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Perspective on an urban transportation strategy with BRT for developing citiesFumihiko Nakamura*¹⁾, Kazuhiko Makimura²⁾ and Yurie Toyama³⁾¹⁾Department of Civil Engineering, College of Urban Sciences, Yokohama National University, Hodogaya-ku, Yokohama 240-8501, Japan²⁾Institute of Behavioral Sciences, Shinjyuku-ku, Tokyo, 162-0845, Japan³⁾Mitsubishi Research Institute, Japan

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Abstract

A Bus Rapid Transit (BRT) system is one of the best strategies for urban transportation, especially in developing cities, mainly because of its cost-efficiency. Starting from Curitiba, Brazil in 1974, including Bogota, Colombia in 1999, many cities in Latin American Countries have implemented a BRT system. In almost all cases, BRT systems are working as a reliable high capacity service. In some cases, BRT systems are well coordinated with an urban transportation strategy framework and/or an urban planning strategy framework, integrating other transportation modes and land uses. Alternatively, there have been very few cases of BRT systems in Southeast Asian countries. Many cities considering implementation of BRT systems do not consider other urban transportation strategies such as Transit Oriented Development (TOD). The objective of the paper is to discuss the perspective of a BRT for developing cities. First, the paper reviews the history of BRT systems followed by a field survey of the results in Curitiba, mainly from an urban transportation and planning strategy point of view. Second, multimodal and inter-modal aspects are discussed, where the relationship with city buses, a balance between private car use and parking policies are emphasized. Third a framework of urban bus planning, management and operation is discussed considering the roles of public and private sectors based on the experiences of several developed cities. Finally, in terms of an urban planning strategy, reviewing the original and applied concepts of TOD, the authors discuss how a TOD strategy could work with BRT systems. The authors address the possibilities and limitations of BRT systems, especially in developing cities. More specific implications are presented in the case of medium sized cities of Southeast Asian countries.

Keywords: Urban transportation strategy, Bus Rapid Transit (BRT), Transit Oriented Development (TOD), Developing cities

1. Introduction

The Bus Rapid Transit (BRT) system is one of the best alternatives for urban transportation especially in developing cities mainly because of its cost-efficiency [1-2]. Starting from Curitiba, Brazil in 1974 and in Bogota, Colombia in 1999, many cities in Latin American countries have implemented BRT systems [3]. In almost all cases, the BRT systems works reliably with higher-capacity. In some special cases, BRT systems are well coordinated with urban transportation strategy frameworks and/or with urban planning strategy frameworks, taking other transportation modes and land uses into account [4-5]. Alternatively, there have been very few cases of BRT systems in Southeast Asian countries. Many cities have been considering BRT introduction, most of which, however, do not look to have sufficient consideration with respect to an urban transportation strategy or an urban planning strategy such as Transit Oriented Development (TOD). The objective of the paper is to discuss the perspective of BRTs, particularly for cities in developing countries. In Section 2, the history of BRT systems in the world is introduced. The section also discusses the case of Curitiba, mainly and the basis of its

urban transportation strategy and urban planning strategy. In Section 3, several related aspects are discussed, including multimodality, the framework of planning, management and operation, implications of urban planning and design such as Transit Oriented Development. In Section 4, as conclusions are presented, the authors address the conditional possibilities and limitations of BRT systems, especially in case of cities in developing countries. More specific implications are also introduced in case of medium-sized cities in Southeast Asian countries.

2. History of BRT*2.1 Definition of BRT*

The phrase, Bus Rapid Transit, first appeared in a report published by the USDOT (United States Department of Transportation) in 1975 [6]. This book notes that a BRT can be applied to high density city centers with minimal introduction costs and low environmental impact. Thanks to this system, the use of automobiles can be controlled and the system can be flexibly improved with the growth of a city. Figure 1 shows the years that BRT operations were started

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1970s	1980s	1990s	2000s	2010s	
71 72 73 74 75 76 77 78 79	80 81 82 83 84 85 86 87 88 89	90 91 92 93 94 95 96 97 98 99	00 01 02 03 04 05 06 07 08 09	10 11	
Curitiba	Goiânia Porto Alegre Nagoya (Key Route) Ottawa Adelaide Pittsburgh	Seattle Paris	Quito Taipei Kunming Brisbane Sydney Boston Eugene Los Angeles Rouen Caen Amsterdam Eindhoven	Bogotá → Jakarta São Paulo Guayaquil Nagoya (Yutorito) Seoul Beijing Hangzhou Orland Miami	Bangkok

Figure 1 Open year of BRT operation

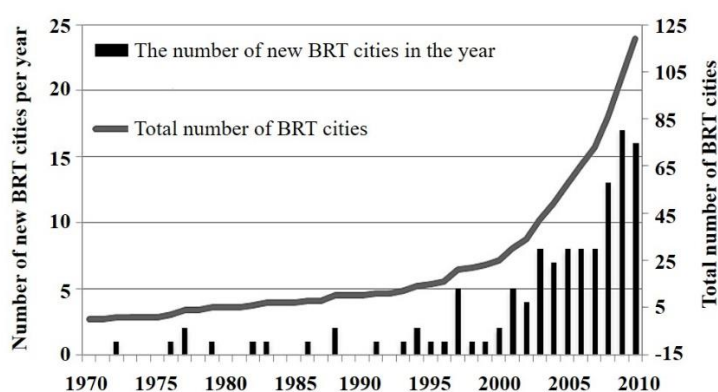


Figure 2 The number of new BRT cities in the year/total number of BRTs

in major cities.

As seen in Figure 1, the earliest BRT was in Curitiba, Brazil. In Curitiba, Jaime Lerner, the mayor of Curitiba, took initiative in making a master plan which set the bus system as an important element in the city. Based on this master plan, the BRT in Curitiba finally started its operations in 1974. After its introduction, several other Brazilian cities tried to start BRT systems. Later on, some cities in Mexico, Colombia, Peru and Ecuador introduced BRTs. The BRT system in Bogotá, the capital of Colombia, was designed based on Curitiba's BRT experience with some of their own local ideas. The Bogotá's bus system is named as Transmilenio and it started operations in 1999. Transmilenio has very high level of performance with respect to speed, capacity and presence [7-8]. As Figure 2 shows, the number of BRT systems dramatically increased from 1999 to 2003 after Bogotá's start. Therefore, Bogotá's Transmilenio can be regarded as a milestone for BRT systems.

Transjakarta in Jakarta, Indonesia is an example that mirrors Transmilenio. A non-profit organization, called ITDP, opened a branch office in Jakarta to install a new BRT system in Jakarta. ITDP Indonesia took the initiative to learn from Transmilenio. Transjakarta should be appreciated as it has more than 120 km of busways in total, which were constructed within 5 years. The scale and speed of the BRT infrastructure construction is very remarkable and it has influenced other Asian cities.

Additionally, buses in North America, including the United States and Canada, Australia and European countries have evolved in their own ways. Runcorn, one of the British

new towns, is famous for its busway system. It was installed in accordance with the new town construction. Essen in Germany was the first city to have a guided BRT system (Guided BRT). In recent years, more Indian and Chinese cities have been interested in constructing BRTs. According to a report by the EMBARQ, thirteen Chinese cities and four Indian cities installed BRT systems in 2012. African and Middle Eastern cities such as Dar es Salaam and Amman have discussed introduction of exclusive lanes and pre-fare collection systems.

The first Japanese BRT-like arterial bus started to operate in Nagoya in 1982. In Seoul, the bus system was completely reorganized in 2004 and started to operate with center-located exclusive bus lanes. This is also regarded as an example of BRT. Seoul municipality based its reformation on Curitiba's bus system. There are also about ten Southeast Asian cities, including Vientiane and Khon Kaen, trying to develop new BRT systems. BRT systems are expected to play more important roles because construction of a BRT is easier and cheaper than that of trains.

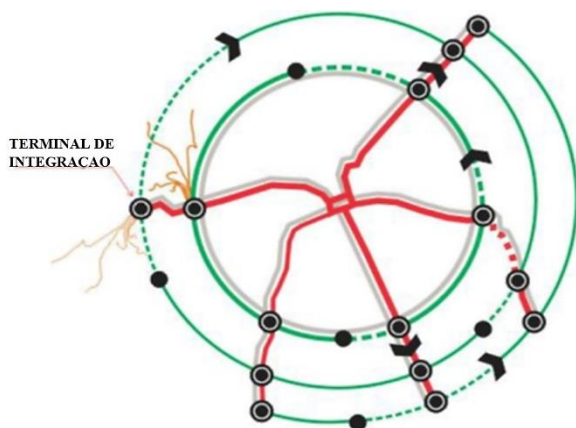
Curitiba is the root. Bogota is a turning point and Jakarta is a milestone in a Southeast Asian context. The authors summarize the basic information on BRTs in those three cities in Table 1.

2.2 Curitiba's experience

Curitiba's bus system has been noted for its uniqueness in terms of the following:

Table 1 BRTs in Curitiba, Bogota and Jakarta

	Curitiba, Brazil	Bogotá, Colombia	Jakarta, Indonesia
Features	World's first BRT Bus with development	High performance Information technology	Asian longest network
Population	1.85 million	7.36 million	9.59 million
Area	435 km ²	352 km ²	660 km ²
GDP per capita	US\$ 10,816	US\$ 5,967	US\$ 3,005
The year of operation start	1974	1999	2004
Length of busways	72 km	84 km	123 km
Number of vehicle	185	519	524
Average passenger per day	350,000	812,000	360,000

**Figure 3** Busway in Curitiba**Figure 4** Concept of the hierarchical bus network.

1) Its center is located in a busway with high rise mixed use development along the busway. This creates a development axis or structural corridor as shown in Figure 3.

2) It has a hierarchical network called an RIT (Integrated Route network of buses) with different colored buses according the route category regardless of the operator. Figure 4 shows the concept of a hierarchical network in which the color of the lines represents the color of buses on the line. Red colored buses operate on the main lines using busways in the structural corridors. Orange colored buses operate on the feeder lines connecting to the main lines at

free transfer interchanges. Green colored buses connect the interchanges along the depicted rings. Silver colored buses operate along red and green bus routes with a limited number of stops to enhance the operation speed to compete with the increased use of private cars since the early 1990's.

3) All the service is planned by IPPUC, the Institute for Urban Planning, managed by URBS. This is a public company for urban infrastructure that is operated by private company.

4) There is an integrated bus interchange collocated with branches of the city hall and some public service facilities.

5) It has a tube-style pre-boarding fare payment bus station with articulated or biarticulated buses.

It should be understood that a dedicated median located busway is just one element of the whole system. Bogota and Seoul are the well-known adopters of Curitiba's approach. Bogota used most of Curitiba's elements, but there is no coordination between urban development and systemwide management. Rather, Bogota focused intensively on capacity, speed, and security aided by information and communication technology as well as modal shift from cars to buses, bikes and pedestrian lanes with restrictions on car use through license plate control, special taxes for petroleum and an annual car-free day. Seoul allows implement most of these elements without coordination with urban development. The Seoul busways are not truly busways, but just designated bus lanes without curb segregation. Seoul changed the whole bus system of around 8,000 buses at once. Jakarta followed Bogota's example but it gave insufficient consideration to capacity and speed. It did not invest in information and communication technology. We should understand the importance of having a framework and implementing strategy together.

Lessons learned from Curitiba's case should be useful when we consider planning of a BRT.

Curitiba wanted to introduce an urban rail system but was unable due to funding problems. They needed a system that used only buses. The city considered the bus system as something new with potential.

Curitiba strove to avoid disordered expansion of urbanization. A development axis was originally a guideline for urbanization. It was flexible as it could extend according to the speed of growth and other exogenous factors.

Busways with curbs were not designed for capacity, speed and priority. The side lanes of the busways are for local traffic having light volume and low speed. The busways were not necessary from the perspective of traffic engineering. The appearance of a transportation infrastructure appeals to the citizens of Curitiba.

As the traffic in the side lanes of busways is light and slow, bus passengers can easily cross these lanes before boarding and upon exiting a bus. Continuous development along busways on the ground and second floors for business and shops attract many people to these streets. Curitiba

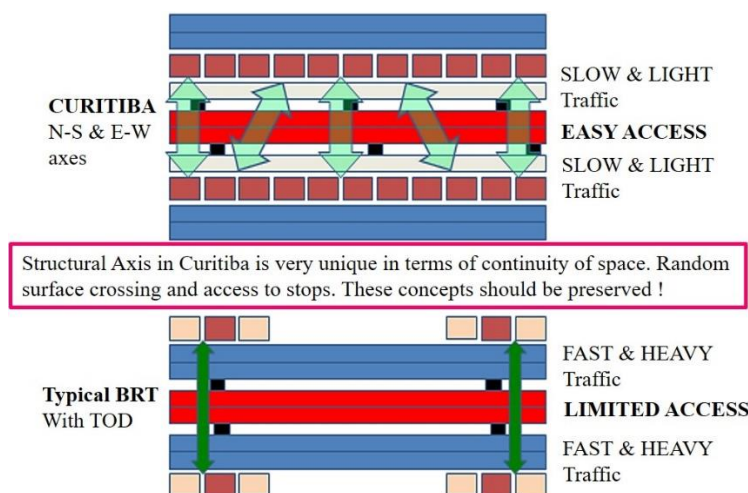


Figure 5 Difference in the busways of Curitiba and other BRTs

respects freedom of pedestrian movement and the relationship between urban activities and buses. The difference between Curitiba’s busway and other BRTs busway is illustrated in Figure 5.

The pre-boarding fare payment in bus stations and a biarticulated bus fleet introduced in Curitiba was the first in the world. The idea did not come from available technology but from demand. The IPPUC team once seriously considered a system to carry 15,000 passengers per hour in each direction by bus at just one minute intervals. The solution required more than large capacity buses. To make boarding times at the stations as short as possible, a prepayment station system was developed. Needs driven pressure drove innovation.

As in many cities in Latin America, the residences of lower income people were located in suburban areas. In order to achieve social inclusion, it was important to provide a connecting public transport system with a new technology of which the residents could be proud.

The first pedestrianized street in Curitiba is connected to a big tube-bus station. The street was pedestrianized in 1972, when Munich and Asahikawa also started pedestrianized streets in their town centers. The street is often full of citizens who are very proud of it.

2.3 Current situation in Curitiba: Problems and possible solutions

In spite of Curitiba's efforts, our case studies and interviews show that situation in Curitiba has changed completely since 2004. At some tube bus stops, as shown in Figure 6, there are long queues during peak hours which results from poor design of tubes and use. Moreover, the operators have never tried to improve customer service.

The Brazilian federal government's policy promoted car purchases and this led to road congestion. Less priority was given to traffic signals for buses. Now traffic jams in peak periods are very serious as shown in Figure 7. Condominiums along the busways have become so popular that their prices increased. Many affluent people with cars live here. The issues about utilization of platforms, management of operation companies, training activities for staff, traffic management and regulations for car use are serious. As the political pressure from car users is very

strong, a bus priority signal system was stopped and the cycle times at grade-intersections with busways were changed to give longer green lights for cars and less for buses. Until 2004, new car parking garage construction was prohibited in the downtown area. Then this measure was abandoned. After that, a lot of parking garages were constructed and now they compete with each other. According to our survey, more than half of the space is dedicated for garages in some blocks in the city center.



Figure 6 Queue of waiting passengers at a tube stop



Figure 7 Morning traffic congestion in Curitiba

Segregated busways and vehicles including articulate and biarticulated buses perform well even at present, but the capacity of the stations is not well managed. During the peak hours, some stations have queues of waiting passengers. Passengers are uncomfortable while waiting for their bus. Each biarticulated bus uses only one door (the third door) for boarding at median stations though it has five doors. As a result, congestion occurs near the third door and stopping times at stations tend to become longer. This causes buses to bunch and longer waiting time for passengers reducing the appeal of buses. In addition to the problem of the stations, unsafe driving of buses is often observed. This comes from poor management of drivers by operators. This should be controlled by the URBS, the public company managing all of Curitiba's BRT systems.

As the corridors became occupied by rich people, low income groups have been obliged to live far from the city center or even outside of the city. As the bus system is well integrated with neighborhoods, they can reach the city center using connecting buses. Therefore, buses on the busways are congested. However, as the bus network has flat fare system, which favors the poor sectors, its cost effectiveness is worse as most of the passengers are long distance riders. These negative issues, combined with federal promotion of motorization, induced higher automobile use. There is much political pressure for elimination of strong traffic management and control.

Furthermore, new residents of Curitiba who migrated from other regions neither know the history of the city nor are proud of their city as human oriented environmental capital. They do not know the history of buses. Recently the policy of social welfare has been changed. Formerly all citizens were asked to join city activities and work. Otherwise, there would be no subsidies. Nowadays, the number of street beggars has increased as they do not have to work. All of these factors have made the security level worse and discouraged people to use buses. The points to be learned are as follows:

- 1) The strategic location of a low income group residential district should be coordinated with their activities patterns. An advanced public transport system will make them socially included while providing reliable and smooth access to the city center.

- 2) The history of the city should be learned by all the citizens in Curitiba. Educational opportunities should be provided, even for elder people.

- 3) Security is the first priority for public transport to attract car owners. Bogota's BRT Transmilenio is a reliable, speedy and secured public transport system that attracts middle to high income white collar business persons in the peak hours.

- 4) Mobility for a wide range of individuals must be provided. People should be able to travel safely and comfortably without private cars.

3. Aspects to be considered for successful introduction of BRT

3.1 Multimodal and Inter-modal aspects

The experience of the BRTs in several cities tells us the importance of multimodal and inter-modal transportation. Here "multimodal" refers to choice environment of various modes. In other words, urban transportation strategies should provide a choice environment to all the travelers. Public

transportation modes such as a BRT should become one of the choices of all travelers [9-10]. Public transportation modes should be designed so that all travelers recognize one possible alternative to travel to their intended destination. Under this concept, the role of regular buses and cars must be discussed in detail [11]. An integrated network of public transportation modes consisting of a BRT, regular buses and possibly paratransit modes would enable efficient mobility. As car restrictions in city centers also affects multimodal transportation. It would be important to set the role of cars in the context of other modes.

The term, intermodal aspect, refers to the connectivity between transportation modes, which includes not only public transportation but walking and bicycling and among others [12]. The walking mode is the main feeder mode for public transportation systems and should not be ignored. All of the successful BRTs in the world improved the walking environment around BRT stations.

3.2 Separation of planning, management and operation

In many cities, the bus system was started as a service business. As such, the bus companies planned the service, managed the company, and operated buses and managed the drivers. Under these conditions with no control and regulation, companies compete for more passengers. In most cases, the drivers also compete to for more passengers their salary is proportional to the number of passengers carried.

As seen in Curitiba's case, the separation of planning, management and operation is highly recommended. There might be variety of the separation patterns. In the case of Seoul, planning and management is done by the city, while the operation is done by operators based on their contracts with the city. In Curitiba, planning is done by the City Planning Institute, just under the mayor, while management is done by a public company for urban transport infrastructure and systems. Operation is done by private operators based on the contracts with the management public company. In both cities, all the bus services are in the same framework. Therefore, coordination and integration of a public transportation system was achieved at a very high level. In the case of Bogota, the BRT system is in a single framework, while regular bus routes are not. Bogota city has a very clear strategy that existing bus routes shall be replaced gradually. In the end, all the routes will be in the same framework. City planning and urban design should always be coordinated. Management should be coordinated with financial planning and infrastructure management. Operation should be coordinated with traffic management.

3.3 TOD

A BRT could provide a more punctual and reliable transport option to citizens. It alone will not mitigate traffic congestion. If any city needs to mitigate traffic congestion, some sort of modal shift should be considered. All travelers should be considered intelligent enough to make logical and rational judgments about their transportation options. This is sometimes difficult in developing cities. Furthermore, security problems are serious. So, a modal shift for a BRT in developing cities can be quite difficult.

To address this situation, the TOD concept should be used as it could change the life styles of citizens by enabling them to not rely on their automobiles. The TOD advocates development of excellent walkable environments that do not require the use of cars. Security for towns and BRTs are also needed.

4. Conclusions

This paper provides an overview of the history of BRTs, mainly in developing countries. It focuses primarily on Curitiba's case as the first and an excellent planning experience for the use of buses and a BRT. Learning from Curitiba's history, important aspects for BRT planning were summarized.

The authors emphasized the multimodal and intermodal aspects, the framework of planning, management and operation and TOD concepts needed for successful BRT systems in developing cities.

A BRT should have a new appearance, be clean, safe, speedy and reliable to appeal to citizens especially potential users who use cars and motorcycles at present. From an engineering point of view, capacity, demand and traffic engineering are important. Priority should be given to developing clear and easily understood goals. Simple but comprehensive proposals are required for connections with other public transport modes, car restrictions and activities in an urban setting.

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