Experience and Reference of Implementing Public Transport Priority Strategy Dominated by Urban Rail Transit in Tokyo

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Abstract. Urban public transportation is the main effective way to solve the problem of increasingly congested city ground traffic, and public transport priority is the important guarantee to realize the way. Due to the short domestic history, there are problems to be solved in the respects of on the implementation of "public transport priority" in specific operation method, implementation measures and matters needing attention etc. Some oversea cities with high population density and serious traffic congestion have made some exploration in public transport priority development whose experiences are worthy of reference. Tokyo, the typical oversea city, has been selected out by this paper. Analysis has been down on the issue of the experiences and achievement of Tokyo in implementing the public transport priority strategy which is donated by urban rail transit, and experiences are summed up. On the basis of it, some suggestions have been proposed for the implementation of China's large cities public transport priority strategy.

Introduction

With the advancement of urbanization in our country, the phenomenon of increasingly congested road in large cities is increasingly serious, which lead implementing the public transport priority strategy to an inevitable trend in urban traffic. It is not only the effective measure to alleviate urban traffic congestion, but to improve the urban living environment and to promote sustainable development of cities. Priority to the development of public transport has become a global consensus of easing city traffic congestion.

From a managerial point of view, public transport priority mainly includes the following two aspects. First, various modes of transportation should be coordinated legitimately. It means that bus, BRT, urban rail transit should be arranged reasonably, so that the city public transport system can be built as a whole and can realize its whole optimization, which will lead to the promotion of the attraction of public transportation. Second, public transport priority policy should be formulated and implemented. Bus lane is the manner often used in road public transport. Although bus-only lanes can encourage people to use more public transportation on travelling by improving the rights of way of public transportation, this method still has a lot of inevitable shortcomings. On the one hand, the reallocation of road traffic facilities and way rights makes the limited road resources more strained, which inhibiting other vehicles’ using. On the other hand, the continuity of driving bus and the exclusiveness of bus lanes increase the detour distance of other traffic behavior actors because of increasing obstacles on the road. In addition, bus station layout’s first consideration is the convenience of buses’ stop and start because the main purpose of setting bus-only lanes is to provide fast driving conditions for buses. Due to this, interference may be produced by passengers who are getting to other lanes of traffic state.
To avoid the problems above, and to save the land resources in the tense urban land, some cities in developed countries have adopted public transport priority strategy dominated by urban rail transit. Tokyo is a representative city of them.

Overview of Tokyo urban rail transit

Infrastructures construction. Japanese cities implement the policy of public transport priority strategy which is dominated by urban rail transit. Tokyo is a typical representative. Tokyo, the capital of Japan, a large city with a population of 12 million intensity, is generally divided into three areas including 23 wards, Tama area, and islands consisted by offshore islands such as the Izu islands and the Bonin islands. It effectively alleviates the urban ground traffic congestion problem by using advanced rail transit.

As one of the world’s richest and most developed cities, Tokyo has the world's most complicated urban railway transport system with dense flow of people and commuter station group. Downtown Tokyo has a strong rail transit network constituted by 17 Shinkansen lines, 13 the private railway lines, as shown in figure 1.

Fig. 1. Tokyo subway route map

A system extending in all directions has been made in Tokyo with more than 800 sites and dozens of subway and tram lines which has become an important part of the public transport system in the city. It is the urban rail transit network with high density that supports the busy people in this crowd city. The goal of saving land resources, smoothing road traffic, saving energy and protecting the environment is reached by constructing a large number of urban rail transit infrastructures, encouraging people to use more public traffic to travel instead of car.

Line scale and density. Downtown Tokyo uses Musashi loop line as the boundary of the city. In this district, there are about 50 lines of subway, light rail, monorail, automatic track, and other forms of urban rail transit, which are of 830 km and operated respectively by more than 10 state-owned companies and privately owned railway companies. Outside the loop there are doses of suburban or inter-city rail transit lines distributing and the length of the total is about 1500 km. Taking the parts which are constructing into consideration, the density of rail line network in central Tokyo is up to 2.2 km/km², and both the line’s length and density are first in the world.
**Network speed combination.** Japan has various forms of urban rail transit. Besides the ordinary Wheel-rail subway and light rail, there are cross monorail transport system, hanging monorail transport system, linear driving rail traffic system, and new automated guided transport systems etc. In Tokyo urban rail lines, four different speed level standards are offered, including high-speed Shinkansen, fast intercity lines, medium-speed train lines, and the ordinary light rail line. The distribution of velocity is shown in table 1.

<table>
<thead>
<tr>
<th>Speed per hour [km]</th>
<th>high-speed Shinkansen</th>
<th>fast intercity lines</th>
<th>medium-speed train lines</th>
<th>ordinary light rail line</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>260</td>
<td>100</td>
<td>80</td>
<td>50~70</td>
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</table>

**Coverage rate of central area.** Coverage rate of central area refers to the ratio of the sum of 800m in each side along the line of the net and the geographical area of downtown. As Tokyo rail line network density is high, the sum of total 800m calculation area along each side of the line is far more than the geographical area in Tokyo downtown. As a result of it, the central area of coverage of the rail line network in Tokyo metropolitan circle is 100%.

**Number of transfer nodes.** As mentioned above, rail transit line network covers the whole downtown Tokyo, dotted with the transfer nodes formed by the cross of lines. According to an incomplete statistic, only wild, the number of transfer nodes number is up to 112 within the Musashi loop line. The nodes are joined by at least 2 lines and at most 5 lines. Taking the stations which average distance between two of them is about 1 km into account, the subway station density in downtown Tokyo is even as much as the bus station’s in cities of China. A metro station can be met in Tokyo with 15 minutes’ walk.

**Convenience**

**Convenient public transport hub transfer system.** In Tokyo, there are 32 major transport hubs, which take the urban rail transit, regular bus, the National Railways JR lines and other transportation systems together as a whole. Through these hubs, passengers are distributed, converted and transported efficiently every day. Tokyo traffic hubs can generally realize platform transfer among the various modes of traffic. Hub stations often have several layers. The platform number of the ones connecting to large railway station is up to a dozen. Taxis and buses distribute on both sides of the hub on the road surface or the underground surrounding, while bicycles, cars and designed to park under the ground. Besides this, rail transit lines and train lines are elevated above the ground layer, in which way both the railway traffic security and rapidity can be guaranteed and do not hinder the development of urban land. The road traffic, ground bus lines, and rail transport are all on their own orbits with no cross interference. Passenger flow is organized reasonably, efficiently and orderly. Urban life efficiency is ensured by the seamless connection of traffic inside and outside the city. Figure 2 describes the Shibuya station transfer system.
The interwoven network of trolley bus and subway in Tokyo is very convenient for people to change. Without getting out of stations, people can travel to any part of Tokyo through transfer to different lines. This network provides convenient conditions for people to travel. What’s more, some lines set in large buildings, and link to multiple other tram lines, in which way change to another line is easy. Due to this, people travel more in rail transit, and private cars become a burden instead.

**City public transport hub buildings.** Transport hub construction not only solved the problem of traffic transfer, but also formed a unique Tokyo urban hub public buildings, where become the center of the city's main public activities and play comprehensive functions in city life. For years Tokyo has formed a variety of distinctive public centers integrated transport hub. Among its 32 large-scale hub stations, Shinjuku, Shibuya, Ikebukuro, Tokyo, Ueno are more famous. These five largest integrated transport hubs are all located in JR Yamanote line.

**Advanced Equipments.** Urban rail operator attaches great importance to the introduction of equipment to meet different customer needs. This is helpful to attract customers. Some of the measures are listed as follows:

1) The introduction of automatic vending machines and automatic doors;
2) Install accessibility for people with disabilities;
3) Set up clear signs at the stations;
4) Issue generic cards which can be used in different operators’ routes;
5) Strengthen interaction between different modes of transport, such as bicycles, taxis, buses and private cars.

**Eliminate the inconvenience**

**Setting barrier-free facilities.** In the Government's Overall Development Plan of the Tokyo Metropolitan Area, Tokyo proposed the public transit-oriented urban land policy. The purpose of adjusting the distribution of urban functions is to spread urban functions to the outskirts of the city, by which the central area of the tidal transportation and can be reduced and traffic conditions can be improved. As Japan's trend of population aging is accelerated, the Japanese government promulgated traffic rules and regulations that barrier-free facilities should be designed at the station tunnels and station squares to facilitate the travel of the senior and the disabled citizens.

**Easing noise and vibration.** The noise and vibration generated by the running train are a significant disadvantage in rail transportation. To alleviate the noise and vibration in line on the "elevated" and "ramp" lots, these following measures are adopted by Tokyo.
1) Develop and use the appropriate type of insulation equipment;
2) Develop and adopt effective track structure;
3) Grind tracks and wheels very smooth.

**Eliminate plane intersections.** With the rapid development of highway transportation and the improvement of train speed and departure frequency, plane intersection of rail transportation and highway become a serious social problem. Interchange is widely promoted in Tokyo to solve this problem. However, due to the substantial costs, it is extremely necessary for highway department, urban rail transit operators and the government to co-operate.

**Other supporting methods in Tokyo public transport priority strategy**

**Limit private cars.** A high capacity bus occupies a certain road area, which is equal to area occupied by two cars, while its passenger capacity can be 40 times of the two cars. The increase of private car ownership has a great pressure on urban traffic. Therefore, there is a close relationship between private car guidance and the realization of the "bus priority".

For proper control of the fast growing of private cars, Tokyo government stipulates that car traffic volume should be controlled within 25% of the total traffic volume. Two measures have been taken to ensure this policy: one is to raise taxes, such as car license tax, fuel tax; the second is to enhance the charge standard of cars, such as vehicle performance fees, insurance premium, fuel prices, parking fees, highway tolls, etc.

**Set the residential area along the urban rail line.** In order to develop their business, private railway companies all hope to form a large-scale residential area along the railway. Tokyu Corporation, one of the largest private railway companies in Japan, extended its railway line into a southwest suburb of Tokyo, and transformed the original agricultural area which along the line into a large-scale residential in the absence of any government assistance in the case of funds. This is a typical example of using private railway company's vitality to develop a city.

**The ground bus system.** As a supplement of subway line network systems, Tokyo ground public transport system is built along the city road and showed as a network-like distribution;

Lots of bus lanes are divided to ensure the priority of bus transport system which also ensures the fast, accurate and efficient of buses. The ground public transportation system is mainly formed by buses and taxis, and it closely connects with rail transit stations, urban transportation hub and foreign transport hub. This system offers short transfer distance, a high standard of service, high distribution density, and clear instructions.

More than 90% of the residents and office workers are within the scope of rail transit and ground transit station service which radius is 400 meters. Most of the citizens' basic travel requirement has been met by those facilities.

**Revelations to the development of public traffic priority in our big cities**

**Worthy points of Tokyo mode**

**Urban planning first.** When forming a new overall urban planning, urban public transport planning should be incorporated into the overall urban planning. As urban rail system in our country is in its infancy, researching layout and scale from the vision of urban traffic hub development will lay a good foundation for the healthy development of urban traffic system. Only by taking construction of advanced regional public transport and guiding urban residents to public transport before the popularity of the private car, can the city public transport priority system have enough space to develop.

**City transferring hub planning and construction.** By improving the transfer conditions, which can improve the comfort of the public traffic, more pedestrian can be attracted to. In addition to the
transfer platform of buses and trams, the problem of long transfer distance between different line sites, intersections between import and export, bus and subway, different subway lines are all exits. Location of bus stops should be reasonable emplaced and can be easily reached from subway stations. Rapid bus transit strategy should also be implemented, which can make the residents travel choice more diversified.

Large public life center can also be built in traffic hub, by which can the hub’s comprehensive service level be enhanced.

Scientific Management. Scientific management is the guarantee of the smooth implementation of public transport priority. Urban traffic management departments should be integrated to avoid fragmented situation. The efficient, reliable coordination mechanisms and rapid response of road transport network and rail transit network can be realized by centralized scheduling operations. Beijing has taken measures in this regard. Beijing rail transit command center, area of 1350m², had been put into use in 2008. It not only manages Beijing subway lines, but also takes the 4th line, owned by the MTR Corporation, into it for unified management by the MTR Corporation.

Rethink points of Tokyo mode

Ordinary road transport development is limited. Tokyo subway is complex with numerous sites and lines. It often takes one hour around for pedestrian to get to their destination. Tokyo road buses is few in number, and the line is generally from one rail traffic station to another, which means that it only plays a supporting role. If Chinese people can obey the traffic rules, reducing unnecessary blockage, taking buses in China will be much more convenient than taking Tokyo subway with many transfer stations.

Excessive dependence on rail transport. Most residents take the radically private railways in outskirts of Tokyo to travel. Once there is a problem, such as typhoon or electric system problem, many lines will outage which can affect hundreds of thousands people in rush hours. No alternative can be chosen because of the infrequent bus and extremely expensive taxi.

In addition to bad weather, suicide cases often occur in Tokyo subway, such as jumping from the track. Those cases cause outages. As rail traffic is "too perfect", many lines are connected directly. For example, Odakyu Line is connected to Tokyo Metro Chiyoda line; a Tokyo Line's tram which comes out from Yokohama turns into a subway at station Shibuya, and turns into a Tobu tram when out from Asakusa. This consequence is that, once one of the lines is in accident, all lines will be affected. And if there are problems, 30 minutes, sometimes even several hours outage will happen.

Aging and seriously overloading equipments. Both rail and highways are faced with the problem of aging and seriously overloading equipments. Ginza subway line has opened for 100 years. Because of the too small original tunnel size, up to now only a narrow train can be used, which lead to the extremely crowd people in the train and station, especially at peak hours.

Accelerate the separation of business districts and residential areas. The remarkable development of Tokyo rail network accelerates separation of business districts and residential areas, which forms the world's famous remote commuting flow. What’s more, there has a significant difference on the environmental requirements between business district and residential areas. Rationality of urban development planning which cannot prevent the skyrocketing land prices is open to question.

Pedestrian emergency evacuation in hub. In 1995, Tokyo subway was attacked by Sarin gas which killing 12 people. More than 5,000 people were injured, and 14 people were permanently disabled in this accident. As the subway is constructed underground, it is limited in space and has a high personnel density. Once the case of natural disasters, emergencies and other unforeseen circumstances occur, casualties and property losses will be much greater than that in other types of buildings. Therefore, pedestrian emergency evacuation in integrated hub station must be considered in the development of rail transportation.
Conclusions

In conclusion, the public transport priority strategy which is donated by urban rail transit in Tokyo has many places worth us to learn from, while there are some points for us to rethink. By absorbing its essence and discarding its dross, domestic public traffic priority strategy can be better implemented.

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