical problem in the construction of the airport group. The New York Airport Group has made a successful demonstration. The division of labor in the New York Airport Group is inseparable from its unique operating system. The unified deployment of the airport group by an agency makes the operation of the airports in each airport group no longer independent, but well-organized. Besides, United Airlines was approved to exclusively operate all the business in the New York Airport Group for the Asian market and exclusively operate at Newark Airport. This particular deployment can maximize the benefits of the entire New York Airport Group but must be approved by the government. Therefore, it is essential to find the management mode that is most suitable for the development of the airport group.

3) *Establishing an integrated urban transportation system:* It can be found in the case study that the success of the airport group is inseparable from the assistance of a developed urban transportation system with the airport. The use of rails, railways and highways to connect the airport with the airport, the airport and the city center, and the establishment of a jointly operated transportation system to achieve air-ground transport will not only improve the operational efficiency of the airport group, but also drive regional economic development.

4) *Valuing the role of base airs:* In the construction of the airport group, not only the role of Full-Service Airlines to the hub airport should be emphasized, but also the role of Low-Cost Airlines. Low-Cost Airlines tend to exert their advantages in the airport group, especially for secondary hub airports. Low-Cost Airlines are more likely to meet passenger demand in terms of fares, but usually choosing airports farther from the central airport can often make up for the gaps in routes of more marginal airports. Besides, they also play an important role in driving the development of secondary airports. In addition to Low-Cost Airlines, the dual primary airline model of Chicago O'Hare Airport is also worth learning. The two major airlines, which are

mainly responsible for different regional routes, jointly operate an airport, which can not only compete in an orderly manner but also bring double economic benefits when used correctly.

5) *Making full use of small airports to create business jet airports:* Teterboro Airport in the New York Airport Group, PWK Airport in the Chicago Airport Group, and Farnborough Airport in the London Airport Group are all business jet airports in each airport group. The role of business airports may seem insignificant, but they are standard in all world-class airport group. Teterboro Airport is one of the most popular business airports in the world. These business airports are often smaller and more remote in the airport group. Building them into business airports can not only meet the aviation needs of business jets but also relieve the pressure of other airports and give full play to their effectiveness.

V. PROPOSALS FOR THE CONSTRUCTION OF GUANGDONG-HONG KONG-MACAO AIRPORT CLUSTERS

The Guangdong-Hong Kong-Macao Greater Bay Area is unique in that it has multiple centers, so the development of the Guangdong-Hong Kong-Macao Airport Group has its foundations and challenges.

A. Clarifying the positioning of the airports

As the international aviation center of the Guangdong-Hong Kong-Macao Greater Bay Area, Hong Kong International Airport should continue to increase international routes to cover as many cities as possible in the world. It can also rely on financial and logistics advantages to develop new aviation industries and high-end service industries. Guangzhou Baiyun Airport is a composite hub airport, located in one of the other central cities in the Guangdong-Hong Kong-Macao Greater Bay Area. In the absence of conflict with Hong Kong on international routes, sufficient international business should also be expanded to make it an airport with global influence. Shenzhen Airport is positioned as a large-scale backbone airport, can be developed into a major international aviation transit center when it is relatively close to Guangzhou Airport. At the same time, develop as many domestic routes as possible and strive to become a more influential domestic and foreign aviation hub. As an essential cargo airport at the Pearl River port, Zhuhai Airport continues to develop the aviation industry. At the same time, it can appropriately expand domestic and international routes to relieve pressure for the three major airports. Since Macao Airport has no long runway and is relatively small, it can become a business jet airport for the Guangdong-Hong Kong-Macao Airport Group.

Besides, we must step up the use of small airports other than the five major airports. At present, the development of domestic Low-Cost Airlines lags far behind the western developed countries, and the Low-Cost Airlines can be developed using the expanding remote area airports such as Huizhou Airport. The use of edge airports can alleviate the pressure of abundant passenger flows in central cities, and

the development of Low-Cost Airlines can fill the gap in the market while meeting the needs of diversified tourist travel.

B. Establishing a unified coordination mechanism on the premise of independent development

To coordinate the airports in the airport group, it is necessary to give play to the role of local governments for unified management. In order to establish a community of interests in the Guangdong-Hong Kong-Macao Airport Group, a unified coordination mechanism can be established with the support of the SAR government and the local SASAC. The agency is responsible for formulating common development goals and plans, allocating airport division of labor, and regulating restrictions. It is worth noting that, unlike other bay areas, the Guangdong-Hong Kong-Macao Greater Bay Area is essentially an economy with three megacities, each of which has its substantial transportation requirements. Therefore, while advocating centralized planning and coordinated development, we must pay particular attention to administrative monopolies. It is necessary to give full play to the ability of independent construction to maintain a relatively competitive landscape. At the same time, open connectivity and healthy interaction can effectively develop and release capacity.

C. Establishing an integrated transportation system with multiple airports as main nodes

The Guangdong-Hong Kong-Macao Greater Bay Area still lacks an integrated transportation system that can quickly connect cities between regions. In addition to making full use of the Zhuhai-Hong Kong-Macao Bridge to improve the level of cooperation among the three places, cities should use rail transit and shipping to create an interoperable transportation network. Shenzhen can strengthen the construction of urban rail transit from Baoan Airport to Shekou Wharf and connect Shenzhen Airports, Hong Kong Airports, and Macao Airports by sea. It should also rely on Guangzhou Baiyun Airport and Shenzhen Baoan Airport to establish airport high-speed rail stations to connect important transportation hubs between cities and realize the Guangdong-Hong Kong-Macao Greater Bay Area Air-Iron integration.

D. Establishing airport group information management system to realize information sharing

The construction of the airport group in the Guangdong-Hong Kong-Macao Greater Bay Area requires the support of innovative technologies. It is possible to use the integration of Internet informatization and transportation to create a smart airport group to achieve transportation connections, information communication, and service sharing between airports. Information sharing not only enables tourists to query the comprehensive information of various airport transportation networks and enjoy convenient services at any time while in the Guangdong-Hong Kong-Macao Great Bay Area but also facilitates managers to coordinate and manage regional airports and transportation and optimize the efficiency of the entire airport group.

VI. CONCLUSION

Research on the three world-class airport groups, including the New York Bay Airport Group, the Chicago Airport Group and the London Airport Group, shows that each successful airport group already has a relatively complete operating model. Important factors include: (1) clarifying the division of labor; (2) having a unified organization for management and planning; (3) establishing a regional comprehensive transportation system centered on each airport; (4) making full use of base airlines and so on.

With the continuous progress of the construction of the Guangdong-Hong Kong-Macao World-Class Greater Bay Area, the importance of the Guangdong-Hong Kong-Macao Airport Group is becoming increasingly significant. Aiming at the problems of improper airport coordination, inadequate management mechanism, incomplete construction of the transportation system, and the characteristics of multi-core cities in the Guangdong-Hong Kong-Macao Airport Group, this paper makes some suggestions summarized as follows:

- The five major airports should differentiate their division of labor, and tap the potential of emerging airports in marginal areas to give play to their advantages and expand scale.
- Establishing a unified management mechanism and coordinate development under the premise of maintaining relative competition and exerting the independent capabilities of each airport.
- Establishing an integrated transportation system with each airport as the core, and promoting the integration of land, sea and air to achieve regional connectivity.
- Using Internet and the technology of information management to realize information sharing and intelligent management in the Guangdong-Hong Kong-Macao Airport Group.

REFERENCES

- [1] De Neufville, Richard. "Management of multi-airport systems: a development strategy." *Journal of Air Transport Management* 2.2 (1995): 99-110.
- [2] Nagesh, and Nayak. "Estimation of the impact of single airport and multi-airport system delay on the national airspace system using Multivariate Simultaneous Models". University of South Florida, (2012).
- [3] Attaalla, Farouk Abdelnabi Hassanein. "Multi-airport system as a global tourism phenomenon: a critical review and a new concept."
- [4] Chen Haiming. "Hong Kong and Macao lookout." *Pearl River Economy* 4 (1999): 47-48.
- [5] Zhang Ning. "Integration of airport groups based on optimal allocation of transportation resources." *Comprehensive Transportation* 6(2007): 16-20.
- [6] De Neufville, Richard. "Planning for multiple airports in a metropolitan region." *Built Environment* (1978-) (1984): 159-167.
- [7] Atkins, Stephen. "Observation and measurement of metropolplex phenomena." 2008 IEEE/AIAA 27th Digital Avionics Systems Conference. IEEE, 2008.

- [8] Bonnefoy, Philippe A., Richard De Neufville, and R. John Hansman. "Evolution and development of multi-airport systems: Worldwide perspective." *Journal of transportation engineering* 136.11 (2010): 1021-1029.
- [9] Sun, Xiaoqian, et al. "Multiple airport regions based on inter-airport temporal distances." *Transportation Research Part E: Logistics and Transportation Review* 101 (2017): 84-98.
- [10] Zhou Yinxing, and Hu Zhiyong. "Looking into the network structure of Chinese urban system from the perspective of air transportation." *Geographical Research*, 21.3(2002):276-286.
- [11] Zhu Yingming. "The study of air transportation links among urban compact district of Huninghang." *Human Geography*, 18.5(2003):22-25.
- [12] Wang Jiao'e, Mo Huihui, and Jin Fengjun. "Spatial pattern of the worldwide airports and its enlightenment." *World Regional Studies*, 17.3(2008):8-18.
- [13] Hao Yuan, and Quan Bo. "Airports development strategies in Beijing-Tianjin-Hebei, a World-Class Cluster of metropolitan areas." *Urban Transport of China*, 14.3(2016):67-71.
- [14] Fan Yuan, and Jiang Xinchun. "Research on the spatial layout mode of world-class airport group in California." *Urban Planning International*, 1-23(2019):11-21.
- [15] Wang Jiakang. "Influencing factors, paths and challenges of the development of American Airport Groups." *Air Transport & Business*, 11(2018):42-46.