International Transport Forum

Integrated Transport Development in China's Emerging Urban Agglomerations

A Case Study of Transport Integration in the Beijing-Tianjin-Hebei Urban Agglomeration

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Abstract
Recent years, China has increasingly seen a new type of urbanization characterized by urban agglomerations. The rapid development of urban agglomerations, such as the Yangtze River Delta area, the Pearl River Delta area, and the Beijing-Tianjin-Hebei area, has contributed significantly to economic growth, balanced development between regions, and land development in China. Transport offers a basic framework for the development of urban agglomerations and plays an important part in shaping spatial patterns. Rationally planning for integrated transport development is of significant importance to the healthy and sustainable development of urban agglomerations in China. This paper focuses on China's urbanized areas, examining the characteristics and trends of transport development as well as transport needs in China's urban agglomerations, and further proposing general strategies for promoting integrated transport development in these areas. In particular, this paper looks at the acute problems faced by transport development in the Beijing-Tianjin-Hebei urban agglomeration and offers a solution based on general strategies for promoting transport integration in this area.

1. Overview

Urbanization in China has been progressing rapidly during the more than 30 years of reform and opening-up experienced by the nation. The urbanization rate grew at an average annual rate of 1.02 percentage points from 17.9% in 1978 to 54.77% in 2014. Thanks to the rapid urbanization, a large portion of the rural labor force has been employed and factors of production are more efficiently allocated between urban and rural areas, contributing significantly to the fast and sustained growth of the Chinese economy and the overall improvement of living standards amongst urban and rural residents. According to the global pattern of urbanization, China will continue to see rapid urbanization. However, the development of cities has been increasingly constrained by the problems, such as energy shortages and resources deficiencies, environmental deterioration, and traffic congestion, which are presented by such fast urbanization and motorization,. China's National New-type Urbanization Plan (2014-2020) calls for accelerated changes to the approach to urbanization, balancing the development of cities and small towns mainly by creating urban agglomerations, and enhancing the sustainability of cities by increasing their comprehensive capacities.

Urban agglomeration is an advanced form of spatial organization for cities. Against the backdrop of economic globalization and informatization, intellectual innovations and institutional changes have been further integrated into urban systems and networks. Urban agglomerations, a brand-new basic geographic unit for countries to participate in global competition and the international division of labor, will become the central growth pole offering the strongest vitality and potential in the national landscape of economic development (Allen, 2001). According to projections by the UNDP, China's urbanization rate will reach 70% in 2030 which means that in more than ten years, about 300 million rural residents will migrate to cities, mostly to urban agglomerations. The healthy development of urban agglomerations will play an important role in helping China push forward to its new style of urbanization, narrowing development gaps between regions and between urban and rural areas, and escaping the middle-income trap.

Experience shows that well-developed networked organizations are essential to the development of urban agglomerations. Networked systems help to reduce the costs of spatial connections and transactions between urban agglomerations. The development of transport systems determines the depth and scope of spatial interactions within urban agglomerations and greatly affects their spatial structure and size as well as efficiency in resource allocation. The transport system in China's urban agglomerations is now at a stage of ongoing improvement. To support and guide the development of urban agglomerations is now a pressing issue for China to figure out, in the process of urbanization, namely how to give play to the comparative advantages of different

means of transport, break down market barriers, and build a convenient, efficient, economical, safe, and eco-friendly integrated transport system. This paper presents an overview of urban agglomerations in China, examining the transport needs and trends in urban agglomerations. Its ultimate goal is to propose general strategies for promoting transport development in such areas based on a case study of transport integration in the Beijing-Tianjin-Hebei urban agglomeration.

2. Urban Agglomerations in China

An urban agglomeration is a complex, open and large-scale system characterized by fuzzy boundaries, periodic changes in the sphere of influence, and other elements. It can be defined differently from different perspectives. Therefore, scholars around the world have different understandings and designations for urban agglomeration. Similar concepts include conurbation, metropolitan area, and megalopolis. We believe that an urban agglomeration is an aggregate of a considerable number of cities of different natures, types, and sizes, with a small number of megacities or big cities in the center. Furthermore, it is formed on the basis of certain environmental conditions, industry or value chains, and well-developed integrated transport networks. As far as spatial evolution is concerned, driven by the double forces of concentration and expansion, an urban agglomeration usually experiences the transition from the primary stage featuring the expansionary development of a single city to the advanced stage featuring the development of a cluster of cities.

China's urbanization process has experienced three stages of development, focusing on small towns, cities, and urban agglomerations respectively. The 11th Five-Year Plan puts forth for the first time that urban agglomerations should be considered as the main form of promoting urbanization. Since no consensus has yet been reached as to the quantity and scope of urban agglomerations in China, this paper does not deal with the criteria for defining China's urban agglomerations and their classification. Rather, it examines the 21 urbanized areas [1] listed in the National Main Functional Area Plan. The 21 areas are China's priority or preferred development areas (The State Council of China, 2010), and also represent an important future direction for cities. Some of them have already developed into mature urban agglomerations, such as the Yangtze River Delta area, one of the world's six largest urban agglomerations. Others are still in the initial stages of development. China's urban agglomerations have the following basic features:

- **Urban agglomerations are the most economically developed areas of China.** The 21 urbanized areas incorporate a total of 198 cities whose combined populations and GDPs total approximately reach 890 million and RMB 52 trillion, respectively, thus accounting for approximately 66% and 90% of the national totals. The most developed three urban agglomerations, namely the Yangtze River Delta, Pearl River Delta, and Beijing-Tianjin-Hebei, occupy 4% of the country's territory and are inhabited by 20% of its population but contribute to 38% of its GDP. Moreover, urban agglomerations are where the majority of China's young population is centralized and also attracts the country's migrant population. According to the data [2] regarding migration before the traditional Chinese Spring Festival, the major hubs of migrants in China are the most economically developed Pearl River Delta area, Yangtze River Delta area, and Beijing-Tianjin-Hebei area.

[1] The 21 urbanized areas include Beijing-Tianjin-Hebei, Yangtze River Delta, Pearl River Delta, the middle reaches of the Yangtze River, Chengdu-Chongqing, west side of the Taiwan Straits, Shandong Peninsula, Harbin-Changchun, central and southern Liaoning, Central Plain, area along eastern Longhai Railway line, Guanzhong-Tianshui, Beibu Gulf, Taiyuan, central Yunnan, central Guizhou, Hohhot-Baotou-Erdos-Yulin, Lanzhou-Xining, northern slopes of Tianshan Mountains, Yanhuang area of Ningxia, and central and southern Tibet.

[2] Source of data: "Baidu Migration" map, http://www.qianxi.baidu.com

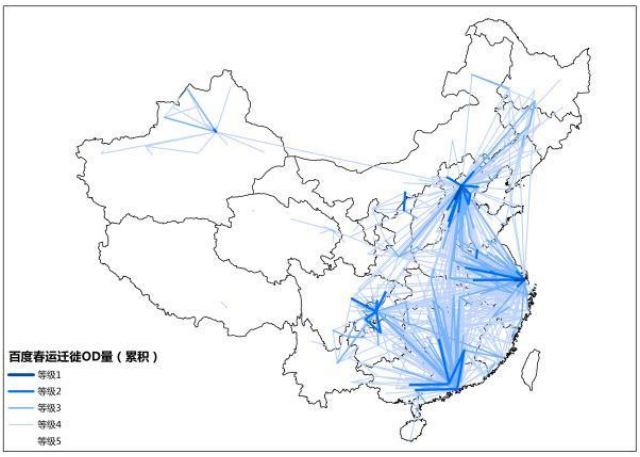

Figure 1：Baidu's Origin-Destination Statistics on Spring Festival Migration

- **Urban agglomerations appear where the economy and transport are well developed.** In the process of reform and opening up, China has also made a shift from T-shaped to π-shaped national spatial development, gradually creating three axes of economic development along the coast, the Yangtze River, and the Longhai and Lanxin Railway Lines. It has thus developed the three major economic zones of Yangtze River Delta, Pearl River Delta, and Bohai Economic Rim, where China's urban agglomerations are primarily concentrated. Fifteen of the 21 urbanized areas are located within these three axes and three major economic zones. In the future, China will build three important railway lines between Beijing and Lanzhou, Shanghai and Kunming, and Beijing and Kowloon, while developing the "two horizontal and three longitudinal" [3] axes. The purpose is to create a multi-center spatial development network.

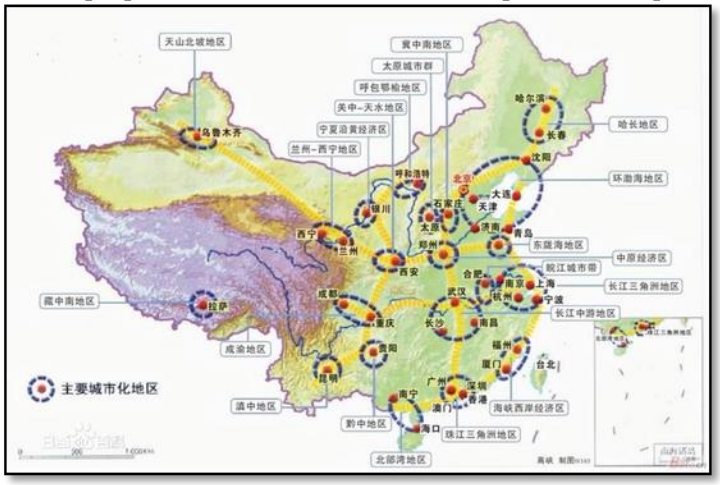

Figure 2：China's "Two Horizontal and Three Longitudinal" Axes for Urbanization

[3]The "two horizontal and three longitudinal" axes refer to the land bridge and Yangtze River axes horizontally and the coast, Beijing-Harbin/Beijing-Guangzhou, and Baotou-Kunming axes longitudinally.

- **Urban agglomerations are densely distributed in the east but are sparse in the west.** There are marked differences between regions in the distribution of urban agglomerations, which are consistent with their regional imbalance of economic space. On the whole, urban agglomerations appear in larger quantities and are densely distributed in eastern China while there are only a small number of sparsely-distributed urban agglomerations in central and western China. Those in eastern China are composed of contiguous areas. There are metropolitan areas where the cities in the center are closely connected to the towns in the periphery. There are also contiguous cross-provincial metropolitan areas. For example, the Yangtze River Delta urban agglomeration has Shanghai and 15 cities of Jiangsu and Zhejiang Provinces in the center, and is expanding into Anhui Province.

Figure 3：Yangtze River Delta Urban Agglomeration

- **Urban agglomerations differ significantly in the stage of development.** On the whole, those in eastern China are at more advanced stages while those in western China are at earlier stages. The urban agglomerations in eastern China are relatively more mature and characterized by larger sizes, higher population densities, and higher levels of development. For example, each of the areas including the Yangtze River Delta, Pearl River Delta, Beijing-Tianjin-Hebei, west side of the Taiwan Straits, and Shandong Peninsula has a population of more than 50 million and a GDP of over RMB 1 trillion. The first three areas, in particular, are the most mature and open urban agglomerations in China, each of which has a population of more than 100 million and a GDP of over RMB 5 trillion. Moreover, they have essentially transformed from a formerly unipolar structure into a multi-center network. The urban agglomerations in central China, including the middle reaches of Yangtze River (Wuhan, Changsha-Zhuzhou-Xiangtan, and Poyang Lake Rim), Harbin-Changchun, and Central Plain, are in the process of development with the influence of cities in the center on the rise but lacking close industrial collaborations between cities. In western China, only the Chengdu-Chongqing urban agglomeration is well developed but the level of urbanization is quite low. Other urban agglomerations are in the initial stages of development or are underdeveloped.

3. Transport in China's Urban Agglomerations: Characteristics and Trends

3.1 Characteristics

Transport plays an important role in supporting and guiding the formation and development of urban agglomerations in China. Urban agglomerations grow along with an improving process of transport system.

- **Urban agglomerations differ widely in the structure of their transport system.** In eastern China where urban agglomerations are well developed, there are closer industrial collaborations between cities and exchanges between cities and towns. Accordingly, the transport system in such areas is undergoing a transition from a radiating structure with a single central point to a multi-center, networked structure. The urban agglomerations in central and western

China are mostly in the stage of "strengthening the core" and their road networks usually have a "radiating structure with nodes".

- **Urban agglomerations appear mainly along transport corridors.** Urban agglomerations and their transport systems affect and promote each other in the process of development. In particular, expressways and high-speed railways shorten the traveling time between cities and thus strengthen the economic ties between them. Therefore, urban agglomerations exhibit a tendency to grow along transport axes (Wu et al., 2013). For example, in the Beijing-Tianjin-Hebei area, there are five cities along the Beijing-Guangzhou transport corridor[4], namely Beijing, Baoding, Shijiazhuang, Xingtai, and Handan, whose combined GDP makes up 51% of the area's total.

- **Rail transit plays an increasingly prominent role in passenger transport in urban agglomerations.** In such areas as Beijing-Tianjin-Hebei, Yangtze River Delta, Pearl River Delta, Chengdu-Chongqing, and the central reaches of the Yangtze, trains run between cities in the center and the construction of intercity railways is gathering speed. A total of 3,000km and 1,900km of intercity railways have been planned for the Yangtze River Delta and Pearl River Delta areas, respectively. In terms of the connections between cities in the center and towns on the periphery, suburban railways and urban rail transit are able to adequately meet the transport needs of commuters and students or those of business trips, offering cities in the center more room for development.

- **Urban agglomerations are important transport hubs.** They are usually located at the junction of multiple transport arteries with access to a rich variety of transport resources, serving as important hubs of outbound transport and transshipments for the surrounding areas. Particularly, a variety of domestic and international transport factors are highly concentrated in the three major urban agglomerations of Beijing-Tianjin-Hebei, Yangtze River Delta and Pearl River Delta, making them gateways to international exchanges as well as international competition and cooperation for China.

- **Transport is highly integrated in urban agglomerations.** There are close economic connections between cities in an urban agglomeration, as well as frequent flows of persons and goods. Transport is highly integrated and convenient. For example, in the urban agglomerations of the Yangtze River Delta and Pearl River Delta, "all-in-one" cards for public transport, connected ETC systems for expressways, intercity public transport, and coordinated emergency rescue operations have made traveling much more convenient for travelers.

- **Mechanisms for coordinating regional transport development come into play.** In an urban agglomeration, transport is usually developed according to well-devised plans. Joint meetings of local governments, such as the joint meetings of mayors in the Yangtze River Delta area and the inter-provincial joint meetings in the middle reaches of the Yangtze River Delta, are held to coordinate the development of transport systems in different cities. However, such coordination mechanisms are relatively loose and their capacity is limited.

3.2 Development Trends

As China's new approach to urbanization advances, urban agglomerations will reach a higher level of development and transport needs will present new characteristics as discussed below, posing new demands and challenges to the development of transport systems.

- **High Growth:** As the level of urbanization risng, China will see approximately 20 million people migrating to urban areas every year, mostly moving to urban agglomerations. The average frequency and distance of travel among urban residents are seven times and five times

[4]The Beijing-Guangzhou transport corridor consists of a few routes including the Beijing-Guangzhou passenger transport route, Beijing-Guangzhou Railway, Beijing-Kunming Expressway, and Beijing-Hong Kong/Macao expressways.

respectively those among rural residents. Therefore, urban agglomerations will have ever-growing demands for passenger and cargo transport and travel by urban residents will surge.

- **High Density:** Various types of transport are needed where urban agglomerations are concentrated, including intercity passenger transport, urban delivery, intercity freight transport, and through transport. A single means of transport would be hard-pressed to satisfy the strong and urgent need for diverse transport facilities.
- **High Efficiency:** The demand for internal passenger transport by Chinese urban agglomerations will grow faster than that for outbound passenger transport in the future. In most cases, passenger transport in urban agglomerations will cover short to medium distances. A typical example would be intercity passenger transport. It is estimated that passenger transport within 200km will account for 95% of the national total. Since passenger transport is time-sensitive, intercity transport needs to be very fast and very convenient.
- **Balanced:** Currently, the majority of urban agglomerations in China are in a stage where cities in the center are expanding as the most influential poles. Their spatial structure has yet to balance out at a higher level of development, and transport needs are not evenly distributed, resulting in traffic being primarily concentrated along the major transport axes. As urbanization and industrialization advance, multi-center, networked urban system will become a mature form of spatial organization for urban agglomerations, and transport needs will experience a transition from axial to relatively balanced networked distribution.
- **Diverse:** Future travel needs in urban agglomerations will be mainly resulting from commuting, business activities, tourism, and leisure activities. In terms of freight, there will be an increase in the transport of raw materials and semi-finished products between upstream and downstream industries, which will be more door-to-door and time-sensitive transport of goods in smaller quantities but with increased frequency that will result in a further improvement to time efficiency.
- **Intensive:** Urban agglomerations are densely populated. Population density is approximately 500 persons per square kilometer in the urban agglomerations in central and eastern China, and up to 1,000 persons per square kilometers in the Yangtze River Delta and Pearl River Delta areas. Given the environmental and resource constraints, urban agglomerations need to focus on developing intensive, low-carbon, and eco-friendly public transport.

4. Strategies for Developing Integrated Transport in China's Urban Agglomerations

The government intervenes, to varying degrees, in the spatial organization and development of urban agglomerations. As a result, a widespread phenomenon has emerged in which cities are striving to be "big and all-inclusive", competing to be top-notch by the same standard. Cities in the center are supposed to serve the majority of functions, with a high population density. "Big city issues" such as massive congestion, long commutes, and environmental degradation have begun to take their toll on the sustainability of China's urban agglomerations.

In such a context, to develop integrated transport in urban agglomerations, China should focus on giving play to the role of transport in shaping their spatial structure and improving industrial distribution. Consideration should be given to transport links between cities in the center and surrounding satellite cities, between cities in the center, between urban agglomerations and other economic zones, and between the world's major countries and regions. Based on such considerations, China should promote the balanced development of transport arteries, networks, and hubs in urban agglomerations, coordinating service delivery and management between different cities and different means of transport, and adopting a focus on the six strategies of "transport first, corridor connectivity, network improvement, hub integration, service improvement and coordinated management". This will ensure that the transport system caters to economic development and land use which is conducive to regional sustainable development.

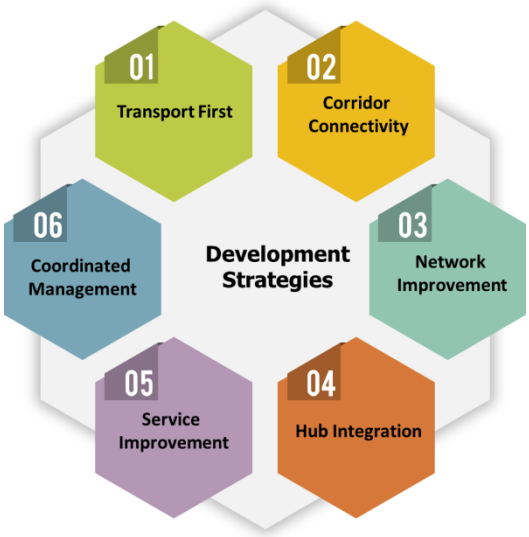

Figure 4：Strategies for Developing Integrated Transport in China's Urban Agglomerations

4.1 "Transport First" Strategy Catering to Long-term Needs

First, to improve the spatial organization of urban agglomerations, full consideration should be given to long-term layout of urban areas and industrial distribution, and transport networks should be used to shape the spatial structure of urban agglomerations and facilitate the concentration and diffusion of people, industries and factors of production. For example, the Hangzhou Bay Bridge, Ningbo-Hangzhou High-speed Railway and other projects completed since 2008 are changing the "Z" pattern of the Yangtze River Delta area into the shape of a diamond, and the radiating structure of the regional urban landscape is morphing into a networked system.

Second, some urban agglomerations in China, particularly those in eastern areas, are faced with tighter environmental and resource constraints (CPC and The State Council, 2014). Land, coastline and other resources are becoming increasingly scarce. It would cost too much to readjust transport facilities, particularly several years after they have been completed. Readjustment is not even an option in some cases. Therefore, "Transport First" strategy should give full consideration on the long-term needs of passenger transport and freight. An integrated transport system in the urban agglomeration should be built advancely, leaving space for its sustainable development.

4.2 "Corridor Connectivity" Strategy Featuring Rapid Transit

Urban agglomerations are usually very large in China. They can cover an area of approximately 200,000km^2, as do Beijing-Tianjin-Hebei, Yangtze River Delta, and Chengdu-Chongqing, or even 317,000km^2, as does the middle reaches of the Yangtze River. To advance the development of large-sized urban agglomerations, it is crucial to bring cities closer and to promote the rational distribution of resources and economic ties between them by developing convenient transport links. To this end, intercity rapid transit systems should be established based on urban area layout and industrial distribution. A comprehensive network of fast transport arteries with large capacity should be built based on rail transit and expressways, connecting key cities in the agglomeration. In highly urbanized and densely-populated urban agglomerations, it is particularly important to develop intercity railways to meet the needs of large-scale and frequent transit between cities. The Yangtze River Delta area is now accelerating its construction of an intercity railway network that effectively connects the 16 central cities.

Moreover, urban agglomerations are important growth poles for the country. They have a role to play in driving the growth of the national economy and in helping China better integrate into the global landscape of development. Therefore, urban agglomerations should intensify efforts to build gateways to the outside world such as airports and seaports and to strengthen their transport links with other economic zones both within China and globally.

4.3 "Network Improvement" Strategy for Achieving Full Connectivity

To develop urban agglomerations in China, it is essential to reduce the cost of connecting cities and towns within an area and to promote the area's concentration and diffusion of industries and resources to achieve economic integration by developing a multi-tiered and integrated transport network featuring full connectivity (Ni, 2014).

First, it is necessary to strengthen the comprehensive transport arteries that have large capacities, high densities, and rapid connections between cities in their centers. In particular, cities which are a short distance away and have close ties should work together to build integrated transport systems based on intercity railways and expressways.

Second, fast and convenient transport links mainly including expressways and trunk line railways should be established between cities in the center and secondary cities so that the former can positively influence the latter.

Third, direct transport links, including expressways and national or provincial trunk highways, between secondary cities ,particularly those that neighbor one another, should be strengthened . Direct rail transit links may also be established if there is a strong demand for intercity transport.

Fourth, a metropolitan rapid transit system should be developed for commuters between built-up areas of cities in the center and satellite cities. The system should include urban/suburban railways, expressways, and rapid shuttle transit. In cases where distances are short and conditions permit, central city rail transit systems may be extended to cover the surrounding satellite cities. For example, Line 11 of the Shanghai Metro is extended to Huaqiao, Kunshan, Jiangsu Province so that it only takes one hour to travel between downtown Shanghai and the town of Huaqiao. This helps Huaqiao better integrate into the Shanghai metropolitan area.

Fifth, the transport links between cities and small towns should be mainly national/provincial trunk highways and rural highways to enhance interconnectivity between nodes.

4.4 "Hub Integration" Strategy Focused on Defining Specific Roles

Transport hubs are important components of an integrated transport network and are crucial to the smooth connection and transfer of in-transit passengers and cargo. Some urban agglomerations in China, particularly those well-developed ones in eastern China, have at least two transport hubs. These can include seaports and airports, and such hubs are usually located in areas administered by provincial authorities. Since large transport hubs such as airports and seaports have a very wide sphere of influence, it is common to find different hubs serving the same focus market. If the roles of transport hubs are not precisely defined, unprincipled competition and wasting of resources are sure to occur, and their functions will not be performed effectively. Therefore, urban agglomerations should look at the big picture and define the roles of different hubs precisely according to their market demand, fundamental conditions, and development potentials. The hubs in different areas should be developed in a coordinated and market-based approach through the bond of capital.

4.5 "Service Improvement" Strategy Relying on Information Technology

Compared with other areas, urban agglomerations are characterized by more frequent person-to-person exchanges, closer industrial collaborations, higher resident demands for time-effiency, comfort and safety, as well as more efficient, cost-efficient and reliable transport of goods required by dynamic economic activities. In developing integrated transport, urban agglomerations should focus on improving transport services and close integration of modern information technology with transport. Technology and standards should be brought into full play in integrating and facilitating service delivery across areas and between different means of transport within urban agglomerations.

4.6 "Coordinated Management" Strategy Centered on Removing Barriers

Urban agglomerations in China are faced with administrative barriers and fragmented management to varying degrees, which hinders the proper and efficient allocation of transport resources. Looking to international practices, a strong coordination mechanism is the basis for achieving regional transport integration. Therefore, urban agglomerations should establish a strong coordination mechanism to balance the interests of different authorities, promote the integration and efficient use of transport resources, strengthen coordination between different areas and different means of transport in transport planning, policy making, standard formulation, and law enforcement, and also to boost the efficient and coordinated management of transport.

5. A Case Study of Transport Integration in the Beijing-Tianjin-Hebei Urban Agglomeration

5.1 Transport Development in the Beijing-Tianjin-Hebei Urban Agglomeration

The Beijing-Tianjin-Hebei area, one of the three largest urban agglomerations in China, includes Beijing, Tianjin and the entire province of Hebei, involving 13 prefecture-level or higher cities. With a land area of 216,000km^2, 2.3% of the national total, this urban agglomeration accounts for 8% of the country's total population and 10.4% of its total GDP. In 2014, the Chinese government made it a national strategy to promote the coordinated development of Beijing, Tianjin, and Hebei, thus relieving Beijing of some of its functions that were not required for a capital city. This resulted in the construction of the Beijing-Tianjin-Hebei area into a world-class urban agglomeration.

Transport in this area is better developed than that in other parts of the country. Widespread highway and rail networks make this area an important road transport hub for the country. The density of both highway and railway networks is more than three times of the national average. The Beijing Capital International Airport is the world's second busiest international airport by passenger traffic volume. There is also a cluster of modern ports scattered along the C-shaped coastline, including the Port of Tianjin, Port of Qinhuangdao, Port of Huanghua, and Port of Tangshan.

Table 1: Economic, Social, and Transport Development in Beijing-Tianjin-Hebei Area (2014)

Indicator		Unit	Whole Area	Beijing	Tianjin	Hebei
Economy & Society	Land area	km^2	216,000	16,000	12,000	188,000
	Resident population	million persons	110.52	21.52	15.17	73.84
	GDP	billion yuan	6,647.4	2,133.1	1,572.2	2,942.1
	Government revenue	billion yuan	886.4	402.7	239.0	244.7
Transport	Road network density	km/(100km^2*10,000 persons)$^{0.5}$	3.4	3.9	4.9	3.3

	Railway network	km	8509	1285	971	6253
	Expressway network	km	8005	981	1135	5889
	Passenger traffic volume of highways and railways	billion persons	1.44	0.66	0.19	0.61
	Passenger turnover of highways and railways	billion persons km	179.2	27.3	24.6	127.4
	Freight traffic of highways and railways	billion tons	2.73	0.27	0.4	2.06
	Freight turnover of highways and railways	billion tons km	1,309.4	103.7	86.8	1,118.9
	Handling capacity of ports	billion tons	1.49	-	0.54	0.95
	Container throughput of ports	TEUs	15,810,000	-	14,000,000	1,810,000
	Passenger traffic volume of airports	million persons	109.55	91.06	12.07	6.42

Note: The calculation of road network density involves both highways and railways.

Passenger transport and freight in this area exhibits different characteristics. Passenger traffic volume is concentrated along the Beijing-Guangzhou and Beijing-Tianjin arteries. The most frequent flows of passengers occur between Beijing and surrounding cities such as Tianjin, Langfang, and Baoding. People also travel frequently between coastal cities, particularly between Tangshan and Qinhuangdao. Passenger traffic between other cities is rather light. In terms of freight, there is frequent transport of goods between Beijing and Tianjin and the busiest traffic is found between Beijing-Guangzhou and coastal arteries. The two west-east arteries, namely Inner Mongolia-Zhangjiakou-Beijing-Tianjin and Shanxi -Shijiazhuang-Hengshui-Cangzhou, are charged with the task of transporting coal from Inner Mongolia and Shanxi via ports to southern China. Railway freight traffic is particularly heavy.

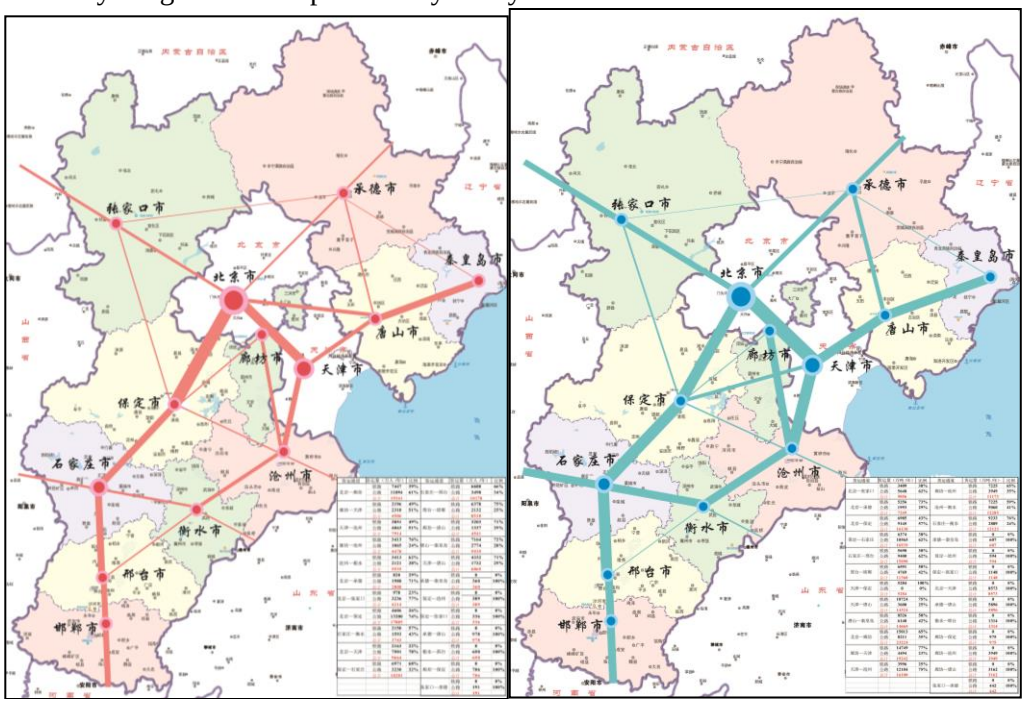

Figure 5 Passenger and Freight Traffic in the Beijing-Tianjin-Hebei Area

5.2 Acute Problems Faced by Transport Integration in the Beijing-Tianjin-Hebei Urban Agglomeration

To coordinate the development of Beijing, Tianjin and Hebei, and to attain the goal of building a world-class urban agglomeration, many problems have yet to be solved in terms of transport.

- **Unicentral, radiating transport networks await improvement.** The highway and rail networks in this area radiate from the only center – Beijing. Some expressways are closed at one end and some sections of national/provincial trunk highways are prone to congestion. All these factors undermine intercity connectivity. Due to the imbalanced road networks and transport structures, an enormous amount of transport between northeast areas and northern and northwest areas is through Beijing, which results in negative impacts on transport and the environment in Beijing.
- **Rail transit is underdeveloped and transport structures lack balance.** The intercity railways between Beijing and Tangshan, Chengde, and Zhangjiakou, and those between Tianjin and most cities of Hebei Province are far from adequately meeting demand. There is also a lack of urban/suburban railways between the built-up areas of big cities and satellite cities. Given the limited freight capacity of railways and the Beijing-centered radiating highway network, the transport of coal and other strategic resources from Shanxi and Inner Mongolia depends heavily on the highways of Beijing and Tianjin, resulting in unusually high usage of highways by bulk transport vehicles.
- **Transport hubs are not developed in a coordinated fashion and there is a lack of smooth connection between different means of transport.** The roles of transport hubs in this area have yet to be precisely defined. Beijing is over-burdened as a regional transit and organizational center for passenger transport and freight while the roles of other cities in the center such as Tianjin and Shijiazhuang are not being used to their full potential. Take airports as an example. In 2014, the passenger traffic volume at Beijing Capital International Airport was 86.12 million persons, exceeding its design capacity of 82 million persons, while that at Tianjin Binhai International Airport was 12.07 million persons, less than half of its design capacity of 25 million persons. The volume at Shijiazhuang Zhengding International Airport was not even one-third of its design capacity. Moreover, it is not convenient to transfer between different means of transport. Port transport systems are not up to par. For example, over 70% of the iron ore at the Port of Tianjin is transported via highways and less than 30% via rail. Port-dedicated highways are also used by common vehicles, which also causes serious problems.
- **Passenger transport and freight are not fully integrated and the level of convenience is low.** Transport development in this area faces administrative barriers. Transport policies and standards are not well-targeted. Coordination mechanisms are yet to be improved. An integrated transport market is yet to be created. The integration of transport services and convenience are at low levels. For example, the "all-in-one" cards for public transport cannot be used across cities, and intermodal transport of passengers and goods on one ticket cannot be achieved.
- **Information sharing is not adequate and management is yet to be modernized.** Beijing, Tianjin, and Hebei's efforts to promote IT application in transport are not planned as a whole. It is rather hard to share information between different areas, different means of transport, and different authorities. Administrative enforcement, operational management, emergency response, traffic guidance, and other aspects are not well coordinated. Advanced information technology is not adequately applied. The development of IT-based, smart transport is uneven within the area.
- **Transport development is extensive and faces growing safety and environmental challenges.** A very demanding task confronting this area is to ensure safety in the operation of major transport facilities, vehicles, civil aviation and railways, and offshore operations in coastal areas. In addition, since the public transport system is yet to be improved, private cars are growing rapidly in number and exhaust gas has become one of the major sources of air pollution in cities.

5.3 Transport Integration Solution for the Beijing-Tianjin-Hebei Urban Agglomeration

To advance transport integration in this area, efforts should be aimed at creating a spatial structure featuring "one core, two cities, three axes, four zones, and multi-nodes" [5]. To relieve Beijing of non-required functions for a capital city and facilitate its industrial upgrading and transfer, the focus should be put on promoting networked system, smart management and integrated services, and building an integrated transport system featuring "safety, convenience, high efficiency, environment-friendliness, and economy".

Figure 6 "4+4+1" Integrated Transport Arteries in the Beijing-Tianjin-Hebei Area

(1) Improving the infrastructure network for integrated transport

A networked structure is the basis for transport integration. Currently, the transport network in this area is not sound mainly because Beijing as the only center of the regional road network is over-burdened in performing its hub functions. On the one hand, connectivity in this area is not strong. Beijing is a transit point in the transport between northeast areas and northwest and northern areas, and between the Port of Tianjin and northwest hinterland. On the other hand, roads in this area are not fully connected, which is not good for the stable operation of the road networks. Therefore, a new multi-center, networked structure should be created and the highway and railway networks should be improved, featuring four longitudinal, four horizontal, and one circular arteries for integrated transport.

First, building the "Beijing-Tianjin-Hebei on the rails". Rail transit, intercity railways in particular, is a weak part of the transport infrastructure in this area. In the future, full consideration should be given to the needs of commuting between Beijing and cities to which some of Beijing's functions are transferred, surrounding new cities, and satellite cities as well as the needs of fast, frequent business travels between key cities within this area. More efforts should be made to speed up the development of intercity railways, particularly those between cities in the center such as Tianjin and Shijiazhuang and other key cities in this area. If possible, general passenger railways may also be used for trains running between cities or between build-up and suburban areas of cities. The intercity railway network can also be connected to the parts of Beijing where people with strong business travel needs are concentrated, such as Zhongguancun and CBD. Urban rail networks should be more closely connected to trunk and intercity railways.

Second, developing a more convenient and unobstructed highway network. The highways of all key cities and towns in this area should be connected and the closed ends of some expressways should be opened. The technical grade of national/provincial trunk highways should be increased;

[5] "One core" refers to Beijing; "two cities" refer to Beijing and Tianjin; "three axes" refer to the development axes of Beijing-Tianjin, Beijing-Tangshan-Qinhuangdao, and Beijing-Baoding-Shijiazhuang; "four zones" refer to the central core function zone, eastern coastal development zone, southern function expansion zone, and northwest ecological conservation zone; "multi-node" refers to regional key cities such as Shijiazhuang, Tangshan, Baoding, and Handan as well as other cities such as Zhangjiakou, Chengde, Langfang, Qinhuangdao, Cangzhou, Xingtai, and Hengshui.

provincial connections should have consistent technical grades; the congestion problem in some sections of cross-region national/provincial trunk highways should be cured.

(2) Giving better play to transport hubs

First, the specific roles of Beijing, Tianjin, and Hebei as transport hubs should be defined more clearly. Beijing should focus on transferring some of its functions as freight center and playing a bigger role as the gateway to foreign countries based on its airports. Tianjin should serve more functions as a regional freight and logistics center based on its port advantages. Cities like Shijiazhuang, Tangshan, and Baoding should increase their capacity to serve the organization of passenger transport and freight.

Second, Tianjin and Hebei should draw on each other's strengths in port resources to achieve common development. The Port of Tianjin should play a bigger role as a shipping center. Priority should be given to container transport on trunk highways and great efforts should be made to develop modern services and improve the capacity for and level of integrated services. The purpose is to develop Tianjin into an international shipping center in northern China. The ports of Hebei Province should focus on increasing service capacity in the transport of bulk cargo such as energy and raw materials. Moreover, shipping lanes, anchorages, pilotage, and other resources should be shared between different parts of the area. Port enterprises of Tianjin and Hebei should be encouraged to establish joint ventures, collaborate on projects, and forge alliances for better allocation of port resources.

Third, the major airports of this area should give full play to their respective strengths to promote the comprehensive use of airport resources. Beijing should improve its airport's international competitiveness and turn it into the gateway to international exchanges. Tianjin should develop its airport into a regional hub and an international aviation logistics center. Shijiazhuang should give full play to low-cost airlines and gradually grow into a regional aviation hub. In addition, airports and airline companies should establish joint ventures and develop cooperation based on market demand to achieve balanced allocation of regional air capacity deployment and route and flight resource. Rail transit links between major airports should be strengthened to lay the foundation for the coordinated development of airports.

(3) Providing better integrated transport services

Service integration between key cities and towns and different means of transport should be boosted through such means as information sharing, coordination of standards and regulations, and application of universal paper documents to establish a "one-bill system" for freight and "one-ticket system" for passenger transport. Information technology such as "Internet+" and cloud computing should be fully used to provide the public with comprehensive travel information services, promote the application of mobile payment in bus, subway, light rail, taxi, and intercity railway services, and boost the use of "all-in-one" cards for public transport across cities. The intermodal transport market should be developed faster, with focus on rail-water connection, highway-water connection, water-water transfer, highway-rail connection, and air-land connection. More transport node facilities such as comprehensive passenger transport hubs and freight hubs (logistics parks) should be built to achieve "seamless connectivity" and "zero distance transfer". The formulation, revision, and implementation of transport service standards should be promoted to improve the quality and level of transport services.

Administrative and market barriers should be removed to establish an open, fair, transparent, and integrated transport market. A blueprint for the development of smart transport in this area should be drawn up. A mechanism should be established to promote information sharing between Beijing, Tianjin and Hebei, and between different authorities, and the sharing of resources

between different means of transport. All the transport information can be shared and exchanged on "one platform". The emergency response systems of Beijing, Tianjin and Hebei should be connected and the road network operation information should be made available online to create a single system of transport supervision and emergency response for the whole area.

(5) Establishing an effective coordination mechanism

A high-level coordination mechanism led by central authorities should be established, involving relevant national authorities and the authorities of Beijing, Tianjin, and Hebei. Taking into account their respective interests, Beijing, Tianjin, and Hebei should work together on major issues in the field of transport such as plan formulation, construction arrangements, and operation and management, to ensure "consistent plans, synchronous construction, integrated transport, and coordinated management". A joint meeting system should be established at provincial level to act on the major decisions made by the national government, facilitate the resolution of specific issues, and promote the implementation of specific projects.

(6) Promoting the intensive, low-carbon development of transport

First, developing an urban transport system with public transport as the mainstay. Core cities such as Beijing, Tianjin and Shijiazhuang should focus on developing rail transit and building a large-capacity public transport network by constructing different forms of urban rails. Big cities such as Baoding and Tangshan should coordinate the development of different forms of public transport, and develop a public transport network with medium- to large-capacity public transport such as rail transit and BRT system constituting the framework, and conventional bus service as the mainstay. Medium-sized cities should focus on improving their conventional bus system.

Second, establishing an integrated transport safety management system featuring full coverage, fast response, integrated command, and coordinated actions. National highways, key bridges and tunnels, ports, and key vehicles should be better monitored. Offshore search and rescue systems should be established in the coastal areas of Tianjin and Hebei to ensure response within 90 minutes after an emergency occurs less than 100 nautical miles offshore.

Third, promoting the development of green, low-carbon transport. Land, coastline and other resources should be used comprehensively. Energy-efficient cars and those fueled by new and clean energy should be promoted. Electric vehicle charging stations, and other clean energy filling facilities should be provided at more locations. Beijing, Tianjin and Hebei should apply the same standards regarding motor vehicle emissions and oils, and promote drop and pull transport on highways. Anchored ships should be encouraged to use electricity on shore to reduce emissions.

6. Conclusion

This paper examines the characteristics of China's urban agglomerations and transport development by specifically looking at the 21 urbanized areas listed in the National Main Functional Area Plan. On the whole, Chinese urban agglomerations are mainly concentrated on the three axes of economic development along the coast, the Yangtze River, and the Longhai and Lanxin Railway Lines, better developed and more densely distributed in the east than in the west. Transport plays an important role in supporting and guiding the development of urban agglomerations. Transport networks, services, and management have been improving. China's urban agglomerations have been growing along with transport. For the healthy and sustainable development of integrated transport in China's urban agglomerations, this paper examines the transport needs and trends in such areas and argues that future transport will feature high growth,

high density, and high efficiency, and there will dire needs for balanced, diverse, and intensive transport. Taking into account the realities of urban agglomerations and their transport development, this paper proposes six strategies of "transport first, road connectivity, network improvement, hub integration, service improvement and coordinated management" for developing integrated transport, and specifically points out the prominent problems facing transport integration in the Beijing-Tianjin-Hebei area and offers a solution to the problems.

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