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China National Energy Development Strategy and Policy Analysis

西安市发展快速公交系统技术报告

TECHNICAL REPORT ON XI'AN BRT SYSTEM DEVELOPMENT

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Contents

1. Challenges and solutions to Xi'an's urban transportation problems

1.1 Motorized vehicle ownership dramatically increased

As economic development and per capita income level improve, motor vehicle ownership in our city is increasing rapidly, which has caused serious traffic congestion and will worsen in the future despite government efforts to alleviate this situation. According to the latest survey data, motorized vehicle ownership in Xi'an has already reached almost 300,000. Based on the forecasts prepared by Chang'an University, motorized vehicle ownership in Xi'an will exceed 500,000 by 2010. This rapid increase pattern is putting additional pressure on the current traffic system. It produces a greater chance of traffic system overload. At the same time, the increase in emissions has caused serious air pollution to the urban environment. Added to this, Xi'an is a historical city and major tour site in the world, which means it has a fundamental advantage for development and commerce, so the traffic system being heavily challenged.

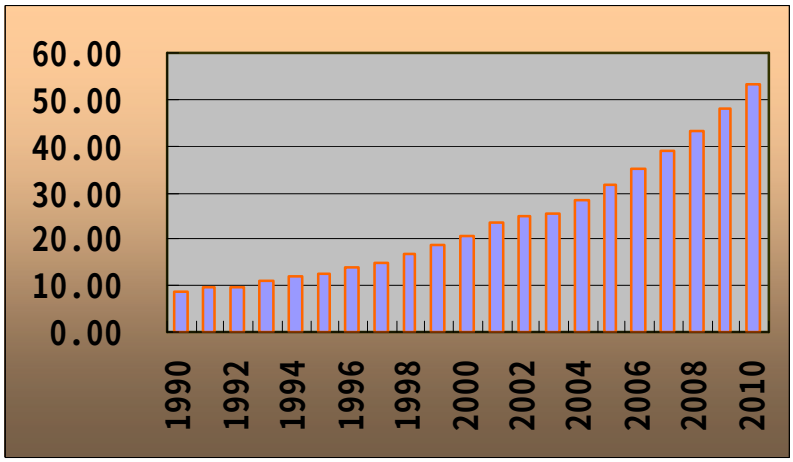


Figure 1. Annual Vehicle Ownership

1.2 Urban road resources are scarce compared to vehicle ownership

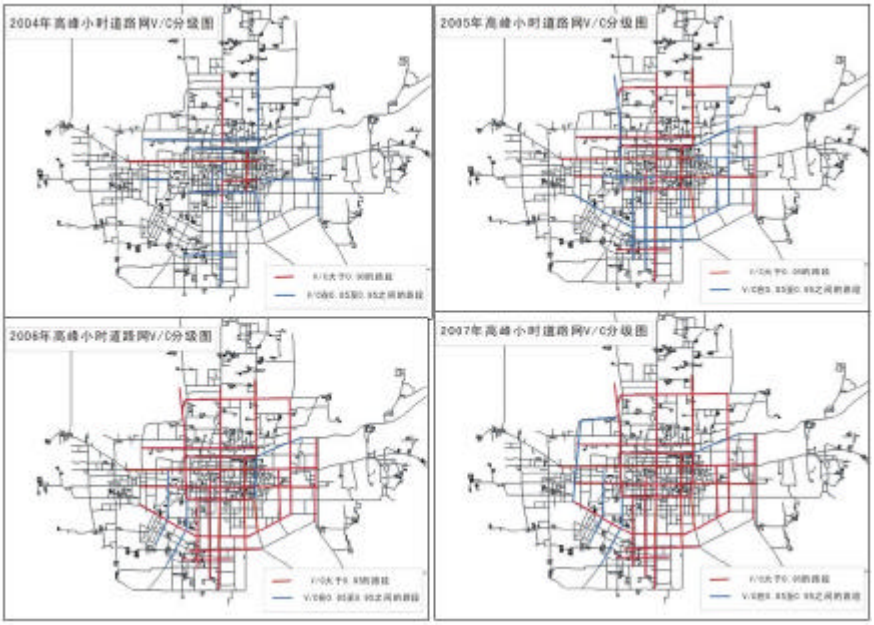
Xi'an was once the capital of 13 dynasties in Chinese history. The road network in the downtown area has remained almost unchanged since the Tang Dynasty. The road resources are scarce comparable to motorized vehicle ownership; they can't meet the demand of car owners. According to survey data, the total trips in the area within the 3rd Ring Road will reach 6 million trips per day. Within the 1st t ring road area, 21% of the trips are done within 5 percent of the urban area, and the area within 2nd Ring Road occupies 33 percent of the entire urban area, contains nearly 55 percent of the urban population and also generates about 60 percent of total resident travel. The urban master plan of Xi'an has put forward the urban space development model of "Nine Palaces Pattern" which accelerates the satellite town with full urban functions in order to reduce the construction density in the urban area. But in the next 10 years or even 20 years, the trips to the downtown area would still have a sharp increase. The heart of political,

economic, and commercial and municipal administration is centralized within the ancient city wall, which is unique in the world. This situation makes the area within the ancient city wall a major attraction. At the same time, road resources within the ancient city wall are still scarce and cannot be increased.

If Xi'an can't change the transportation mode of its residents, it will suffer constant and widespread traffic congestion witnessed in western countries at the beginning of the 1970's. This will slow down the urban economic development and hinder people's lives improvement seriously.

1.3 Increasing road resources is not a solution

Xi'an has carried out several road improvement projects that lead to increased road capacity and played a role in alleviating traffic congestion. Traffic congestion was reduced in 2004 after the completion of the projects. But according to forecast data, road capacity will be insufficient in the near future; traffic congestion will resume in 2005, increasingly heavier in 2006, and by the end of 2007 nearly all roads within the 2nd Ring Road will be seriously congested.



Note: The ratio of present traffic volume to capacity (V/C); the blue and red lines exceed 0.85 and 0.95, respectively.

Fig. 2 Annual congestion distribution in the road network

1.4 Low service level of public transit

As shown in Table 1, the current problem in Xi'an's public transport is its weak service: low density transit network, low coverage rate of transit website, low operation speed, and lengthy trips. Currently, the area covered by public transit within a short amount time is tiny. Travel from the Bell Tower to the 2nd ring road takes 30 minutes; in an hour, a bus can reach the 3rd ring road (see Fig. 3 and Fig. 4). This has caused several problems in the transit system and more people are choosing alternatives to public transit. According to

the trip survey in 2000, 54 percent of residents believed the best choice for certain trips was public transit, but actually only 23 percent actually used public transit. According to a 2003 transportation survey in Xi'an，the proportion of people who take public transit dropped slightly.

Table 1. Public Transit Service Level Evaluation Index of the Current Situation

Evaluation items		Current index	Standard value (or recommended value)
Average transfer coefficient		1.43	=1.5
Speed of circuit transports (km/h)		16.76	16-25
Route coefficient (not straight lines)		1.30	=1.4
Network Density (km/km^2)	Centre district	2.52	3-4km/km^2
	Periphery area	1.17	2-2.5km/km^2
Time consumed in trips (min)	Average time by public transit	40.72	60 (most time consuming trips)
	Average time walking*	8.22	
	Average time waiting	7.30	
	Total	56.24	
Coverage rate of public transit website	300m	24	=50%
	500m	41	=90%

Figure 3: Area covered by public transit in 30 minutes (left) and 60 minutes (right)

1.5 Solutions to traffic congestion and related problems

The urban traffic system in Xi'an is facing unprecedented challenges. Xi'an needs to adopt swift and cost effective measures to alleviate traffic problems arising from increased vehicle ownership. Widening roads or building new ones offer temporary relief, but neither can completely solve Xi'an's mounting traffic problems. Road resources in Xi'an are finite. A better solution is to improve the efficiency of road resources. Developing high-quality transit to alleviate traffic congestion is a widely accepted solution worldwide, especially those cities that have already been troubled by traffic congestion for several years. Bus rapid transit (BRT) is a relatively new public transportation mode but is becoming more popular and welcome in many cities.

Xi'an should develop a BRT system, which operate at close to subway speed, but at 1/10

subway construction and operation costs.

2. Brief introduction of Bus Rapid Transit

2.1 Definition of Bus Rapid Transit

Bus Rapid Transit is a flexible, high performance, rapid transit mode that combines a variety of physical, operating and system elements into a permanently integrated system with a quality image and unique identity.

2.2 Characteristics of Bus Rapid Transit

- BRT vehicles operate on dedicated bus corridors. Operating speed is 20-35km/h, close to the speed of the rail.

- Capacity could reach 15,000-25000 passengers per hour in a single direction, which is equal to medium capacity railway system (LRT). High standard BRT capacity could be up to 40,000 passengers per hour, exceeding most railway systems.

- Most systems use advanced articulated vehicles, which are as long as 18-25m. A single vehicle could accommodate 200-250 persons.

- BRT vehicles are easily identifiable in order to show its brand effect.

2.3 Major elements of Bus Rapid Transit

Bus Rapid Transit is a flexible, permanently integrated package of rapid transit elements with a sophisticated marketing identity. This section describes the characteristics, range of options, (where possible) costs, and a variety of other critical planning parameters for the following six major BRT elements.

1) BRT Corridors

BRT corridors are the most critical element in determining the speed and reliability of BRT services. Corridors are also often the most significant cost item in the entire BRT system. As the most visible BRT element to potential and existing customers, they can have a significant impact on the image and identity of the system.

Figure 5. Different BRT Corridors

2) Stations and intermodal terminal

The stations are usually equipped with fare collection and operating information systems. The stations platforms meet the vehicles floors to allow for convenient alighting and boarding.

Figure 6 BRT Stations

3) BRT vehicles

The BRT buses are usually uniform with bright colors to embody the brand effect of system. Vehicles with low floors are very convenient for passenger alighting and boarding. The use of articulated buses is to increase the capacity and lower the average operate cost; the BRT system in many cities are prefer to the clean buses which have little influence to the environment.

Figure 7 Different Types of BRT vehicles

4) Service plan

There are two kinds of BRT route structures. One is a single trunk line with feeder lines similar to railway systems. It establishes the feeder at the origin node, destination node point or main vital hinge node, to combine the arterial and the lateral together. Another is to use the convoy technique.

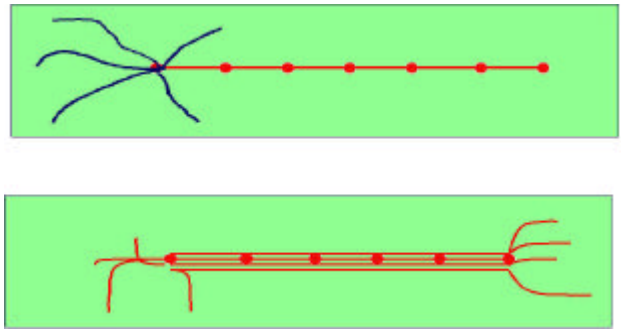


Figure 8 BRT Route Structure

Figure 9 Combined standard, express, and direct routes

5) Fare collection

BRT system includes an integrated fare collection system of a ticketless system, magnetic strip technology, and smart cards. Pre-board fare collection is used to allow for simultaneous alighting and boarding and reduce time delays.

Figure 10 Ticketing and BRT stations

6) ITS application

Intelligent Transportation Systems (ITS) can greatly enhance the success of BRT systems. At relatively modest costs, ITS can replace some of the functions provided by expensive and difficult to maintain physical infrastructure, or other types of rapid transit. They can be used to convey passenger information in a variety of venues, monitors, or control bus operations, provide priority at signalized intersections, enhance safety and security on board vehicles and at stations, and even provide guidance for BRT vehicles. ITS mainly aids operation management and vehicle control.

Figure 11 Advanced Intelligence Management Systems

Figure 12 Station information management system

2.4 Advantages of BRT Systems

1) Lower capital and operating costs

One of BRT's advantages is that its investment and operation cost are much lower. Generally, it is only 1/10 the cost of rail. The average cost of a subway in China is 200 million to 700 million RMB per kilometer at present, the average cost of BRT is 20 million to 70 million RMB per kilometer. If the corridor of a BRT system does not need to be relocated, the capital cost is about 20 million RMB per kilometer; if project construction needs to remove the work in a large amount, the cost may be up to 70 million RMB per kilometer. The cost for one kilometer of rail is equal to ten kilometers of BRT corridors.

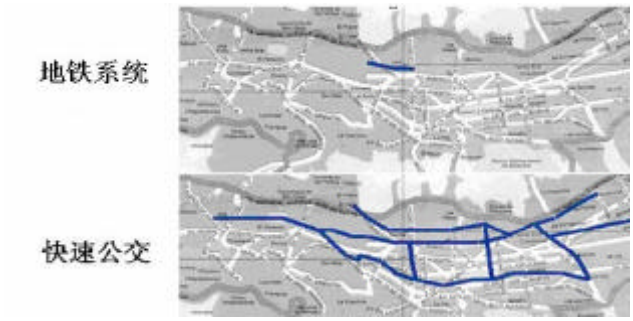


Figure 13: Scale of Metro (top) and BRT (bottom) with same investment

2) Shorter construction period

The construction period from start to end for a single bus rapid transit corridor can be finished in 1-2 years, whereas the same distance for light rail transit (LRT) will take 4-6 years, and subway 8-10 years. By contrast, because the construction period for BRT is shorter than subway, it will have an instantaneous effect on alleviating traffic issues in the city.

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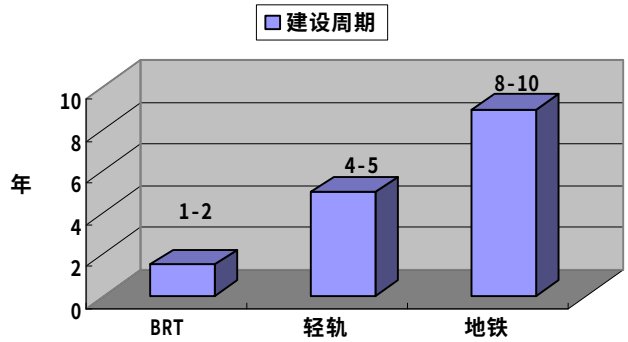

Fig. 14 Construction Cycle for Three Modes of Transportation (BRT, Light Rail, Subway)

3) Higher speed and reliability

BRT buses operate on a segregated corridor. They have a relatively minimal impact on other traffic. The travel time is shorter than the conventional bus transit and is more reliable. In addition, level alighting/ boarding and pre-board fare collection reduces boarding time delays--- the average speed of the vehicle can be increased. The average speed in six US cities is shown in Figure 15.

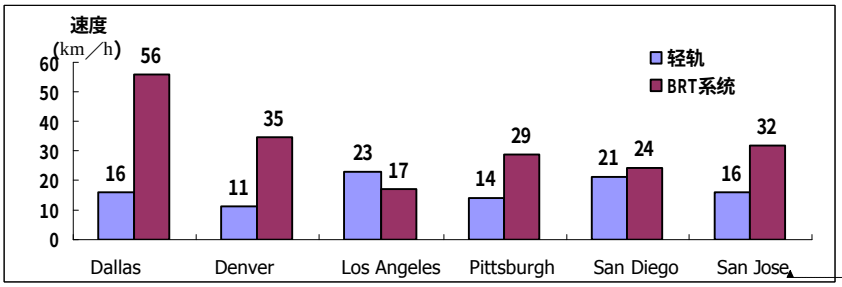

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Fig. 15 Average speed of BRT vs. Light Railway Transit (LRT) (1999)

4) Higher flexibility

The BRT is more flexible than rail transit because the system can operate before the entire system is completed. Rail can only be operated after routes, stations, vehicles, fare collection and management system are complete. BRT can be implemented step-by-step. The other feature of flexibility is that BRT can be operated on different routes, which is significantly different from rail that can only be operated on the fixed route.

5) Customer friendly

The advanced buses have the advantages of low noise, small vibration, spacious and comfortable space. Level boarding is convenient for passengers, especially those who delivering goods and those with disabilities. The passenger information system provides clear information and increases passengers' trust in public transportation.

6) Environment friendly and low energy consumption

Advanced technology buses have lower emissions and energy consumption. The separated or exclusive bus lane avoids repeated acceleration, slowing, and stopping, which aids in reducing emissions and energy consumption. Statistics show Transmileno in Bogotá reduced 40 percent of the pollution than that of conventional bus transit and BRT system saved 30 percent of fuel consumption than that of conventional bus transit in Curitiba. According to a 1999 report by The Energy Foundation on the emissions and energy consumption of different transportation modes, BRT is the most energy efficient and environmentally friendly transportation mode.

Table 2. Emissions and Energy Consumption for Different Modes (per million per kilometer)

Pollutant \ Mode	Private car	Taxi	Conventional bus	BRT	Rail transit	Motorcycle
CO_2 (ton)	140.2	116.9	19.8	4.7	7.5	62.0
NO_x (kg)	746.0	662.0	168.4	42.0	17.5	90.0
Oil consumption (ton)	49.2	41.0	6.9	1.6	2.6	21.8

7) Better security

The BRT system is completely separated from other traffic, which reduces the possibility of accidents. The application of GPS (Global Positioning System) and accident handling system allows immediate response to accidents as soon as they occur. After Transmileno was in operation, the fatality rate for accidents on this corridor was reduced 93 percent.

8) Transit-supportive land development

Like railway system, BRT can also promote transit oriented development in urban areas. Developing land with higher floor area ratio (FAR) buildings will bring added convenience to passengers traveling to stations in these areas, increasing the attractiveness of public transportation and provides guaranteed ridership.

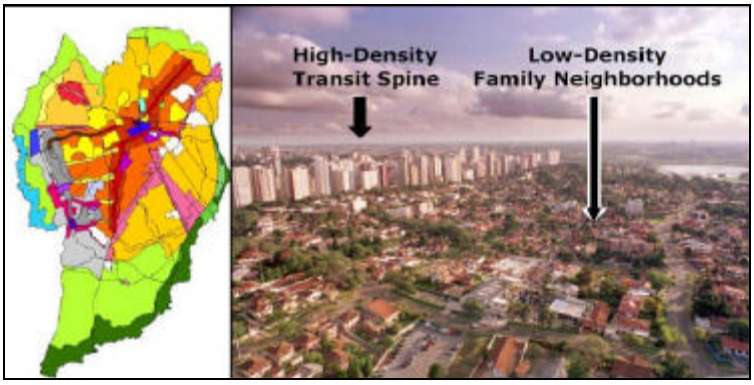

Fig. 16 The higher FAR along BRT line vs. lower FAR in non-BRT district in Curitiba (1999)

9) Fully utilize the existing operation management
Though the operation management style of BRT is slightly different from that of conventional bus transit, they are similar in the operation and management of routes, drivers and conductor management system, operation dispatcher and vehicle maintenance. Operation and management can easily be carried out based on experience with conventional bus transit. It often only takes about one week for one BRT new line to complete a trial operation; while 3 to 6 months is required in trial operation for railway system.

2.5 Global overview of BRT development
Since the 1970s, many cities in the world have focused on reducing traffic congestion. Through the experience from the cities in all over the world, we can see that it has little effect to alleviate the congestion by constructing new roads or widening the existing roads, even makes the traffic condition worse and worse.

Although the huge funds have been devoted to the railway system construction in many cities, it is hard to cover a large area in limit time, so the railway system has a limit capacity to transfer passengers. Nowadays many decision makers of city are looking for the better transit mode, BRT with unique advantage wins the support in the developed and developing country.

Since the first BRT route in the world was established in Curitiba, Brazil ,1974, BRT has already become popular in the world quickly, and get much supports from large and international financial organizations(such as United Nations Development Program, World Bank, Asian Development Bank, Central America Development Bank, Global Environment Facility) many foundations and other organizations. Currently, BRT systems are being planned and implemented in cities in North America, Europe, and Asia. For instance, more than 20 cities in North America, including Los Angeles, New York, Chicago, Seattle, Pittsburgh, Miami and Boston in United States, Ottawa and Vancouver in Canada, Mexican city in Mexico; more than 20 cities in Europe, including Paris and Lyon in France, Leeds and Runcorn in U.K; Brisbane and Sydney in Australia, Oceania; and Nagoya in Japan, Asia.

Moreover, in some developing countries with strong economies and high vehicle ownership, BRT is also making a strong impact. These cities include: Sao Paulo, Bogotá and Quito, Ecuador in South America; Seoul, Jakarta, and Bangalore in Asia.

BRT is not only advantageous for metropolitan areas, but also for less developed cities with different development stages. In metropolitan areas, BRT, is an important part of the transportation system and can be used as a complement, extension or substitute for rail. And BRT in a medium-sized city can be used as the framework of public transportation system. Furthermore, between the satellite town of a city and the downtown area, it can link these areas.

In recent years, BRT has garnered high regard in China, Document NO.520 presented by the Development Research Center of the State Council encourages “speed(ing) up BRT development”, and the Ministry of Construction’s No.38 policy report[2004], 《Recommendations to Prioritize Urban Public Transport Development》 also puts forward the opinion that the cities can develop BRT system with the existing road network upgrading.

Many Chinese cities are interested in implementing BRT systems at present. Beijing is a leading city, the secretary of Municipal Committee of the CPC Qi Liu, mayor, Qishan Wang support the planning and construction of the BRT system strongly. The first demonstration line of BRT –Beijing BRT line 1 already started construction at the end of 2003 and will be completed at the end of 2005. The 80 kilometers of BRT routes are planned for Beijing before the 2008 Olympic Games. Chen Liangyu, secretary of Municipal Committee of the CPC of Shanghai, has recommend developing a BRT system which adapts to Shanghai strongly, Shanghai is preparing to build BRT in Zhonghuan road, Pudong, and other new urban areas.

Chengdu has discarded previous plans of an elevated road in the Second Ring Road and turned to BRT integration with 2nd ring road upgrades and will build BRT into the east-west main arterial highway-Sudu road at the same time. Moreover, Shenyang, Chongqing, Hangzhou, Tianjin, Fuzhou, and several other cities are making arrangements for the preliminary preparation of BRT project at present.

3. Why BRT in Xi’an?

1) Alleviate the imbalance between supply and demand of traffic
BRT needs little investment but has an instant effect. It can improve the utilization ratio of the existing road network and decrease the use of private cars in the central area as the rail transportation mode and at the same time it can meet the high level of travel demand. So BRT can improve the attractiveness of public transportation greatly, which is a means to alleviate the imbalance between supply and demand of traffic essentially.

2) Easier implementation

BRT is in line with the requirements of National Scientific Development View. Constructions costs are low for BRT, while profits can be high once in operation. It is operated effectively and can decrease the energy consumption. It is in the direction of the urban public transit development so that it does not need special approval. The road condition of Xi'an is good. It is suitable to put BRT on the current road with few change. It can be designed, completed and effectively operated in the one year. The cost of a high-standard BRT system of about 20 kilometers is only 300 million RMB.

3) Helpful to preserving the style and features of the ancient city

As the world-class ancient city, the historical relics are preserved in Xi'an several dozen meters thick underground. And the style and features of the ancient city are protected. The BRT system only needs to open up 2 lanes on the existing road and it does not need extensive rebuilding. BRT system uses clean energy, which can improve the environment of the city too.

4) Complements urban land development

The experience from the developed country indicates that BRT is the same as the rail transportation that can guide the urban expansion because of low investment and instant effect of BRT. If we can put the essential bus route between newly developed area and the center, it can realize the intention of expanding the urban to the newly developing area soon.

5) Help to reduce costs for residents and the government

The fare regulation and reasonable fee structure of BRT system can reduce expenses for residents. The inexpensiveness and minimal operation expenditure will save a large amount of fund for the government. It can form the BRT network in a short time.

6) BRT construction and subway construction are not contradictory

If we do not consider construction and operation costs and only think about the urban land, transport capacity and speed, obviously, it is the best way to use subway. The advantage of light railway and BRT are equal basically. If we consider the question of the expenses, BRT is superior to light rail. But we need concrete analysis of the relation between BRT and subway. Generally, if we do not consider investment and operation funds, the subway comes out ahead. If a city is facing financial pressure, it can consider the BRT appropriately. If we want to give up BRT in the future, we only need to scrap or remove some truck station facilities on the road. So the waste of investment is little, and the city can regard it as the transition, extends, substitutes and competition for rail transportation.

Our city needs to pay attention to three following problems in the construction of subway at present:

- The uncertain implementation by the burden of investment. According to the plan at present, the subway line one and subway line two will be built from 2004 to 2012. The total length is 43.54 kilometers and the estimated investment is 15.347 billion RMB. It requires almost 1.9 billion RMB (without the interest) every year, equivalent to 20 percent of Xi’an’s income. In addition, annual subsidies of 300 to 500 million RMB may be needed. This would be a major financial burden to Xi'an and would require a feasibility study from multi level government. Hangzhou and Chengdu，which have better economies than Xi'an, applied for many years but still have not

received permission yet. Xi'an should not rely on the subway as the only solution to the traffic problem.

- Long construction period. The planning, design, construction and troubleshooting for subway requires an extensive amount of time and it make take up to eight years to take affect. How can urban traffic problems be solved quickly? The government needs consider several factors making BRT the rational choice at present.

- The attractive range of BRT. Even if the subway line is implemented, it needs to be integrated with other transport modes to meet traffic demand. Because without a network, rail transport is weak. The implementation of BRT is also necessary to integrate with subway.

7) BRT system has important meanings to improve the city identity and promote the development.

A BRT system can improve the image of the city. It uses attractive public transit vehicles with distinct colors. The stations are also well-designed and attractive. BRT can bring a clean, fresh traffic environment and will become the beautiful scenery in Xi'an. The BRT system itself can be inestimable tourist resources too and it is important to promote the sustainable development of the whole tourist industry of Xi'an. As a kind of convenient transportation mode，BRT system will inevitably quicken the development rhythm of a city, promote the development of whole urban economy and create the good condition for the investment.

8)BRT can be the key element of the Xi'an metropolitan development

As a low investment, fast operation and large capacity public transit mode, BRT can provide high level public transport between each cities and can become the key element in promoting Xi'an metropolis development.

4 BRT development in Xi’an

4.1 Planning of the BRT network

4.1.1 The analysis of the main passenger transport corridors

In August 2003, the work team carried on the investigation on bus lines and ridership in the main arteries, as the figure 17. By analyzing the bus lines and ridership in the peak hour, we can define the main passenger transport corridors at present in Xi’an as following: the 3 corridors from the east to the west, the two corridors from the south to the north and the two ring roads. The specific conditions are as described in Table 3.

Figure17: Current main passenger transportation conditions

Table3: Ridership per hour in different transportation corridors

PASSENGER TRANSPORT CORRIDOR	NAME OF THE LINES	RIDERSHIP DURING PEAK HOURS	RIDERSHIP IN ONE HOUR
3 corridors from the east to the west	Daqing road－Lianhu road－ the East and West Five Road –Changle road	12,128	10,162
	Fenggao road－the West stree－the East street	13,530	11,534
	Keji road－Xiaozhai road－Xiying road	6,500	5,800
Two corridors from the south to the north	The North street－the South street－Chang'an road	19,540	17,365
	Jiefang road－Heping road－Yanta road	13,602	9,992
Two Ring Roads	1ST Ring Road	11,648	5,862
	2nd Ring Road	6,590	3,278
Trunk Highway	Xi'an－Lin Tong	8,200	－
	Xi'an－Xian Yang	5,250	－
	Xi'an－Chang'an county	6,600	－

4.1.2 The analysis of the main city's extending axes

According to Xi'an's Master Plan, road conditions and passenger travel demand, the potential BRT corridors are:

- **The corridor from Xi'an to Xian Yang.** The development of Xian Yang is inevitably dependent on Xi'an, so it is more important and necessary to integrate with Xi'an by the transportation corridor. The ridership in the peak hour on the Millennium Road is 5,250.

- **The corridor from downtown to the High-Tech Development Zone**. The High-Tech Development Zone can make radial driving functional for Xi'an just by rapid passenger transport corridors between the city center and the High-Tech Development Zone.

- **The axis from Xi'an to Chang'an County.** In past two years, urbanization has been so rapid that the newly－built district has combined with the central city. We calculated the ridership during peak hours from downtown to Chang'an is 6,600 by set up survey spots in the south of the Television Tower.

- The economic and technological development zone－the high-tech development zone －Qujiang entertainment development zone.

- **The corridor from the downtown to Lin Tong.** Tourism is a pillar industry of Xi'an. Strengthening tourism is critical. Tourism drives commerce and commerce promotes tourism, which speeds up the progress of marketization，industrialization, and internationalization. Lin Tong is the main scenic spot in Xi'an. Strengthening a fast connection route with Lin Tong is a crucial factor in developing Xian's tourism.

- **The corridor from the downtown to the north.** Wei Yang district is the basement of the life necessity supply. Wei Yang district has become the new place of entertainment for people, which has the Qin dynasty Afang Palace，Ming Dynasty Chang'an Fortress, Tang Dynasty Da Ming Palace, Wei Yang Lake, and Wei Shui Garden hotsprings. The ridership in peak hours along Wei Yang Road can reach more than 5000.

4.1.3 BRT network planning

According to the analysis of the main urban passenger transport corridors and the main urban extending axes, draft construction routes of BRT as follows.

- Millenium Road of Xian Yang－Daqing Road－Lianhu Road－West Five Road (Xiwulu)－East Five Road (Dongwulu)－Changle Road－Lin Tong

- Fenggao Road－East Street (Dongdajie)－West Street (Xidajie)

- Xianyang Airport－North Railway Station－Railway Station－Jiefang Road－Heping Road－Yanta Road

- Weiyang Road－North Street－South Street－Chang'an Road

- Zhuhong Road－Fenghui Road (W.2nd Ring Road) －Tangyan Road

- The cross of Tangyan Road and the S.2nd Ring Road–the S.2nd Ring Road (sections) －Youyi Road

- Keji Road－the Xixieqi Road－Xiaozhai Road－Xiying Road－Xingfu road and Wanshou Road

- The whole line of 2nd Ring Road

Figure 18: Xi'an BRT Network Plan

4.2 Short term implementation plan

Considering the possibility of implementation by the current government, the network can be implemented during its tenure, which is five years before a new government takes office. Short term planning consists of East Five Road to the West Five Road and the extension line, North Street to the South Street and the extension line, the economic technique development area－W.2nd Ring Road－Tangyan Road－Chang'an industry area in the high technology zone , the Railway Station－W.2nd Ring Road－Tangyan Road－Chang'an industry area in the high technology zone and the North Square Of The Railway Station－the North Railway Station.

Figure 19: Short term BRT Implementation Plan

4.2.1 The reason for short implementation planning

There is a huge ridership along Daqing Road－Lianhu Road－the West Five Road－the East Five Road－Changle Road, which is the transportation corridor from the west to the east of Xi'an and links the West Railway Station to the East Railway Station. This route overlaps with the No.1 line of the subway that will take 5 to 8 years to build. The BRT route can be used as the transition to the No.1 line of the subway and development the ridership in this period. Most of the roads have a pattern of at least three blocks and a width of more than 40m; for instance, there are four blocks in Zaoyuan Road and a wide medium green belt that is about 50m and 6 or 8 lanes in both directions in Daqing Road. Because of the nice conditions, it facilitates implementation of BRT.

The transportation corridor with the largest passenger flow in Xi'an is the North Street－the South Street－Chang'an Road, the axis from south to north in Xi'an and the most direct corridor linking each economic and cultural centers. At the same time, this route is overlapped with the No.2 line of the subway. If the No.2 line can be implemented in the near future, the BRT route can develop the ridership for it, and if it can't be built in the near future, the BRT route can take on all the ridership. The existing cross section of this route has three or four blocks, and from 4 to 8 lanes in both directions and more than 40m wide. The condition of the roads is so nice carrying out BRT.

Based on recent experience, urban development is quite fast in the north and the south of Xi'an. The route along the economic technology development zone－west 2nd Ring Road －Tangyan Road－Chang'an industry zone in the high-tech zone and the route from west to east can facilitate the trip generated within the northern central area, Caotan area,

high-tech zone, Chang'an industry area and western colleges town. This BRT line is supportive to land use development and integrates the concept of transit-oriented development. This corridor has very good road condition for developing BRT except for a short distance on Zhuhong road with 4 lanes needing widening.

The BRT planned line along he Railway Station－W.2nd Ring Road－Tangyan Road－Chang'an industry district in the high-tech zone will facilitate the travel demand with downtown and the sub-downtown, alleviate traffic issues in the downtown area, relieve traffic pressure and lead the city to better urban layout (multi-center layout).

The North Railway Station will be completed in 2008, and the subway will not be in operation at that time. That would limit the effectiveness of the station. The implementation of the route along the north square of the Railway Station to the North Railway Station can meet the transit demands and drive the urban expansion northeast.

4.3 Cross section scenarios for the implemented lines

The cross section scenarios for the implemented lines are relatively simple so that the existing cross section can be maintained, the cross section scenario for each planned line in the short term is shown hereunder in detail:

1）The East Five Road and the West Five Road and the extension line

a．Operation

Median exclusive bus lane is established for BRT and the stations are placed in the median of the road that can make full use of the median green belt in Daqing Road.

b．The 3D drawing for this line

The 3D drawing after implementation is for Lianhu Road, West Five Road, East Five

Road and Changle Road.

Because the cross section of Daqing Road is similar to that of South Chang'an Road, the 3Ddrawing can be referred to South Chang'an Road shown hereunder.

2） The North Street and the South Street and the extension line

a. Cross section after BRT implementation

This is the best choice considering its significant role in the network. It has the largest passenger flow, will improve capacity, and has an abundant median green belt along the corridor.

b． The 3D drawing after BRT implementation

3） The economic technique development area－W.2nd Ring Road－Tangyan Road－Chang'an industry area in the high technology zone

a. Cross section scenario

Median bus lane is established for BRT, and the station is placed on the median green belt that can make full use of the medium strip.

b． The 3D drawing after BRT implementation

The 3D image after implementation in Tangyan Road as follows:

The scenario in Zhuhong Road can be referred to that in Lianhu Road and the extension line, and scenario in other parts can be referred to that in the South Chang'an Road.

Scenario 1:

Scenario 2:

4） The Railway Station－W.2nd Ring Road－Tangyan Road－Chang'an industry area in the high technology zone

Considering the right of other vehicles, it's the appropriate way that utilizing the existing bus lanes in the overlapped parts. The median busway can be used in Jiefang Road, which has the similar cross section to Lianhu Road, which has no median green belt. The detailed cross section can be referred to in Lianhu Road.

5） The North Square Of The Railway Station－The North Railway Station

The cross section form is flexible and BRT can be integrated with road upgrades.

4.4 The trunk and feeder lines service plan

The BRT system and conventional bus system must receive the benefit equitably. To do so, the Xi'an public transportation corporation should be the main shareholder to balance the benefit share between BRT and bus.

Within the BRT corridor, it provides the transfer service for BRT only and cancels the conventional bus lines. The conventional bus lines can become feeder lines for BRT.

We can select some arterial bus routes to provide "free transfer" systems, which can improve the attractiveness of public transportation and reduce private car travel.

4.5 Transportation Management planning to complement BRT

Parking is banned along sides of road with BRT, in the pedestrian areas with red lines. Left turns are not permitted in intersections with BRT corridors. Vehicles, other than BRT vehicles, are not permitted to use the bus lanes.

4.6 Estimated total cost and recommendations for implementation

The cost of BRT project is mainly for constructing the bus lanes and BRT vehicle purchase. According to the investment scale in Beijing, the investment estimate is shown the Table 4.

Table 4: The investment estimate for short term implementation plan

Name of Route	Departure point	Terminal point	Circuit length (Km)	The number of stations	Total investment of system (hundred million dollars)

East Five Road and West Five Road and the extending line	The East Station	West Station	13.5	14	2.84
North Street and South Street and the extending line	Zhang Jia Bao	Television Tower	15.5	17	3.37
Economic Technology Development area－W.2nd Ring Road－Tangyan Road－Chang'an industry area in the high technology zone	Feng City 7^{TH} Road	Lock Gate Village	19.0	13	4.00
Railway Station－W.2nd Ring Road－Tangyan Road－Chang'an industry area in the High-Tech Zone	Railway Station	Lock Gate Village	16.0	12	1
The North Square Of The Railway Station－The North Railway Station	The North Square Of the Railway Station	North Railway Station	13.6	10	2.75
Total			77.6	66	13.96

We recommend that in the construction period all expenses should come from government, and if we want to improve the attractiveness of public transportation, the fund for vehicle purchases can also be undertaken by the government so that ticket price can also be lowered. The fund for the vehicle purchase can also invested by Xi'an public transportation corporation at a large percent and the remaining can come from the social funds or the government, the government will not subsidize BRT in operation period and the guide the enterprise to make a reasonable ticket price.

We recommend the demonstration line be completed by the end of 2005 and the entire plan be implemented in 2006.

5. Analysis of the benefits of BRT in Xi'an

The benefit of the public transport system is reflected mainly in the social benefits (aspect), and the social benefit of this project construction reflects mainly in the following aspects:

- Alleviating traffic congestion in Xi'an quickly and putting the city on the road to sustainable transportation development.

- Setting up city traffic mode that is people-centered as opposed to a vehicle-centered mode that considers the needs of vehicle owners. A people centered mode will

develop a traffic pattern that conforms to the style and features of this ancient city.

- Solves the road supply and demand conflict in Xi'an.

- According to international experience, there can be certain profits in financial benefit. The profit of our city can adjust and control by the intention of government.

6. Work plan for the Xi'an BRT system

It is proposed to establish the leading group of BRT system immediately. This group is lead by the mayor, such departments as the urban construction committee, urban transportation bureau, traffic management bureau, planning bureau, public affairs administration; etc. participate in together. It consists of the working, research and executive group and is responsible fro planning the BRT program of the whole city, and making out the implementation plan and annual work plan.

- Complete the conceptual design for the demonstration line and insure a finance source by the end of 2004.

- Finish the construction engineering design for the demonstration line and the scenarios for electronic equipment, signal system, vehicle type in the first half of 2005.

- Finish the demonstration lines construction and troubleshooting of equipment, trying to run it in the second half 2005 and setting about the scheme research work of other projects.

- Implement other BRT lines in 2006.

7. Conclusions

Solving Xi'an's urban traffic problems through increasing road supply is impossible. Therefore, the solution is to improve road efficiency. Developing a good public transportation system is the only way to solve the traffic problems in Xi'an.

Now the level of service is low and public transportation is unattractive. Therefore, it is difficult for public transport to play its important role in alleviating traffic congestion and related issues. In addition, the rail railway system's construction investment is huge, and its construction period is also very long, making it a bad short term solution. Based on the above analysis, BRT becomes the best choice to solve the traffic problem of the center of Xi'an in current stage.

This report puts forward several scenarios for BRT lines from the view of the effect and efficiency for Xi'an decision maker’s reference.