BUS RAPID TRANSIT:
A COMPARATIVE STUDY OF BRT IN CURITIBA AND LOS ANGELES

by

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Bus Rapid Transit

Bus Rapid Transit (BRT) is a broad term attributed to different transportation systems that provide a service that is of higher quality than a regular bus line. BRT can be a part of a system comprised only of buses or can be part of a system that incorporates buses, light rail, and heavy rail. Each BRT system has different elements and improvements but most share common elements.

Before even using the name Bus Rapid Transit, this system gained popularity in the United States when the federal government began to provide more funding for urban mass transit in the 1960s. The first busway given an exclusive right-of-way in the United States was the El Monte Busway connecting El Monte with Los Angeles, first opening in 1973 (Wikipedia, 2006). Since then, BRT systems have been implemented all over the world. BRT systems are located in North America, South America, Europe, Asia, and Australia, with the most successful system in Curitiba, Brazil.

As times change, communities are starting to think differently about how mobility options are provided and the cost alternatives for these options. The way in which transportation infrastructure is used is also a concept that must be evaluated. BRT is certainly a very innovative way of thinking about all of the above issues.

According to the Surface Transportation Policy Project, the majority of federal money used to fund transportation went to roads between the years of 1992 and 2001. Only a small amount (5%) went to transit. (Wikipedia, 2006) While this is unfortunate, trends show that this will continue for a substantial amount of time. Strategies that influence the massive investments that are made in roads and highways are needed
and BRT seems to be the answer. The system reduces the cost of providing transit to riders therefore increasing the value of the road investments. The BRT system does not sacrifice quality or carrying capacity.

Because of its obvious benefits, the Federal Transit Administration (FTA) recognizes that BRT is the best hope for increasing the carrying capacity of transit. In its 2004 budget, the FTA discussed changing the requirements for “New Starts” projects from just rail projects to bus projects as well (Wikipedia, 2006). This was done in hopes of encouraging communities to implement some form of BRT as its public transit. With that said, however, the FTA subjects both rail and bus projects to the same analysis of capital and operating costs.

The United States General Accounting Office (GAO) has found through research that the capital costs for BRT are much lower than that of light rail systems. It was found that the capital cost for operating a BRT on arterial streets in the Los Angeles model (to be discussed later) was only 2% of that of the average light rail capital costs. The GAO found similar data for operating costs. It is found that BRT has a lower operating cost per vehicle per mile than that of light rail systems. Also, it was concluded that BRT systems have a lower cost per vehicle per revenue mile. (Wikipedia, 2006)

In addition to the cost savings that BRT systems provide, it has also been concluded that there is more of an opportunity for economic vitality to be drawn around BRT stations. BRT systems have been found to draw substantial transit oriented-development and have had a positive correlation with land values around stations.

BRT systems are oftentimes quicker to implement and can be more appropriate in scale for locations that have moderate density. The possibility of being rerouted is
also a good testament to the flexibility of BRT systems. The simple fact that these vehicles are not permanently attached to a predetermined route is a sign of the flexibility of the system as a whole.

Components of BRT Systems

BRT uses the best features of rail transit with the flexibility and cost benefits of street transit. There are seven major components of BRT systems. Communities often choose from a number of options in order to meet their needs and budgets. (Vincent, 2006)

1. **A dedicated right-of-way** is important in a BRT system. It maximizes speed and decreases travel time along the route. Regions often include a grade-separation of rights-of-way as well. Dedicated rights-of-way also give the system more flexibility than rail because these rights-of-way can be shared with emergency vehicles and/or high-occupancy vehicles. These special rights-of-way are considered a preference for the buses. While not in the special right-of-way lanes, BRT vehicles also make use of technologies that manipulate the traffic system timing in order to minimize delays at traffic signals. (Vincent, 2006)

It is important to note, however, that BRT systems that make use of dedicated rights-of-way have capital costs that are 13 times greater than those systems that do not make use of dedicated rights-of-way. (Vincent, 2006)
2. **Station design** and utilization is another important aspect of BRT systems. Basically, BRT stations are convenient and easily accessible. Stations vary in design. Some are just a step above regular bus shelters, perhaps with a bench. Some are more futuristic, subway-like structures. Because land use oftentimes follows transportation, permanent stations will encourage economic activity around them. Depending on the needs and profile of the community, stations may include parking, shopping, restaurants. Pedestrian and bicycle access are usually a staple of these stations. (Vincent, 2006)

3. **The vehicles** seem to be the most important part in the BRT equation because without them, there would be no BRT system. There are several vehicles used in BRT systems around the world. The common characteristics are that they are convenient, easy to board, comfortable to ride, and quiet both inside and outside. The most advanced vehicles offer optical or magnetic guidance. This feature improves safety and allows the vehicle to come within inches of the platform, which brings more ease to the boarding process. Ideally, these vehicles can hold more than 150 people, which maximize the carrying capacity during peak hours. (Vincent, 2006)

4. **Fare collection** is an aspect of BRT that decreases the amount of time spent at the platform when boarding passengers. Like rail systems, fares can be collected before boarding the bus. In regions where there is also a rail system, the same system of fare collection is oftentimes implemented. This allows riders
to use the same fare card or tokens for boarding both types of transportation. (Vincent, 2006)

5. The service that is provided by the BRT systems eliminates the need for a trip schedule. The service is provided frequently during the day (and/or night.) BRT systems also have the opportunity to provide local and express service to riders. The flexibility allows all of the needs of riders to be met. (Vincent, 2006)

6. Route structure in BRT systems is the key to eliminating the need for feeder routes, therefore streamlining the system as a whole. This also allows the routes to go into communities and neighborhoods getting rid of the need for people to use a personal automobile or other modes of transportation to get to the bus. Bringing the transportation to the people and changing the route structure decreases the need for complicated maps or schedules and makes the lines more appealing to more riders. (Vincent, 2006)

7. Intelligent transportation systems (ITS) are used to keep track of the vehicles, control traffic signals, update passengers on travel time, and perform other important tasks. Some of these systems are located in the vehicle or at the boarding station. As technology advances, it is becoming possible to transmit the messages to riders.
Statement of Purpose

This project explores the Bus Rapid Transit system that is currently being implemented in Los Angeles, California. While this system is already in the deployment stage, this analysis can help enhance parts of the system plan to be implemented in the future.

Curitiba, known as the most successful system of Bus Rapid Transit in the world, is researched and analyzed in order to find similarities and differences between the two systems. After such research, conclusions are drawn on the cross-system lessons learned as well as whether or not Los Angeles’ system can benefit from any of the planning and/or implementation strategies utilized by Curitiba.

Bus Rapid Transit is becoming increasingly popular all over the world. It has already been known to have a tremendous effect on cities in areas such as economics, traffic and crowding, environmental protection, etc. It is important therefore to look at the most successful cases and learn from them.

Methodology

This project is considered a case study. The primary information was gathered through a literature search on Bus Rapid Transit. The search continued toward a background and plan search of the deployment of Bus Rapid Transit in Los Angeles. Both searches involved books and peer-reviewed journals. Research was done as a
field study in Los Angeles in order to provide more information about the project and its implementation thus far. Interviews and first-hand experience were conducted in Los Angeles, paying particular attention to observing riders, routes, and the way the system worked during peak and off-peak times.

**BRT in Curitiba, Brazil**

During the past fifty to sixty years, much of Brazil has seen rapid urbanization. The city of Curitiba has experienced a ten-fold population jump since the 1940s. In order to keep up with this growth, planners in the city developed a master plan that would make the growth process easier on the citizens and infrastructure of the city. The master plan addressed transportation and economic issues as well as a wealth of other planning issues. In 1974, the BRT system was implemented. This is known as the most significant change in the entire city. The Curitiba BRT system contains most of the key aspects of a BRT, contributing to its success among riders, residents, and admirers alike. (Friberg, 2006).

*Dedicated Right-Of-Way*

All of the bus lines in the Curitiba BRT system have dedicated rights-of-way. This increases the speed and efficiency of the bus service in that the buses are not intermingled with the rest of the traffic on the roadway. This has contributed heavily to the popularity and dependability of the bus lines (Horizon, 2003).

From the beginning of construction of the BRT system, Curitiba made use of
structural, arterial roads. Two of the now five existing roads were constructed in 1974. Not only did these arterial roads contribute to the success and efficiency of the BRT system, but they also dictated the growth pattern of the city. The remaining three structural, arterial roads were completed in 1982. (Friberg, 2006).

The structural corridors are composed of a triple road system with the central road having two restricted lanes strictly for express buses. Parallel to the bus lanes are two local roads that run in opposite direction. This allowed local traffic and transit traffic to coexist while maintaining the efficiency of the transit system. (Friberg, 2006).

**Station Design**

The Curitiba BRT system makes use of a station design that allows prepayment for transit rides. The stations, known as tube stations, also allow passengers an actual space to be sheltered within as seen in figure 1a. The stations provide safe places to wait for the bus to arrive. They also serve as boarding platforms for passengers, which decreases the time of boarding and increases the efficiency of the system as a whole. (Friberg, 2006).

The tube stations are made of glass and steel. They are 10 meters (32.8 feet) long and 3 meters (9.84 feet) in diameter, as shown in figure 1b. In order to accommodate elderly and handicapped passengers, some tube stations are equipped with side elevators. (Friberg, 2006).
Figure 1a: Curitiba station design

Source: www.wikipedia.com

Figure 1b: Curitiba station design

Source: www.eniosouza.com.br/English/Curitiba/curitiba_bus.jpg

**Vehicles**

One of the many reasons that the Curitiba BRT system is considered the most successful in the world is because of the varying styles and sizes of vehicles that it makes use of. The most recent improvement to the system was the addition of bi-articulated buses. They are almost triple the length of a regular bus, connecting three
separate parts with accordion-style connectors. The vehicles operate in special lanes and hold a maximum capacity of 270 passengers. (Friberg, 2006).

The bi-articulated buses are part of one of the eight types of lines operating in Curitiba. All eight types of lines make use of buses that have at least two entrance/exits to make for easy boarding and exiting. The type of line dictates the size, style, and carrying capacity of buses necessary. For example, feeder lines are smaller than express articulated lines. (Friberg, 2006). Notice in figure 2 how the size of vehicles increases as the demand and function increase.

**Figure 2: Vehicles used in the Curitiba BRT**

### Table 1: Daily capacity by vehicle

<table>
<thead>
<tr>
<th>Bus Configuration</th>
<th>Capacity (passengers/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional bus on average street (80 Passengers)</td>
<td>1,000</td>
</tr>
<tr>
<td>Conventional bus on bus way (150 Passengers)</td>
<td>1,800</td>
</tr>
<tr>
<td>Double (Articulated) bus on busway (150 Passengers)</td>
<td>2,500</td>
</tr>
<tr>
<td>Direct route with boarding tubes (110 passengers)</td>
<td>3,200</td>
</tr>
<tr>
<td>Biarticulated bus on bus way with boarding tubes (270 passengers)</td>
<td>4,000</td>
</tr>
</tbody>
</table>

Source: Friberg, 2006

### Fare Collection

The city of Curitiba implemented a token/transfer system in order to increase the efficiency of the system. With this system, passengers purchase metal tokens outside of the station at newsstands, terminals and other shops. These tokens are then used to enter the stations and board the buses. Ways in which the tokens are collected vary. At some stations there are attendants that collect the fare. Other stations simply have a machine that collects the fare with a turnstile that allows entry. (Friberg, 2006).

### Regular Service

Regular service is a great asset to all types of bus systems with varied characteristics. For bus systems that do not make use of dedicated rights-of-way,
regular, frequent service is of great value. This is because these systems usually operate on a time point system, meaning that each stop is assigned an arrival and departure time. Because there is no room for flexibility, the buses end up waiting at stops when there is little to no traffic in an area. When the time point system is replaced by frequent service, buses are able to travel at whatever speed the rest of traffic is going while picking up passengers and not waiting for a certain departure time. (Friberg, 2006).

In the case of Curitiba, however, regular service is just an added bonus. Because of the widespread use of dedicated rights-of-way, buses are not affected by automobile traffic (or lack thereof) so the benefits fall directly on the passengers. Passengers experience quicker service without the need for a printed schedule. Times are more frequent which takes away the desire to use a personal automobile in order to achieve a desired level of freedom that is only normally achieved by using an automobile.

*Route Structure*

The route structure continues to be simple and widespread which aids in increasing ridership. Riders are able to access many of the key places without a large amount of walking or using other modes. Curitiba makes use of different types of lines that function in different ways. For example, there are feeder lines that take riders from outside the center city and other hubs and give them full access to the express lines. There are also express lines that take the rider to specific areas as well as direct lanes that give the rider a choice in what they want to access and how they want to access
that place (seen below). While the system looks complicated on the map, it is important
to consider each line individually which proves the lines to be fairly simple. (Friberg,
2006).

*Intelligent Transportation Systems*

The Curitiba BRT system does not make use of most of the aspects of Intelligent
Transportation Systems. Partially because of the ease of using dedicated rights-of-way
in the system, there is not as much of a need to control traffic signals in this system as it
in others. There is, however, a use of intelligent transportation systems in keeping track
of buses, which is a common aspect of all kinds of bus systems in order to maintain
safety and to be prepared in the case of an emergency.
Bus Rapid Transit in Los Angeles

Bus Rapid Transit in Los Angeles started as a response to the comments that riders gave regarding the speed of buses. In a 1991 survey of riders of the Los Angeles transit system, it was determined that riders had the largest issue with the speed of the buses. Before the survey, decision-makers and employees alike believed that the problem with the bus system was rooted more in the number of bus stops, route structure, or times of operation. The survey revealed otherwise. (Los Angeles County Metropolitan Transportation Authority, 2006)

Several years of planning after 1991 led to the initiation of the Metro Rapid Program. The MTA’s Board of Directors directed staff to conduct a feasibility study of the program. This feasibility study was preempted by a visit to Curitiba, Brazil by MTA and City of Los Angeles officials. The feasibility study conducted by MTA staff concluded that MTA and the City of Los Angeles should “conduct a demonstration along two-to-three major arterials which have strong ridership and unique characteristics to provide the Board actual experience regarding the feasibility of full-scale deployment of BRT within the MTA system.” (Los Angeles County Metropolitan Transportation Authority, 2006)

Because of Curitiba’s fame and admiration among other BRT systems internationally, it was used as the initial primary model for the future Los Angeles BRT. From the Curitiba visit, a list was generated of the 12 key attributes associated with the successful Curitiba BRT. See Table 2 below. It is important to note that Curitiba does not include bus signal priority in its system but that this is a
characteristic deemed feasible in Los Angeles. From this list of a total of 13 characteristics, 7 were deemed both financially and physically feasible in the first phase of the BRT system. The remaining 6 would be deployed in Phase II, the Expanded System.

### Table 2: Comparison of Los Angeles to Curitiba during Phase I and II

<table>
<thead>
<tr>
<th>Curitiba Key Attribute</th>
<th>Metro Rapid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Phase I Demonstration</td>
</tr>
<tr>
<td>1. Simple Route Layout</td>
<td>Yes</td>
</tr>
<tr>
<td>2. Frequent Service</td>
<td>Yes</td>
</tr>
<tr>
<td>3. Headway-based Schedule</td>
<td>Yes</td>
</tr>
<tr>
<td>4. Less Frequent Stops</td>
<td>Yes</td>
</tr>
<tr>
<td>5. Level Boarding and Alighting</td>
<td>Yes</td>
</tr>
<tr>
<td>6. Color-coded Buses/Stations</td>
<td>Yes</td>
</tr>
<tr>
<td>7. Bus Signal Priority</td>
<td>Yes</td>
</tr>
<tr>
<td>8. Exclusive Lanes</td>
<td>No</td>
</tr>
<tr>
<td>9. Higher Capacity Buses</td>
<td>No</td>
</tr>
<tr>
<td>10. Multiple Door Boarding &amp; Alighting</td>
<td>No</td>
</tr>
<tr>
<td>11. Off-Vehicle Fare Payment</td>
<td>No</td>
</tr>
<tr>
<td>12. Feeder Network</td>
<td>No</td>
</tr>
<tr>
<td>13. Coordinated Land Use Planning</td>
<td>No</td>
</tr>
</tbody>
</table>

Source: Los Angeles County Metropolitan Transportation Authority, 2006.
Results from Demonstration Phase

Planning of Demonstration Phase was initiated in the summer of 1999. Start-up of the Metro Rapid was on June 24, 2000. The Demonstration Phase was conducted on two lines. (Los Angeles County Metropolitan Transportation Authority, 2006)

1. Line 720 Wilshire/Whittier
   - Very high passenger demand
   - Urban corridor that connects through the Los Angeles Central Business District (LACBD).

2. Line 750 Ventura
   - High passenger demand
   - Suburban corridor serving the Metro Red Line (below ground heavy rail transit).

At the conclusion of the Demonstration Phase, surveys and research were conducted. The surveys concluded that passengers felt the speed improved greatly. In fact, at times passengers felt that speed increased more than it actually had. From the research, speed was determined to have increased by 23%. The original goal was 20% so the system exceeded the goal and expectations. The 23% can be interpreted as 23% less delay of buses. That 23% affects the buses by decreasing overcrowding. The result is more passengers making use of the system.

Ridership increase during the Demonstration Phase was significant. Of the total increase, one-third came from riders who didn't previously take transit and made use of the personal automobile. Another third of the increase came from riders who previously used transit but were making use of it more often. The last third of the ridership increase came from riders who chose the BRT system over the parallel routes that they previously used. Research also concluded that there had been no significant impact on personal automobiles that shared roads with BRT
buses. (R. Gephart, personal communication, May 11, 2006)

**Current State of BRT in Los Angeles**

Demonstration Phase results were so positive that the system was planned for total expansion. Expansion of the system includes building of 28 lines in total. As of May 2006, there are 15 lines built (2000 miles of bus lines) with the rest of the lines being completed by 2008. (R. Gephart, personal communication, May 11, 2006)

*Dedicated Right-Of-Way. This is a characteristic of a successful bus rapid transit system that Los Angeles has not made use of. Not only is this BRT feature expensive, but also it is almost impossible in an area that is already built-out.*

*Dedicated rights-of-way involve widening of roads or taking away personal automobile access on existing streets when implemented in built-out areas.*

Dedicated rights-of-way in Los Angeles were not considered financially or physically feasible during the Demonstration Phase. (R. Gephart, personal communication, May 11, 2006). Currently, as the Expanding System is being implemented, there are two approaches that are proposed. The first proposal is short segments of dedicated rights-of-way where needed based on the amount of congestion. The second proposal is the implementation of full-length, exclusive transit ways. This can be done either on existing arterials or on new, separate rights-of-way.
Station Design. Los Angeles does not make use of permanent stations that riders can enter and board buses from. Instead, the Rapid program makes use of more distinct and unique-looking bus stops as seen in figures 4 and 5. These bus stops can fit on existing sidewalks but allow a distinct place for riders to board the bus. They are easy to build and maintain and are relatively inexpensive. The station design does not allow passengers to board the bus without using steps but these stops do not require special buses for boarding. (R. Gephart, personal communication, May 11, 2006)

Figure 4a: Rapid Station Design
Source: www.the-bus-stops-here.org

Figure 4b: Rapid Station Design
Source: www.the-bus-stops-here.org

Vehicles. From the early stages of planning, one of the main characteristics of the Rapid system was for the stops to be different and color-coded. All Rapid buses are painted red, different from all other buses within the city. Along with the buses, all signs and literature pertaining to the Rapid system are red. This allows the system to stand out in the mind of the rider. (Metro Rapid, 2006)

At the end of the Demonstration Phase, the lines were still experiencing overcrowding. Three vehicles were viewed as options at the end of this stage. (Los Angeles County Metropolitan Transportation Authority, 2006)
- 45-foot vehicles (8-12 more seats than a standard bus).
- 60-foot articulated vehicles (18-20 additional seats).
- 80-foot bi-articulated vehicles (36-40 additional seats).

After much research, the Los Angeles BRT decided to use high occupancy buses, similar to those used on other routes within the regular bus systems in the city. These buses are not specially made for the system and do not include articulated vehicles. These vehicles use steps for passengers to board the buses and a convertible ramp wheelchair and other disabled riders. Bi-articulated buses were seen as too costly and large to serve riders in most areas of the city.

*Fare Collection.* Fare collection is done onboard the BRT buses. It was concluded that the station/pre-payment style of Curitiba's BRT would not be feasible because of the lack of space on the arterial rights-of-way. Currently, there is a traditional fare box located in the front of the bus near the driver. This limits where riders can enter the bus. Riders board the bus at the front, all through one door. Unfortunately this slows the speed of the route because boarding takes longer than in a more ideal BRT system.

A new system is being tested in Los Angeles, however. It is called the TAP system. TAP stands for Transportation Access Pass. The system is a form of automated fare payment and boarding. With the TAP system, passengers of bus and rail systems use a smart card that allows them to tap their cards on the farebox in order to decrease the time for fare payment and boarding. The system should be installed system wide and available to the public in 2007.
Service Frequency. The Los Angeles Rapid system makes use of headway based scheduling. This is different from most bus systems that are not considered rapid transit; they make use of time point schedules. With time point schedules, certain bus stops are assigned arrival and departure times. While this keeps buses on time with a strict schedule, it also limits the efficiency of the line in that if a bus arrives early at a stop, it is required to wait until the time that it has been assigned to depart. (R. Gephart, personal communication, May 11, 2006)

Route Structure. The MTA's basic grid network for regional and local bus services has proven sufficient to serve as feeder routes for the Rapid system. This means that a separate feeder network is not of great importance. (Los Angeles County Metropolitan Transportation Authority, 2006)

As the system is still expanding, the route structure is making better use of the existing arterials. While the Rapid system does not make use of every arterial, making it more widespread, it does make good use of the grid network as connector lines. Each sub-phase of the Expanded Phase is introducing more lines to add to the effort of the system. These lines are expanding to more outlying areas from densely populated areas making both radial and reverse commutes easier for the passenger. Figure 4 illustrates current and future Los Angeles Rapid lines as of June 2006. It also illustrates how the rail system in Los Angeles interconnects with the Rapid lines.

Intelligent Transportation Systems. The Transit Priority System was developed to provide traffic signal priority to buses operating on heavily used transit
corridors. This system not only gives traffic signal priority but also operates the passenger information signs at selected bus stops. These signs inform the passenger of the next bus arrival time (in minutes, not by time). The Rapid Transit Priority System showed a total travel time saving of about 25% in each corridor. A 35% reduction occurred in delay caused by traffic signals. It was also concluded that the impacts to crossing traffic was minimal. (Los Angeles County Metropolitan Transportation Authority, 2006)

The system works by making use of an algorithm. The key players in the system, however, are “loops” in the street, a transponder fastened under the bumper of the bus, and the traffic signal. The transponder, costing on average around $200, corresponds with the loop in the street which then sends a signal to the traffic signal. With the use of the algorithm, the traffic signal has the opportunity to stay green longer, change from red to green faster, or remain yellow longer. All of these options allow the bus to go through the respective intersection faster, improving the speed of the route. (R. Gephart, personal communication, May 11, 2006)
Physical Differences Between Systems

The main physical differences between Curitiba’s Bus Rapid Transit system and that of Los Angeles lie within the main components of the systems. While many of these differences stem from the preexisting infrastructure of the cities, it is still important to make note of the differences in order to explain the differences in usage, ridership, etc.

Environment

Brazil, as a country, went through a time of incredible change and reconstruction fifty to sixty years ago. The reconstruction was a result of a change in government and resulted in an upswing in population and economic vitality. The city of Curitiba took advantage of this stage of reconstruction, and along with other areas of development, created the bus rapid transit system. Because of this almost “blank slate” state of the city, much of the physical infrastructure was able to be changed or replaced. It was fairly simple for the Curitiba government to implement many of the components that are known as essential for a successful BRT system because there was not much infrastructure to work around or preserve.

When it came time for Los Angeles to implement its own bus rapid transit system, on the other hand, it was more like fitting in pieces into a puzzle. Los Angeles was not going through a major reconstruction or revitalization, so decision-makers worked around the existing physical infrastructure and transportation systems. Certain essential components were not as available to Los Angeles planners and decision makers as were to decision makers in Curitiba.
Level of Service

Both the Curitiba and Los Angeles BRT systems make use of headway scheduling, meaning that there are no set time points along the route. There are no assigned times and drivers are encouraged to make it to stops quicker. There is no need for passengers to keep or memorize printed schedules. Instead, passengers know that buses come on a regular basis (e.g. every 10 minutes).

In the Curitiba BRT, buses travel on average 12-13 miles per hour while traveling on the exclusive right-of-way. That speed is twice that of buses traveling in mixed traffic in the same Curitiba corridors. (Clark, 2005) This speed seems extremely low but what is important to be considered is the size of the city and the reach of the systems. Each of the 5 exclusive busways in Curitiba are less than six miles long, making short wait times for passengers possible even with such low speeds.

Network Comparisons

The BRT system in Curitiba is extremely widespread. It consists of different types of routes that serve different purposes. For example, there are lines that serve as feeder routes and ones that serve as direct routes. The lines create somewhat of a web or network that is spread across the city.

At first glance, the BRT in Los Angeles is extremely simple in comparison to that of Curitiba. A map of the Los Angeles BRT, below, shows lines that look like randomly placed lines rather than a network of lines. This would give one the perception that it would be difficult to navigate the area due to the sparseness of lines. It is important to note, however, that Los Angeles also makes use of a
standard bus system.

Currently, the Los Angeles Metro agency is implementing a restructuring program called Metro Connections. With this program, the existing grid-system is being converted to a hub-and-spoke system similar to that of Curitiba’s BRT system. This system will be implemented over the next four years, as a reconstruction of an entire system cannot be a fast process.

Length of Routes

The Curitiba BRT system is a citywide system. It primarily carries riders from home to employment centers and downtown. The system is not far in terms of distance from the city center. The interconnectivity among actual BRT routes within the city tends to be greater than those within the Los Angeles BRT system.

The Los Angeles system is a metropolitan system, reaching outlying areas and cities. While it is considered a Los Angeles system, the BRT vehicles are not exclusive to the Los Angeles city limits. This is mostly because the city of Los Angeles’ residents conduct professional and personal business across many cities in the metropolitan area and commuting to and from many of the employment centers accounts for many of the trips made on weekdays.

Overall, the two systems are somewhat of a tradeoff. Curitiba’s BRT does not cover as much distance or reach as many outlying areas but has a higher degree of interconnectivity among the BRT routes within the city. Los Angeles’ BRT system is more far-reaching but does not offer as many actual BRT lines therefore decreasing the degree of interconnectivity. Even with the other available modes of public
transportation (such as traditional city bus, light rail, and heavy rail), the degree of interconnectivity still seems to be less than that of Curitiba’s BRT.

Ridership

One of the major reasons why Curitiba’s BRT system is considered the most successful BRT in the world is because of its ridership. Of Curitiba’s approximately 2 million residents, 1.2 million use the BRT system daily. The ridership is the equivalent of approximately 60% of the population size.

The Los Angeles Rapid system has not only created more frequent ridership in the group of previous transit riders, but it has also created an increase in “new” transit business. In 2002, after only 2 years in service, the Metro Rapid system increased the ridership of the two existing Rapid lines and parallel routes by 40% (38,800 weekday passengers to 45,000 weekday passengers). Of the 40% increase, only 13% was “new” transit business. (Lightrailnow.com). Rapid ridership is the equivalent of only 1.1% of the population size.

It is important to note, however, that when comparing the ridership percentages of Curitiba and Los Angeles it must be taken into consideration that the Curitiba BRT is a more matured system as well as a more (spatially) widespread system.
Interconnectivity

The city of Curitiba’s public transportation system consists only of buses. There are several types of buses, each serving a different purpose and a different type of route. The five express lines that radiate throughout the city, are surrounded by the supporting lines. Lines such as the inter-neighborhood lines, direct lines, feeder lines, “around-downtown” lines, conventional lines, tourism line, and the inter-hospital line, all serve as a network to connect riders to the express lines. The interconnectivity of the system allows riders to decrease travel time while connecting them to many of the minor locations throughout the city not along the express lines.

While not all of the buses are named express buses, it is important to keep in mind that all buses make use of the key characteristics of bus rapid transit. The entire system makes use of headway scheduling, prepayment, tube stations, etc. All buses operate under one administration, the Integrated Transport Net (in the official Portuguese language, Rede Integrada de Transporte).

Los Angeles’ public transportation system, on the other hand, makes use of a BRT system, a local, traditional bus system, light-rail trains, a subway line, heavy-rail trains, and several regional bus systems.

Exclusive Right-of-Way

Curitiba’s BRT makes use of exclusive rights-of-way, while Los Angeles did not have the option to make use of this component when planning and implementing. Curitiba has seen great success with the exclusive rights-of-way, mainly because of the speed and efficiency that the rights-of-way provide to the
system. These rights-of-way were introduced in the very early deployment stages of the Curitiba BRT system and are a product of the revitalization that the city was experiencing as well as the ability to disregard the existing infrastructure. While the use of arterials for travel in a BRT system leads to longer route times, the system is more cost effective.

Other variations of exclusive rights-of-way are in the planning stages in Los Angeles. For example, certain lanes on arterials are being used at peak travel times for the exclusive use of BRT vehicles.

**Operational Differences**

*Method and Procedure of Payment*

The Bus Rapid Transit system in Curitiba makes use of the most ideal method and procedure of payments. In Curitiba, as explained earlier, riders make use of tube stations that double as prepayment centers. Passengers use either tokens (purchased at an off-site transit center) or standard currency to pay for the ride they intend to take before the bus arrives. When the bus arrives at the tube station, passengers are able to board the bus without the driver having to handle fare payment.

Los Angeles, on the other hand, does not currently make use of prepayment. The city’s preexisting infrastructure removed the option of having boarding tubes, or any other method of pre-boarding or prepayment for that matter. Currently,
passengers board the bus and pay fares at the front of the bus. This leads to a slower boarding time, which in turn leads to a slower route time.

Boarding times should decrease in Los Angeles with the implementation of the TAP system (described earlier) where riders use a smart card that deducts money from a card that is prepaid as the rider enters the bus and taps the card on the farebox. This is extremely close to total prepayment and would allow riders to board the bus without directly interacting with the bus operator.

Method of Boarding

Curitiba’s BRT system makes use of different types of buses. These buses differ in passenger capacity as well as the method of boarding. Some of the buses in the system use two passenger doors and some use just one. In all cases, however, passengers prepay before the bus arrives and wait inside the boarding tubes. Because of prepayment, passengers are able to board the bus through any of the doors and not just through the front where the farebox is traditionally located.

Los Angeles, as previously mentioned, does not make use of prepayment therefore limiting the boarding to the front door where the farebox is located. Even the new TAP system would require passengers to tap their smart card on the farebox, making boarding through the front door totally necessary. This slows down the boarding and overall travel time of the system because of the tendency of passengers (especially those who are physically handicapped) to exit the bus through the front door, which is the same door that is mandatory for boarding.
Physical Setup of Routes/Stops

In Curitiba, the stops are more permanent structures than those in Los Angeles. For example, Curitiba makes use of tube stations. These stations, as described earlier, serve as a shelter for passengers as well as a method of prepayment. These tube stations take up a considerable amount of space on city sidewalks but because the freedom of Curitiba decision-makers and the clean-slate state that the city of Curitiba was in at the time, they were (and still are) feasible for the city. Los Angeles does not make use of tube stations or any other permanent structures for boarding, because as described in previous sections, preexisting infrastructure was not permitting.

Because Los Angeles’ BRT system is rather new, stop design is still being implemented. There are a few different stops that are currently in place. The first is the most intricate of the two stop designs. While not nearly as intricate as the station design of Curitiba, this stop design is more intricate than the traditional bus stops placed throughout the city. The bus stop is basically a traditional bus stop with a more complicated overhead structure.

According to Los Angeles Metro/Rapid decision-makers, this overhead structure is not really meant to be a shelter from weather. It is, however, supposed to be a unique design that makes it easy for riders to recognize the stops. This becomes particularly useful because many Rapid buses make use of the same routes and stop locations as other Metro lines. While the Los Angeles BRT’s most
intricate stops do not serve as many purposes as those of the Curitiba BRT, they are functional in that they are recognizable as stops for the Rapid lines.

The less intricate stops, however, do not serve that purpose. These stops are simply traditional bus stops with signs indicating that a Rapid bus stops at those particular locations. It is important to keep in mind that the Rapid system is still in deployment phase and that eventually all Rapid buses will make use of the most intricate stop design.

*Frequency of Service/Times of Operation*

Both the Curitiba and Los Angeles BRT systems make use of headway scheduling. Headway scheduling has proved to be beneficial for both systems as it allows passengers to ride independent of schedules and allow drivers to move more quickly through the routes.

The Curitiba bus rapid transit system operates seven days a week, with a wide range of times, depending on the type of route. For example, the express routes run approximately every 3-5 minutes.

The Los Angeles Rapid only operates on weekdays (Monday through Friday) from approximately 5:00 am until 8:00 pm. On average, the buses arrive at stops every 5 to 15 minutes during peak hours, depending on the line, the area of operation, and the travel-time mitigation measures (i.e. exclusive lanes for BRT vehicles during peak hours).
Figure 6: Cross-system Lessons Learned In Each System

<table>
<thead>
<tr>
<th>Attribute exclusive to Los Angeles BRT</th>
<th>Attribute exclusive to Curitiba BRT</th>
<th>Attribute of both systems</th>
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1. Dedicated Right-of-Way
2. Sheltered Stations
3. Level Boarding and Alighting
4. Multiple Door Boarding
5. High Capacity Vehicles
6. Prepayment
7. Headway Scheduling
8. Feeder Network
9. Signal Preemption
Figure 6 compares the key BRT components of the two cases studied. As displayed, both systems exhibit level boarding and alighting, high capacity vehicles, and headway scheduling.

The Los Angeles Rapid system, while lacking many of the key features of the Curitiba BRT system, exhibits one exclusive feature. That feature is signal preemption. That feature, however, is not needed by Curitiba primarily because it makes used of exclusive rights-of-way.

Curitiba exhibits several components that can benefit the Los Angeles system. Some of these components may be more feasible (both financially and physically) than others. The most feasible for the Los Angeles Rapid system are multiple-door boarding with prepayment and sheltered stations. While dedicated rights-of-way are less feasible, it is a feature that can be made use of in Los Angeles.

**Recommendations for the Los Angeles BRT System**

The Los Angeles Rapid system, as it has become evident, does not make use of all of the components of bus rapid transit that have been known to be characteristic of successful systems. Curitiba, on the other hand, does make use of most of these components. Based on the success of the Curitiba system and the newness of the Los Angeles system, Los Angeles can benefit from adopting some of the components of the Curitiba system as it continues in its expansion phase.
The Los Angeles Rapid stations would benefit from a redesign. Redesigning the stations in the Los Angeles Rapid system would have an effect on the route travel times. Making stations permanent structures allows for prepayment and would allow for multiple-door boarding. Prepayment and multiple-door boarding, as mentioned in previous sections, both contribute to lower route times and more efficiency of the system.

While it has been concluded that dedicated rights-of-way may not be widely feasible in the Los Angeles Rapid system, the system may be able to benefit from dedicated lanes in major corridors. Dedicated lanes enable the system to run more efficiently by reducing route times as vehicles are able to travel on arterial roadways while bypassing personal vehicle traffic. These lanes serve as a viable alternative to dedicated rights-of-way.
References


