

SOLUTIONS TO PUBLIC TRANSPORT CHALLENGES: THE SOLUTION OF URBAN PUBLIC TRANSPORTATION - THE DEVELOPMENT AND APPLICATION OF BRT

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ABSTRACT

With the development of society and economy, the trend of urbanization and motorization in China has led to the increasing traffic issues in cities, which are mainly shown as traffic congestion, energy shortage, environmental pollution, noise pollution and frequent traffic accidents. The urban public transport system has become the main means to solve the contradiction between the supply and demand of urban traffic and the adjustment of the traffic structure with its less per capita dynamic occupancy of road surface area, low per capita pollution, etc. However, due to the shortcomings of the conventional public transport system, the urban public transport system is difficult to meet the travel needs of residents, especially in the cities where rail transit is not fully developed. Bus Rapid Transit System is an effective means to solve the existing traffic contradictions in the city and to adjust the new traffic layout. The Bus Rapid Transit System originated in Curitiba, Brazil, which uses modified public transport vehicles, operates in the accommodation lanes of public transportation and keeps track of the traffic characteristics. It's a convenient and fast public transportation with flexibility of ordinary bus and a new public transport system between rail transit and bus transit.^[1] That system has low cost, less space, short construction period, fast operating speed, large volume, environmental protection and is easy to develop expressway network crisscross.^[2] These characteristics can effectively alleviate traffic congestion and other problems, reduce the travel cost of residents and improve the quality and efficiency of transportation. But there are also some problems in the development of BRT, such as unclear function orientation, problems in the setting of exclusive bus lanes, and coordinated operation between BRT and regular buses. In view of these problems, the methods and means to solve the problems have been put forward. Through these solutions, the BRT system can be better developed in China.

Key words: Public transport; BRT; Traditional public system; Rail transit

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2 PUBLIC TRANSPORT PROBLEM

Urban public transport mainly includes rail transit and public bus transport system. The followings are the common problem of public transportation system in large and medium cities of China.

1.1 High motor vehicle growth rate and low per capita occupancy of road area

Over the past ten years, the growth rate of Chinese cars soared dramatically. The annual growth rate of vehicle ownership was above 10%. In 2017, the number of cars in Beijing reached 5.640 million. But on the other hand, urban roads did not achieve corresponding rapid growth. The per capita road area of China is about 15.6 square meters, while the average per capita area of developed countries is more than 20 square meters. The growth of road area cannot meet the travel needs of the growing population, thus the traffic situation of urban road is becoming more and more serious.

1.2 Inadequate traffic planning

In the process of planning and construction of many cities, various transportation modes are lack of overall planning. The network level of public transport system is relatively simple. The inconvenience of transfer system makes the attraction of bus greatly reduced, which has a negative impact on the further development of urban traffic. The routes of local area are not reasonable and the density is low. The difficulty of transfer happens occasionally. Even in some places there are fade zones of transit. This phenomenon has brought inconvenience to the urban residents. Besides, traffic planning and urban planning have not been fully cooperated, resulting in the lack of organic connection between the traffic roads and the buildings on both sides of the road. In the long run, urban traffic construction has randomness, blindness and short-term behavior.

1.3 Low service level and sharing rate

The rapid increase in rates of car ownership and the lack of city road construction of planning and investment make the road resources fairly tight, the bus lanes often occupied with cars, resulting in a great reduction of the conventional public transportation service level. The conventional bus is facing the vicious circle problem with road congestion, the decline of bus service level, the attractiveness of bus attraction, the increase of private transportation mode, resulting in worse road congestion. At present, some cities have implemented a series of Public Transport Optimization policies. The total volume of public transport is on the rise. However, the proportion of public transportation is still relatively low, even in some cities showing downward trend.^[3]

1.4 The lack of rail transit development

At present, in most urban public transportation systems of China, buses take up the main body and takes over 80% of the city's passenger traffic. City rail traffic has the characteristics of short-time travel, unoccupied road resources, large capacity, high reliability and fast

speed. In city center, it's undoubtedly the most ideal way of transportation, but it has some drawbacks like high cost (cost for hundreds of millions of dollars per kilometer), long construction period (most of the city needs 20-30 years in order to build a planned rail transit network), and the relatively low coverage rate (mainly in the city center, around the outskirts of the city are rarely considered) and other defects. According to the current situation of urban rail transit system that have been built in Beijing, Shanghai and other cities, the construction of rail transit network will take a long time.

1.5 Serious environmental pollution

The deterioration of traffic conditions leads to the further increase of motor vehicle emission, and traffic pollution became more serious. The pollution of vehicles to the environment comes mainly from exhaust, crankcase, axle, and particles produced by brake wear and tear. The main pollution components are CO, NO, hydrocarbon, lead, solid particles and so on.

2 CHARACTERISTICS OF BRT

2.1 Promoting the sustainable development of Urban Public Transport System

With the rapid development of cities and the continuous growth of car holding quantity, the establishment of bus rapid transit network can alleviate congestion, and make effectively use of urban road resources. Its per capita possession of road resources is only 1/20 of that of car,^[4] which plays a key role in ensuring the normal travel of residents and the sustainable development of urban transport.

2.2 Flexible construction and operation

BRT not only keeps the characteristics of rail transit but also has the flexibility of conventional public transport. This mode of transport combines the advantages of rail transit and conventional bus. BRT does not use track, but uses the same road surface as the ordinary lane, which has good cohesion. Compared with rail transit, which needs to be fully built to operate, the construction and operation of BRT can be implemented in stages and sections. At the same time, the route, frequency, vehicle type and space design of BRT system can be adjusted according to the needs of passengers and local characteristics. The organization and scheduling of system operation are also more convenient and flexible.

2.3 Reduce residents' travel costs

The BRT system in the Brazilian city of Curitiba has reduced the cost of a lot of transportation investment. The local government has used these funds to improve the living environment of the city and the quality of residents' life. Because of the low operating costs of bus rapid transit and government subsidies for public transport, local low-income residents spend only 10% of their income on transportation. The construction of BRT plays an important role in reducing the financial burden of urban government and reducing the travel cost of residents.

2.4 The advantages compared with the traditional public transit system

2.4.1 Large volume and high security

In terms of transportation capacity, the BRT system uses a unique mass transit vehicle to improve the cycle load rate. At the same time, the bus lanes and crossing priority are used to improve the average speed. Therefore, the BRT system can realize the transportation capacity close to the light rail transit. Table.1 presents the data about the transportation capacity of BRT compared with other rail transits. In terms of safety, road and intersection priority is used to completely separate BRT system from other traffic modes, and it will not mix with other motor vehicles or bicycles, which will greatly reduce traffic accidents such as collision and rear end collision. At the same time, the vehicle tracking system and the traffic accident management system are used to improve the emergency response capacity after the accident. After the opening of the 'New Century' line in Bogota, Colombia, death rate on the road reduced by 93%.

Table.1 The Transportation Capacity of BRT Compared with Other Rail Transits

CITY	MEANS OF TRANSPORT	PEAK TRAFFIC FLOW(Per Thousand People/per hour/single-track)
Hong Kong	Metro	81
St.Paul	Metro	60
London	Metro	25
Bangkok	Railway	50
Mexico	Railway	39
Colombo	Light Rail	30
St.Paul	BRT	61
Bogota	BRT	53
Curitiba	BRT	15
Guangzhou	BRT	27
Istanbul	BRT	19

Data sources: Institute for Transportation&Development Policy

2.4.2 High speed and high degree of comfort

Compared with conventional bus, BRT is much faster and more comfortable than conventional bus. It runs on bus lanes and has priority at intersections, so naturally it is less disturbed by other traffic modes. In addition, the system form of selling tickets outside the car, the reduction of the setting of horizontal platform and the decrease of stations shorten the stop time of bus at the station. Therefore, in terms of transportation speed, BRT has the advantage of being able to compete with small cars. While increasing the speed of operation, the intelligent transportation system is widely used to help BRT optimize the operation organization, adjust the departure interval, provide information services and so on, so as to achieve better public transport service. The new type of bus used by BRT is more spacious, less noisy and more comfortable to take. The horizontal boarding system is convenient for bus passengers, especially for passengers with mobility problems and luggage.

2.4.3 Low energy consumption and low pollution

The new type of bus vehicle adopted by BRT has the characteristics of low exhaust emission and low energy consumption. At the same time, the intersection priority and setting of dedicated lanes avoid repeated acceleration, deceleration and stopping when congestion in a certain extent, which can effectively reduce vehicle emissions. Compared with private cars, bus rapid transit systems reduce energy consumption and pollutant emissions by 90% per capita.^[5] Table.2 presents the data about pollutants every 10,000 people and per kilometer discharged by different means of transport.

Table.2 Pollutants Discharged by Different Means of Transport

POLLUTANTS MEANS OF TRANSPORT	Private Car	Cab	Traditional Bus	Rail Transit	BRT
CO ₂ (ton)	140.2	116.9	19.8	7.5	4.7
NO ₂ (kg)	746.0	662.0	168.4	17.5	42.0
Fuel Consumption (ton)	49.2	41.0	6.9	2.6	1.6

Data Sources: International Energy Agency (IEA). Bus System for the Future - Transport Achieving Sustainable Transport Worldwide, IEA/PRESS(02)18, August,2002

2.5 The advantages compared with the rail transit system

2.5.1 Short construction period

The construction period of single bus rapid transit line is generally 1~2 years, that of light rail system is about 4~6 years, that of subway system is about 8~10 years.^[6] Policymakers, by contrast, can make the promise of building a bus rapid transit system a reality in time, making the residents immediately feel the changes it has brought to the city.

2.5.2 Low investment and operating costs

The BRT system uses the road driving mode and does not need to introduce the track special vehicle. The existing road can be used as long as be improved. So the engineering quantity is small and the initial construction cost of the system is low. Although investment in rail transit and bus rapid transit systems varies considerably from place to place around the world, BRT systems cost only 1/10~1/20 of the cost of rail transit in general. Table.3 presents the investment cost of BRT and other rail transits. In the world, the rail transit system in most cities is more than enough to make ends meet, and its operating expenses generally need the financial subsidy of the local government. The Paris subway government subsidizes 780 million pounds a year, 67% of the operating costs of the Mexico City metro are subsidized by the government. The annual loss of subway operation in Beijing was initially 500 million CNY, but later increased to about 1 billion CNY. However, some successful BRT systems, such as those in Bogota, Colombia, have reached a fiscal balance in their first year of operation.

Table.3 The Investment Cost of different means of transportation

Means of Transportation	BRT	Light Rail	Metro
The Investment Cost (per kilometers/billion yuan)	0.3~0.75	0.6~1.7	6~9

Data Sources: National Bureau of Statistics of China

3 THE PROBLEMS OF BRT'S DEVELOPMENT IN CHINA

3.1 Occupation of road resources

Because of the less per capita occupation of road resources, BRT is helpful to relieve the traffic pressure. But this mode of transportation still belongs to the road-based public transport system, and it requires the dedicated right-of-way. Most roads of this system will take up existing road resources except a few additional tunnels and overhead roads. There is no doubt that this situation would create a great impact on the road net and other traffic especially on automobile traffic in some large cities with high traffic saturation and shortage of road resources.

3.2 The functional orientation is not clear

The advantages of bus rapid transit have attracted the attention of many cities. But the functional orientation of BRT is not clear in actual development. The local government cannot propose BRT development patterns adapting to urban development. There are many cities planning and constructing the BRT system, such as Beijing, Hangzhou, Xi'an, etc. Some of these cities have built a certain scale of rail transit, some are building rail transit, some are planning to build an orbit, and some are not planning to build rail transit system. Certain cities have not targeted their own characteristics and economic strength in the development of BRT, and clearly put forward the short-term and long-term functional orientation of rapid transit in urban transportation.

3.3 Obstacles to the setting of exclusive bus lane

There are huge difficulties in setting up dedicated lanes for arterial roads with high traffic loads. This situation greatly weakens the advantage of BRT. For example, the shortage of Hangzhou BRT Line 1 is that most sections are not strictly exclusive. Other vehicles can enter the exclusive bus lane, which affect the speed and punctuality rate of BRT and reduce the transportation service level.^[7] The exclusive bus lane width should reach 3.50m to guarantee safe and rapid operation. But the lanes are too narrow in some cities due to the lack of urban land. For example, only few lanes with a width of 3.50m and the rest are 3.0m wide in Changzhou.^[8]

3.4 Problems on the coordination between bus rapid transit and traditional bus

Many related traditional bus lines have been adjusted during the construction of BRT. But these adjustments often lack of the deep planning and correlation research. This situation could cause the loss of multiple routes and extend the waiting time for passengers. If traditional bus lines to the destination are repealed, passengers will be forced to ride to the BRT station and transfer to BRT. This increases travel costs and passenger flow volume of BRT. Therefore, the operation of rapid bus and traditional bus needs to be coordinated with each other, otherwise it will lead to more concentrated passenger traffic and more serious congestion.

3.5 Limitations of speed and transportation capability

Although the design speed is high, bus rapid transit still would be affected by transverse traffic at the intersection because the exclusive bus lane is not completely exclusive. At the same time, bus signal priority cannot set on all roads and BRT is affected by delays at intersections. As the result, speed and transportation capability will decline.^[9]

4 THE SOLUTIONS TO CHALLENGES

4.1 Create space for BRT's construction

The city structure is facing new adjustment during the process of rapid urbanization. The road for rapid transit and other vehicles should be divided in the process of urban road planning. Meanwhile, the nature of land-use and land use intensity along the road should be limited. Thus, a public transport-oriented land layout model could be realized and this model can create space for BRT's construction.

4.2 Suit measures to local conditions and focus on efficiency

Each city should determine the functional orientation of BRT and choose the suitable route development mode for traffic combining with the population size, distribution of the trip and average trip distance of the residents. At the same time, each city should take different modes of development according to its own characteristics and economic strength to achieve the goal of increasing traffic volume and shortening operating time. If the conditions are suitable, all facilities of system can be built. Otherwise, existing exclusive bus lanes and urban rapid road can be utilized. For example, the fast road inside the Fourth Ring Road is 215km long in Beijing. Rapid bus service could be established in a short time through setting stations and bus lanes on the fast road.

4.3 Coordinate the relationship between BRT and other modes of transportation

Although the bus rapid transit is important vehicle with advantages of low cost and excellent performance, it cannot completely replace other rail transit systems. It is recommended to use rail vehicles such as light rail and subway as the main way to solve traffic problems in the centre of some metropolis, large-city. The planning of BRT system should be coordinated with rail transit and traditional bus. At the same time, it should form a fully functional independent system.

4.4 Accelerate the research of high and new technology

Because of the use of bus signal priority technology, the whole BRT system still can function well, even though the city cannot set the exclusive bus lane. The research indicates that the 30%~40%shortened running time is due to the intersection bus signal priority.^[10] Therefore, it is necessary to accelerate the development of signal priority control technology system, including the release priority system, GIS and signal exchange technology, etc. At the same time, it is necessary to develop the information technology for passenger, vehicle positioning technology, E-ticket and electronic clearing system. These technologies could form a intelligent public transport information system.

5 CONCLUSION

As an indispensable part of the urban public transport system, the public transport system plays an important role in urban transportation and urban development. Rapid public transport is recognized as an effective means to solve the existing traffic travel contradictions in the city and to adjust the new traffic layout of the city. Although there are some problems that cannot be ignored in the development and application of the system, the benefits it brought is far better than that of other transportation modes. Through a series of measures to solve these problems, the development of the BRT system will be more and more successful.

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