Exploring the Current Status of BRT Application in Transportation: A Case Study of Changzhou City

Shuocheng Fan[a]
School of Design, Xi'an Jiaotong-Liverpool University, Shanxi, China

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Abstract: Rapid urbanisation and motorisation in China have led to serious traffic congestion problems, and efficient public transport systems are urgently needed to solve this problem. Bus rapid transit (BRT) systems have emerged as a viable and economical solution to urban transportation challenges. This study employs a case study methodology to explore the inception and evolution of the BRT system in Changzhou City, China. It examines key aspects such as the development history, operational efficiency, environmental impacts, and public perception of the BRT system in the city. The findings indicate that the BRT system has effectively alleviated traffic congestion, enhanced public transport efficiency, and fostered environmental sustainability by utilizing clean energy vehicles. Furthermore, the study highlights the synergy between urban planning and BRT development, underscoring its potential contributions to economic growth. This research offers valuable insights and innovative strategies for advancing BRT systems in urban settings.

1 INTRODUCTION

As urbanization and industrialization accelerate, major cities in China are increasingly grappling with severe traffic congestion. Changzhou, a key city in Jiangsu Province, is no exception and is encountering mounting traffic pressures. To address these challenges and enhance the efficiency and appeal of urban public transport, Changzhou has implemented a Bus Rapid Transit (BRT) system. This initiative aims to transform the existing transportation landscape, thereby improving the quality of life and travel standards for its residents.

To address the escalating issue of traffic congestion, the Bus Rapid Transit (BRT) system has emerged as a solution aimed at enhancing the efficiency and appeal of urban public transportation. The BRT system can be described as a flexible, rubber-tyred rapid transit mode that integrates stations, vehicles, services, operating modes, and information technology into a cohesive and recognizable framework (Levinson, 2003). Positioned between traditional buses and rail systems, BRT offers numerous advantages, including lower operational costs, superior service quality, high efficiency, and ease of implementation. It employs intelligent bus management systems and is synchronized with the broader traffic infrastructure, enabling conventional buses to attain service levels comparable to rail transit.

Given the functionalities akin to those of light rail or metro systems, BRT is often regarded as more reliable, convenient, and faster than standard bus services. A well-configured BRT network delivers rapid, comfortable, and cost-effective urban transport solutions (Wright, 2007). With appropriate features, BRT can circumvent typical delays experienced by regular bus services, such as traffic congestion and lengthy boarding processes. Furthermore, the investment and operational expenses associated with BRT are significantly lower than those required for rail transportation, rendering it an economically advantageous option. As a result, BRT systems are widely used in several cities around the world.

Changzhou City, for example, on November 28, Changzhou Bus officially opened the first BRT smart platform - BRT1 Liaohe Road Changjiang Road Station, BRT can use information technology to support the construction of credit transport, which is conducive to further promote the deepening of Changzhou bus reforms and improve quality and efficiency. Compared with the traditional BRT station, the BRT intelligent station installed an intelligent

[a] https://orcid.org/0009-0007-8721-1941

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ticket system, an intelligent self-service coin exchange machine, and a station without staff, passengers at the intelligent gate complete the self-service card, code or coin payment, and you can enter the station waiting for the bus. Changzhou City, since the introduction of the BRT system, after years of development, has built a more complete BRT network. These routes not only cover the major roads and traffic hubs in the city but also connect a number of important urban nodes, such as administrative centres, tourist attractions, leisure and entertainment venues, major schools and hospitals, etc., which greatly facilitates the travel of the public. However, with the wide application of the BRT system, some problems have been exposed during its operation, such as the environment of in-vehicle facilities needs to be improved, and overcrowding caused by insufficient number of trips during peak hours.

Therefore, it is of great practical significance to conduct an in-depth study of the Changzhou BRT system. This study aims to provide further scientific basis and reasonable suggestions for the Changzhou BRT system by comprehensively analysing the operation status and problems of the system.

2 BACKGROUND OF BRT

The Bus Rapid Transit (BRT) system originated with the launch of the Rede Integrada de Transporte (RIT) in Curitiba, Brazil, in 1974. This system was the first of its kind globally, effectively alleviating traffic congestion and enhancing the efficiency of public transportation in the city. Since its inception, BRT has emerged as a modern public transport solution, positioned between traditional buses and rapid transit systems. Its widespread adoption around the world can be attributed to several advantages, including a relatively short construction timeline, low operating costs, and enhanced safety features, all of which contribute to faster travel for residents.

The rapid urbanization in China is accompanied by a significant rise in the number of motor vehicles, leading to increasingly severe traffic congestion. The existing conventional bus system struggles to meet the mobility needs of urban residents. In response, the government has implemented various policies aimed at enhancing the development of Bus Rapid Transit (BRT) systems. For instance, in 2004, the Ministry of Construction issued guidelines emphasizing the prioritization of urban public transport development, highlighting the numerous advantages of high-capacity BRT systems and encouraging cities with appropriate conditions to actively pursue BRT implementation. Since the late 1990s, China has been making strides in establishing BRT systems, and in 1999, Kunming built the first bus-only lane in China, which means that China's BRT system was formally established (Yang, 2017). Since then, with the continuous progress of technology and the maturity of planning concepts, BRT has begun its rapid development in China. The following is the development of BRT in several important cities in China. In Beijing, the first BRT line was opened in 2005, which used a fixed-route closed system and officially opened the mode of the BRT operation system in China. Hangzhou followed in 2006, becoming the second city in the country to open a BRT line, providing citizens with a faster and more efficient way to travel. Guangzhou also opened a BRT in 2010 and has achieved a number of world firsts, making it an internationally recognised model for BRT systems. Guangzhou BRT's unique mode of operation, which includes "30 flexible routes + 1 ferry line", has effectively alleviated the problem of urban public transport congestion and won a number of international awards. As of January 2011, about 49 new cities are building BRT systems, 16 cities are expanding BRT corridors, and 31 cities are in the preliminary planning stage (Hidalgo, 2011). As of today, more than 30 cities nationwide have BRT systems in place, with a vehicle fleet of up to about 8,800 vehicles. BRT systems in these cities not only reduce urban traffic congestion but also enhance the overall attractiveness of public transport and improve operational efficiency.

The advancement of Bus Rapid Transit (BRT) policies, coupled with ongoing scientific and technological improvements, suggests a promising future for the implementation of BRT systems in an increasing number of cities. To effectively address the diverse travel needs of urban residents, BRT systems will continue to innovate and enhance their service quality. This commitment aims to strengthen the role of BRT within the public transportation framework, ultimately providing residents with a more efficient means of travel.

3 BRT SYSTEMS FOR SOLVING URBAN TRANSPORT PROBLEMS

BRT systems are an evolution of bus priority measures (e.g., designated bus lanes and bus-only lanes), which have been proposed and, in some cases, implemented around the world as early as 1937

(Levinson, 2003). BRT effectively solves many of the problems of urban mobility through a series of innovative designs and advanced technologies. The following are the main ways in which BRT solves traffic problems. Buses in a BRT system have their own dedicated lanes, avoiding the problem of sharing lanes with other motor vehicles and significantly increasing the speed at which buses can operate. This design significantly reduces the time that buses in the BRT system are delayed due to traffic congestion and greatly improves the overall transport efficiency of the bus system. Buses in the BRT system have absolute priority when passing through traffic lights, and through the Intelligent Traffic Signal Control System, buses can be allowed to pass through intersections ahead of time, which further reduces the waiting time and significantly improves operational efficiency. In terms of the environment, most of the buses in the BRT system use clean energy, such as natural gas or electric vehicles, which greatly reduces tailpipe emissions and plays a key role in improving the city's air quality. The BRT system's buses also use low-noise technology, which effectively reduces noise generation and safeguards the quality of life of neighbouring residents. The capital cost of a BRT system is one-tenth to one-third of a comparable rail system (Wright, 2007). In summary, the BRT system provides an effective solution to urban transport problems by improving transport efficiency, reducing environmental pollution and sustainable development and other advantages. With the continuous progress of urbanisation, the BRT system will play its role in more cities. Next, this paper mainly takes Changzhou as an example to analyse the advantages and challenges of BRT in the implementation stage.

4 CASE STUDIES

4.1 Introduction of Changzhou BRT System

The origin of the Changzhou BRT system can be traced back to 2008 when Changzhou City began preliminary planning for the introduction of a BRT system in order to alleviate the city's traffic pressure and improve the efficiency of bus services. As the first real BRT line in Jiangsu Province, Changzhou BRT Line 1 was officially opened on New Year's Day 2008, marking Changzhou's entry into a new era of BRT development. The introduction of the BRT system not only improved the overall quality of Changzhou's public transport but also made Changzhou a model of BRT mode, which has led to a demonstration role in the country. The Changzhou BRT system is a major project in Changzhou City, Jiangsu Province, China, aimed at solving traffic problems and providing residents with a convenient mode of transport. The following is an analysis of the Changzhou BRT system: In terms of traffic, as the economy of Changzhou grows and the population increases, the demand for transport is rising very rapidly. Under these circumstances, the traditional bus system has struggled to carry this burden and also suffers from congestion, slow speed and poor service quality. The Changzhou Municipal Government recognised the need for an efficient public transport solution and introduced the BRT system to Changzhou. In terms of policy, the Changzhou Municipal Government has formulated a transport development plan that promotes the establishment of the BRT system, points the way to sustainable urban development, and improves air quality and travelling efficiency for residents.

4.2 Construction and Development of BRT in Changzhou

Changzhou's BRT system focuses on the passenger experience, implementing uniformly low fares and free transfers, as well as offering discounts for IC card and student card holders and free rides for seniors. The system uses new environmentally friendly buses to reduce noise and exhaust emissions, enhancing the city's image and marking China's first attempt at a new energy BRT with success. More recently, the BRT has introduced solar-powered buses, reflecting the government's focus on environmental protection. The design and construction of the BRT incorporates modern technology, adopting a streamlined middle platform design that echoes Changzhou North Station and Wujin Bus Centre Station and is equipped with an intelligent traffic system. The BRT vehicles use fully imported chassis and engines and apply high-end integration technology, and their number of assigned vehicles is leading in China. The intelligent traffic system is connected to the city's traffic command centre, which effectively improves the traffic command and bus vehicle scheduling capability. Changzhou BRT system has a strong conveying capacity, the vehicle speed exceeds that of ordinary buses, and the benefits of resource integration are remarkable. BRT special lanes are set up through road reconstruction, effectively enhancing the speed of vehicle operation. Changzhou has realised bus integration, and the management of BRT and regular buses are combined to ensure the efficient operation of the bus line network. The BRT system covers Changzhou's main downtown area and five

administrative districts, forming a "cross-shaped" BRT network that connects important areas such as commercial districts, hospitals, schools and parks, and provides convenience for citizens' travelling. The construction of BRT has a positive impact on the city's economic development, improving transport efficiency, promoting land development and utilisation along the routes, and increasing the development of the city. Surveys show that the BRT system has won public recognition and praise, but also faces some controversies, such as in-vehicle amenities and congestion during peak hours. Overall, the Changzhou BRT system shows good results and provides valuable experience for the development of BRT projects in other cities. In 2023, Changzhou Bus opened its first BRT smart platform, which is an important initiative in response to the new infrastructure layout of smart transport. The platform is installed with an intelligent ticketing system, intelligent self-service coin redemption machines, and electronic stops to provide real-time vehicle arrival information, and passengers can enter and wait for the bus through self-service methods (Transportation Bureau, 2023)

4.3 Characteristics and Current Status of Changzhou's BRT System

Changzhou's BRT system has a number of significant characteristics. Firstly, it is equipped with dedicated bus lanes, which can effectively avoid crossing with other modes of transport, thus improving the speed and punctuality of bus operation. Secondly, BRT stations are usually located in areas with high pedestrian flow and are equipped with convenient transfer facilities, making it easier for passengers to transfer to other modes of transport. Automatic guidance systems using video, magnetic or physical devices will continue to evolve to ensure optimal stopping at stations. In some cases, priority lanes will be intermittent; using advanced signalling and communication technologies, lanes will be reserved only a few metres in front of and behind buses, while at other times they may be used for general traffic (Viegas, 2004). In addition, the BRT system in Changzhou City has adopted an intelligent express ticketing system, which allows passengers to purchase tickets by means of mobile payment and e-tickets, which greatly saves time in purchasing tickets.

Changzhou's BRT system is developing very rapidly today, and the following is the current status of development. In terms of route planning, Changzhou City has taken into account the different divisions of each area in the route planning of the BRT system, such as the main residential areas, commercial areas and transport hubs, which have different traffic flows and different types of vehicles, so different road planning and station hubs have been applied to make the public transport services cover a wider range of areas for the convenience of the public. In terms of vehicle configuration, the municipal government has put in place modern, high-efficiency bus vehicles. The facilities in such vehicles are much better than those in ordinary buses, and they are usually equipped with air conditioning, Wi-Fi and other facilities, which greatly improves the travelling experience of passengers. In terms of operation management, Changzhou BRT has introduced an intelligent traffic management system to monitor and dispatch bus operations in real-time, which greatly improves operation efficiency (Xiao, 2012).

4.4 Analysis of Operation Effect

Since the opening of Changzhou BRT in 2008, it has become an important part of the city's public transport and has had a significant impact on Changzhou's traffic conditions and urban development. Next, this paper analyses the operation effect of Changzhou BRT from the aspects of passenger satisfaction, passenger flow, operation efficiency and fare policy:

According to the survey conducted by the Urban Survey Team of Changzhou Municipal Bureau of Statistics, the overall satisfaction level of passengers with BRT operation service is 85.5%, which indicates that most of the passengers are still satisfied with the BRT system. Changzhou BRT has served nearly 1 billion passengers, with the average daily passenger flow accounting for 1/3 of the total daily passenger flow of the whole public transport in Changzhou, indicating that BRT has become one of the most important means of travelling for the residents. Changzhou BRT operates at a fast speed, with an average speed of about 25.64 kilometres/hour, which effectively improves the operation efficiency of buses. BRT fare is RMB 2 for the whole year, free for transfer, 60% discount for IC card, 30% discount for student card, and free for senior card, which attracts a large number of passengers to use BRT service. BRT vehicles use new environmentally friendly vehicles with low energy consumption and low emissions, which help reduce emissions from urban traffic and play a positive role in improving the quality of the urban environment.

5 CHALLENGES AND PROSPECTS

Since the opening of the Changzhou BRT system on New Year's Day 2008, it has become a landmark system in the city of Changzhou, which has been very effective in relieving traffic congestion and improving the level of public transport services to a large extent (Hidalgo, 2010). In recent years, the Changzhou BRT In recent years, the Changzhou BRT system has faced many challenges, such as the problem of transformation. However, opportunities are often accompanied by challenges, and the Changzhou BRT system also has a lot of room for development.

At present, there are still many problems in the BRT system. The first problem is that the line coverage is insufficient, although it is already at the beginning of the scale, there are still some areas in the traffic blind spot. The second problem is the convenience of transfer to be improved, there are many stations can be clearly found in the transfer facilities are not perfect, may affect the passenger travelling experience. The third problem is in the operation and management, how to deal with the peak passenger flow and emergencies is still a problem that needs to be solved. Changzhou BRT system also needs to continue to improve the quality of service, continue to promote the BRT system construction and continue to expand the coverage of the network, especially to strengthen the urban and rural areas and emerging development areas of the bus facilities. While achieving the above requirements, it is also necessary to continuously optimise the route layout so as to adapt to the course of urban development and changes in the travel needs of the public. With the development of intelligent transport, the integration of intelligent transport systems is also a potential for the development of BRT systems, which can improve operational efficiency and passenger experience. In addition, the BRT system also needs to address the connectivity issues with other modes of transport, optimise the station layout and interchange facilities, enhance the interchange convenience between different modes of transport, and build a seamless integrated transport system. In terms of outlook, the Changzhou BRT system is transforming to digitalisation and intelligence.2023 On 28th November, Changzhou Bus officially opened the first BRT intelligent platform - BRT1 Liaohe Road Changjiang Road Station, which is an important initiative of Changzhou Bus to respond to the layout of the new infrastructure for intelligent transportation. The opening of the smart platform not only improves the travelling efficiency and convenient experience of passengers but also enhances the image of the city. Intelligent platform p equipped with an intelligent ticketing system and intelligent self-service coin exchange machine, fully automated, passengers can self-service to complete the card, code or coin payment and other activities. In addition, the platform inside and outside also laid a number of high-definition cameras, and the installation of remote shouting amplification equipment, remote disposal of emergencies will be more convenient. During the year, 19 new BRT smart stations will be added, which will further accelerate the digital transformation of Changzhou buses and guarantee the sustainable development of the bus system.

To sum up, the Changzhou BRT system is facing the challenge of transformation and upgrading, but at the same time, it is also actively following the development trend of intelligent transport, and through technological innovation and service optimisation, it is constantly improving the service capability of the system and the travelling experience of the citizens (Li, 2009).

6 CONCLUSION

This paper examines the development history, characteristics, and operational effectiveness of the system in Changzhou City, China, and discusses its challenges and future prospects.

Since its opening in 2008, the Changzhou BRT system has become an indispensable part of the public transport system and has greatly improved the level of public transport services. The BRT system has improved the passenger experience and the city's image through humanised design, technological construction and efficient operation. Its unique dedicated lanes and priority signal control effectively ease traffic congestion and improve the running speed of vehicles.BRT vehicles use clean energy, reducing environmental pollution and improving urban air quality. Surveys have found that passengers are highly satisfied with the BRT service, with average daily patronage accounting for 1/3 of total bus patronage. BRT buses have a favourable fare policy, which attracts a large number of passengers to use them and promotes the popularity of the bus service. However, despite the remarkable results, the BRT system still faces challenges such as insufficient route coverage and transfer convenience to be improved.

Changzhou BRT system will continue to promote digital and intelligent transformation, strive to introduce new high-tech technologies and continuously improve service quality to enhance

passenger experience. The Changzhou government would do well to expand the coverage of the network, optimise the route layout, and strengthen the bus facilities in the urban-rural areas and emerging development zones. At the same time, it should find ways to solve the problem of connecting BRT buses with other modes of transport and build a seamless integrated transport system. With the development of intelligent transport, the BRT system has high hopes to enhance its service capacity through technological innovation and service optimisation to provide more convenience to residents.

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