SUSTAINABLE INFRASTRUCTURE PARTNERSHIP

GUANGZHOU BUS RAPID TRANSIT(BRT), CHINA ©GuoZhongHua/Shutterstock.com

CHINA

THE BUS RAPID TRANSIT SYSTEM IN GUANGZHOU, CHINA

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The International Good Practice Principles for Sustainable Infrastructure

set out ten guiding principles that policymakers can follow to help integrate sustainability into infrastructure planning and delivery. They are focused on integrated approaches and systems-level interventions that governments can make to create an enabling environment for sustainable infrastructure. This case study illustrates specific aspects of one principle in a country context, showing good practices and challenges, and considering potential for advancement or replicability.

GUIDING PRINCIPLE 2: RESPONSIVE, RESILIENT AND FLEXIBLE SERVICE PROVISION

Infrastructure planning and development should be based on a good understanding of infrastructure service needs and informed by the diverse options available to meet those needs. This includes understanding and managing the changing demand, and meeting needs through renovating or rehabilitating existing infrastructure before investing in new infrastructure. Systems-level planning of infrastructure projects should promote synergies for improved integration, which can lead to improved productivity, efficiency, sustainability, and spillover benefits of investment. Flexibility and resilience should be built into infrastructure plans to allow for changes and uncertainties over time, and plans should be updated.

BACKGROUND

Located in southern China, Guangzhou is the capital city of Guangdong Province as well as China's third largest city. With a fast-growing economy and an influx of people due to urbanization, the demand for transport in Guangzhou grew rapidly in the first decade of the millennium. By the end of 2009, Guangzhou's vehicle fleet had reached 1.35 million. Out of these 1.35 million vehicles, 1.1 million were cars, representing a 17% increase compared to 2008 (He 2010). However, the capacity of the public transport system did not increase sufficiently during this period and overloaded traffic conditions led to serious gridlock, which has threatened the city's economic growth as well as its air quality (Center for Clean Air Policy [CCAP] 2017). During peak hours, the roads in and out of the city centre were congested, with an average speed of 18.7 km/h on the main roads, which is below the internationally recognized congestion threshold of 20 km/h for large cities (He 2010).

THE GUANGZHOU BUS RAPID TRANSIT SYSTEM

To address these accumulating problems, the Guangzhou Bus Rapid Transit (GBRT) system was planned and launched under the mayor's leadership. The GBRT system consists of a 22.5-kilometre corridor of dedicated, fully segregated bus lines running through Zhongshan Avenue, the arterial road that suffered most from the congestion (Sohu News 2007). The conceptual design of the project started in 2004 with support from the Institute for Transport and Development Policy (ITDP), Far East Mobility, and the Guangzhou Municipal Engineering Design and Research Institute (Far East Mobility 2020; Development Asia 2016). The GBRT was then officially inaugurated in February 2010. With its 31 bus routes and 26 bus stations, the GBRT had the second highest passenger capacity out of all BRT systems in the world at that time (World Wide Fund For Nature [WWF] 2012). In the 11 years following its launch, the GBRT has served over 3.49 billion passengers (Dayoo 2021).

Source: Hughes and Zhu 2011

NEEDS-BASED PLANNING BY REHABILITATING EXISTING INFRASTRUCTURE

Inspired by a study trip to already existing and successfully running BRT systems in South America, the Guangzhou municipal government decided against competing options for catering to its citizens' mobility and air quality needs – such as building a subway – and in favour of setting up a BRT system (Far East Mobility 2021).

The fact that the BRT system could be set up by rehabilitating existing infrastructure made it a convenient solution for Guangzhou's congestion and air pollution problems. BRT systems are also cheaper to establish and operate and can be implemented faster than light rail or subway projects, while having a comparable or even higher capacity (Far East Mobility 2021). The government, therefore, opted to create a BRT system through upgrading the existing urban infrastructure, providing priority lanes and signals for bus services operating on existing roads (Asian Development Bank [ADB] 2010).

In addition, the GBRT adopted a needs-based approach to building the necessary additional facilities. The sizes of all 26 bus stations of the GBRT system are designed to meet modelled passenger demand and the needs of bus operations, with station sizes ranging from 55m to 260m (Deng *et al.* 2013, p. 230; Hughes and Zhu 2011, p. 5). To also cater to the needs of mobility-impaired passengers, several accessibility features such as escalators, wheelchair lifts and low floor buses allowing for easy entry and exit were integrated into the design of the GBRT (ADB 2010, p. 2; Hughes and Zhu 2011, p. 8).

PROMOTING SYNERGIES FOR IMPROVED CONNECTIVITY

The GBRT system is connected with different transportation modes in the city, making it a leading example of multi-modal transport integration (Fjellstrom 2010, p. 371). The GBRT is the first BRT system in the world to include direct connecting tunnels between GBRT and metro stations (Lin *et al.* 2014, p. 33). The fare systems of the GBRT and subway were also integrated, further facilitating a seamless transition between the two modes of transport (United Nations Economic and Social Commission for Asia and the Pacific [UNESCAP] 2012).

In addition, the GBRT system integrates non-motorized means of transport: for pedestrians, it provides regular, safe crossings along the GBRT corridor and bridges that connect GBRT stations directly to adjacent buildings (Deng *et al.* 2013, p. 230).

The GBRT system is integrated with Guangzhou's bicycle infrastructure through segregated bike lanes running parallel to the GBRT corridor. Integrating the GBRT system with Guangzhou's bicycle infrastructure has the potential to encourage bike-and-ride, attract passengers from a wider radius and facilitate the door-to-door journey, thereby solving the "last mile" problem of BRT station access (Deng *et al.* 2013, p. 233; Hughes and Zhu 2011, p. 2). To further exploit this potential, a bike-sharing system was set up in 2010,[1] with stations located along the GBRT corridor, nearby commercial areas, and in residential areas. In 2016, the bike-sharing system had 113 stations with 5,000 bikes. Among the 20,000 people who used the bicycle-sharing systems, more than two thirds previously used motorized means of transport (ITDP 2016).

Integrating the GBRT with both non-motorized means of transport and Guangzhou's metro system required clearly defined responsibilities between the agencies involved, as well as effective communication to realize a successful integration of transport modes across the city (UNESCAP 2012, p. 2).

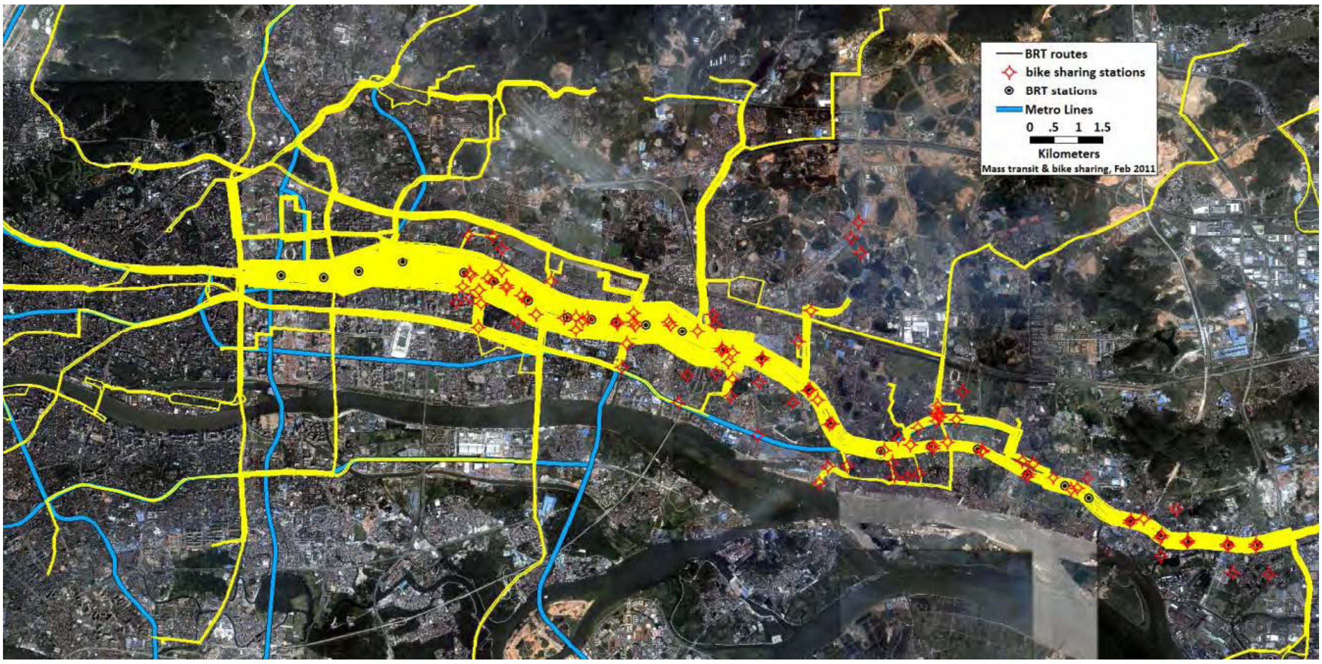

FIGURE 1: BRT-CONNECTED METRO LINES AND BIKE-SHARING SYSTEM IN GUANGZHOU

Source: Hughes and Zhu 2011

IMPROVED PRODUCTIVITY AND EFFICIENCY

Before the introduction of GBRT, traffic speed on Zhongshan Avenue was below 20km/h and was decreasing steadily, with hundreds of buses blocking the traffic flow and trying to pick up passengers from crowded kerbside stops (Hughes and Zhu 2011, p. 3). By 2014, the average operational speed of the GBRT lines reached 23 km/h, 84% faster than prior to the launch of the system (Guangzhou Award 2014). Today, the average operational speed of the system has increased further to 24.8 km/h (Global BRT Data 2021).

These improvements are due to several key design features of the GBRT system, including segregated, dedicated bus lanes, frequent departures of buses (one bus every 10 seconds into the city in the morning rush hour), and ticket controls before boarding (Hughes and Zhu 2011, p. 14; WWF 2012). By virtue of these features, GBRT has brought about significant travel time savings – not only for GBRT users themselves but also for motorists in the GBRT corridor. For the former group, it is estimated that trip times decreased by 29% and for the latter group by 20% (United Nations Framework Convention on Climate Change [UNFCCC] 2021). In addition, reported passenger waiting times decreased by 19% (Hughes and Zhu 2011, p. 11). By reducing travel time along the Zhongshan Avenue corridor, the GBRT also improved access to employment and business opportunities for those residents who were previously constrained by the commuting conditions (Li and Fjellstrom 2016; UNESCAP 2012).

1 The original publicly subsidized bicycle-sharing system has been replaced by several private providers offering the same services since 2018.

Furthermore, the GBRT has proven to be a cost-efficient public transport project. In comparison to the situation before the introduction of the GBRT, the system is now reducing annual operating costs by over 90 million yuan, after an initial capital investment of 950 million yuan for GBRT stations and lanes (Hughes and Zhu 2011, p. 2). These efficiency improvements are also driven by the introduction of competition between seven different bus operators in the GBRT service corridor, whose payment is based on total bus kilometres provided as well as on performance factors such as maintenance of operation plans or passenger complaints (Gunter 2010; ITDP 2010).

The GBRT has maintained the momentum to further improve the efficiency and quality of its services. In 2020, GBRT saw the launch of China's first BRT pilot line to fully adopt a 5G Smart Coordination System. By effectively streamlining the city's public transport scheduling, the application of this 5G System can save up to 10% of the line's transport capacity. In addition, information on the routes of the GBRT buses is transmitted to the city's public transport guidance app, Xingxuntong, enabling passengers to find out about the location and free capacity of the closest buses (Deng 2020).

ENVIRONMENTAL SUSTAINABILITY

Over the past years, the GBRT system has brought significant benefits in terms of environmental sustainability, reducing carbon dioxide (CO2) emissions by an average of 84,000 tons annually (UNFCCC 2021). By also leading to an expected reduction in particulate matter of 14 metric tons annually, the GBRT system is contributing to a decrease in the number of health problems related to emissions in the city *(*UNFCCC 2021). In addition to the modal switches from motorized to non-motorized transport induced by the success of the GBRT system, these reductions can be traced back to the operational savings resulting from higher bus speeds and fewer bus kilometres in the GBRT corridor (UNFCCC 2021).

To further leverage the environmental benefits and the related health benefits of the GBRT system, the bus fleet operating in the GBRT corridor was switched from buses that run on liquefied petroleum gas (LPG) to electric buses in 2018 (C40 Knowledge 2019). By the end of 2019, the city had already introduced 11,394 fully electric buses. This makes Guangzhou one of the cities with the largest number of fully electric buses in the world (UN Sustainable Development Group [UNSDG] 2019). Switching the bus fleet to fully electric buses is expected to lead to a reduction in CO2 emissions of 249,000 tons annually, as well as resulting in reduced air pollution and noise (C40 Knowledge 2019). Provided there is further greening of the overall electricity mix of the province – a critical ongoing challenge – the emission reduction potential[2] of the switch to electric buses could be even higher in the intermediate future (ADB 2018, pp. 22f. and p. 25; Deutsche Gesellschaft für Internationale Zusammenarbeit [GIZ] 2020, p. 5; Wei 2021).

REPLICABILITY

The GBRT model has great potential to be adopted and scaled up in large and medium-sized cities with a high population density, constrained urban spaces and traffic gridlock problems. The success of GBRT also showcases the potential of an integrated multi-modal transportation system that is more attractive to the public in cities with a high population density.

Nationally, the GBRT has now been successfully replicated in several other Chinese cities. Peer learning from the Guangzhou BRT system by senior city officials has been crucial for replicating BRT projects in Lanzhou and Yichang (Far East Mobility 2021). In addition, the Transformative Urban Mobility Initiative (TUMI) has organized a site visit to the GBRT and a training course on BRT in China, with the aim of deepening and improving the capacity of policymakers and technicians to plan, implement and monitor BRT and urban development projects and policies in Chinese cities (TUMI date unknown).

The GBRT has also helped to inspire other BRT systems around Asia and the world. Multiple nations and multilateral institutions such as the ADB are now sending their delegations to Guangzhou to learn from the design of the GBRT and conceive more sustainable transport infrastructure globally (UNFCCC 2010).

2 Compared to the liquified petroleum gas buses that serviced the GBRT corridor prior to the switch to electric buses, electric buses have lower CO2 emissions, but the amount of CO2 reduction will depend to a large extent on the electricity grid (ADB 2018, p. 22).

KEY INSIGHTS

> The GBRT system presents an effective solution to Guangzhou's problems of congestion and air pollution. It is based on upgrading existing infrastructure and taking a needs-based approach to the construction of new infrastructure.

> By integrating the GBRT system with the city's public transport system and non-motorized means of public transport, the catchment area of the system has been greatly expanded, thereby inducing many modal switches from motorized to public transport.

> The well-planned design features of the GBRT system, such as segregated bus lanes or frequent bus departures, as well as the innovative usage of digital tools, have had profound positive impacts on the city's productivity, efficiency and sustainability.

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