Bus Rapid Transit

A Cost-Effective Mass Transit Technology

by Walter Hook

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Some of the most important technical innovations in the transportation field have nothing to do with vehicle technology or alternative fuels. Rather, they involve the way bus services are operated and infrastructure is used to optimize their speed, comfort, and capacity. The U.S. Federal Transit Administration (FTA) has helped to popularize a term for such measures: Bus Rapid Transit, or BRT.

The best examples of BRT are found in Latin America, where the speed, capacity, and quality of service rival all but the best metro and light rail systems. In the United States, unfortunately, the FTA's criteria for calling a system BRT, and hence making it eligible for BRT program financing, are fairly lax. This has allowed some marginal bus service improvements to be labeled BRT. Unfamiliar with what BRT has become in Latin America, many people in the United States have turned against BRT as a poor substitute for rail-based modes. While the quality of recent U.S. BRT systems is improving, and there are a few quite good systems now in operation, none of them compare to the speed, comfort, capacity, or service quality of the best Latin American systems. This article outlines the key features that differentiate even the best U.S. BRT systems from their counterparts in Latin America.

Successful BRT Systems

The first, and still one of the best BRT systems in the world, is in Curitiba, Brazil. Opened in 1974, Curitiba's BRT featured the following characteristics:

- Physically segregated exclusive bus lanes
- Large, comfortable articulated or bi-articulated buses
- Fully enclosed bus stops that feel like a metro station, where passengers pay to enter the BRT station through a turnstile rather than paying the bus driver
- A bus station platform level with the bus floor
- Free and convenient transfer between lines at

enclosed transfer stations
- Bus priority at intersections, largely by restricting left hand turns by mixed traffic vehicles
- Private bus operators paid by the bus kilometer

Prior to Curitiba's BRT system, traffic engineers believed that bus lanes could move approximately 6000 passengers per direction per hour in a single lane at average speeds around 15 kilometers per hour (kph) (assuming normal distances between stations of around 500 m). Curitiba, using bi-articulated buses and the measures mentioned above, was able to move 15,000 passengers per direction at peak hour (pphpd) at average speeds just above 20 kph in a single traffic lane. This speed and capacity is similar to even the best light rail systems.

The cost of construction, at only US$2 million/km, was a fraction of most light rail systems (generally greater than US$20 million/km). The most important measures were the prepaid boarding stations. This reduced the boarding and alighting time per passenger from 2–3 seconds on average to about 0.3 seconds. With large numbers of passengers, this amounts to very significant time savings, far more important than changes in traffic signals.

Because BRT systems are less expensive and can be built much faster, they are able to expand much faster. Only cities that have built and continued to expand BRT systems have actually managed to stabilize public transit's share of total trips.

The share of trips in Curitiba taken by public transport remained above 70% for more than two decades, though it began to diminish when the city stopped expanding the system. Today, it is approximately 54%—still high for a city with motor vehicle ownership of around 400 cars per 1000 people.

Brazilian cities such as São Paulo, Belo Horizonte, and Porto Alegre have built bus lanes superficially resembling Curitiba's, but without the key elements: prepaid platform-level boarding stations, restructured bus routes, and bus priority through the city center. The next full-featured BRT was not opened in Latin America until 1998 in Quito, Ecuador. Quito's electric trolleybus BRT went boldly through the city's historical core on narrow streets open only to buses. The success of the system soon led to a spate of additional BRT systems throughout Latin America.

The most important of the second phase of BRT systems opened in Bogotá in 2000. Bogota's TransMilenio BRT system made several critical technical improvements over the Curitiba system. The main bottleneck in Curitiba is the bus stop. During rush hour, buses back up waiting to discharge passengers. TransMilenio's principal innovation was to put a passing lane and multiple stopping bays at each stop. At TransMilenio's largest stations, up to five buses can allow passengers to board and alight at once. As soon as a bus finishes the boarding and alighting process, it can pull out of the stop, regardless of whether or not the bus in front of it has completed the boarding and alighting process, significantly reducing delay.

The introduction of a passing lane at the bus stop also allowed for significant innovation in the nature of services offered. With a single lane light rail line or BRT system, all services have to stop at all stops. The construction of a passing lane at each station stop makes it possible to put a wide variety of express and limited stop services inside the BRT system.

With the introduction of limited-stop services, TransMilenio achieved an operating capacity of 35,000 pphpd and average speeds of 29 kph. With overcrowding, TransMilenio moves 45,000 passengers per direction per hour, comparable to all but the highest-capacity metros. While the addition of a passing lane consumes additional road space, this passing lane is not required everywhere, only at the station. TransMilenio also built bike lanes and significantly widened sidewalks along the

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Bogota's TransMilenio BRT system with its bus stations and passing lanes.

entire BRT corridor, important because in Curitiba the busway is frequently used by cyclists, often with fatal consequences.

TransMilenio also implemented a number of state-of-the-art contracting procedures. Unlike most Latin American BRT systems, where a monopoly of the former private bus operators was allowed to take control of the new BRT business, in TransMilenio the new services were competitively tendered to four separate operating companies. The performance of these companies is continually monitored against some contractually determined performance indicators, and if they fail to meet these performance targets they are forced to pay fines into an escrow account. These fines are then given to the company providing the best quality of service at the end of each month. This has ensured a very high quality of service.

TransMilenio proved to many cities that they really didn't need to build far more expensive metro systems, and cities that already had metro systems decided to build BRT on corridors that otherwise might have been additional metro lines. Between 2001 and 2009, new full-featured BRT systems were built in Guayaquil, Ecuador; Guatemala City, Guatemala; Jakarta, Indonesia; Perreira, Colombia; Cali, Colombia; Mexico City, Mexico; Beijing, China; and several other cities.

TransMilenio and Curitiba are "trunk and feeder" systems. These require passengers to take a feeder bus (which operates in mixed traffic) to a transfer terminal where they switch to a special, higher capacity articulated trunk line bus that interfaces with the elevated BRT platforms. Because the BRT infrastructure requires special buses, the feeder network allows the system to cover a much larger area without having to buy a large number of special buses. This routing structure does introduce some transfer delay and indirectness of route, however.

Other systems, like in São Paulo and Porto Alegre in Brazil and Brisbane in Australia, use normal buses that operate in mixed traffic, then enter a busway on a major arterial, and then leave it again. Because they are normal buses, their interface with the station platform lacks the special BRT characteristics that allows for very rapid boarding and alighting, so the operation within the trunk corridor is slower and the capacity is lower, and stations tend to experience frequent bottlenecks.

Future BRT Systems

The next wave of BRT systems will be hybrids of the traditional direct service busways and trunk and feeder BRT systems, offering the benefits of direct services with the high speed boarding and alighting of trunk and feeder BRT systems. This will be achieved in two ways.

The new Guangzhou BRT system in China, currently under construction, provides trunk corridor stations that are designed like a traditional trunk and feeder system, with a sufficient number of substations and passing lanes to avoid any bus congestion at the station stop. On the trunk lines, passengers enter all doors of the bus at once from a platform level with the bus floor. Off the trunk corridor, however, passengers will enter the same bus, but they can only enter the front door and pay the driver.

Most of the Johannesburg Rea Vaya BRT system in South Africa, also under construction, is a trunk and feeder service, but some buses will operate on the trunk corridor and in mixed traffic, with the left side doors designed for an elevated BRT station, and the right side doors designed as traditional curbside boarding doors.

BRT Systems in the United States

The U.S. systems most closely resembling Latin American BRT systems are Los Angeles' Orange Line, Cleveland's Euclid Avenue line, Boston's airport branch of the Silver Line, and the Eugene, Oregon system. Los Angeles, Cleveland, and Eugene all have prepaid boarding. While increasing boarding and alighting speed considerably, most of these systems do not have station platforms level with the bus floor, thus do not have the same secure feel of a metro station or the BRT stations in Latin America. Much more could be done with the architectural design of the stations, the pedestrian access facilities, and the level of passenger service amenities offered.

One of the two branches of Boston's Silver Line operates in an expensive tunnel while offering fairly limited time savings, proving that money can be wasted on BRT as well as on rail-based mass transit. The other branch of the Silver Line operates in mixed traffic with an articulated bus. Unfortunately, because it was marketed as a BRT, it has gone a long way to damage BRT's reputation in the United States.

Most U.S. systems operate as if constrained to a light rail line—offering services only within the BRT infrastructure. Denver, for example, is building a large number of light rail corridors, and plans to build one BRT corridor between Boulder and Denver. The BRT corridor has services exactly like the light rail line, with stops at every station. Because Denver is very low density, roughly one quarter of the capital cost of the combined system is for parking places. The entire system is conceived as a park-and-ride system. Yet there is no reason, given the low frequency of the bus services, that the BRT corridor could not have buses continuing on in mixed traffic to the most popular destinations in downtown Boulder and downtown Denver. In fact, if the entire system had been designed as a BRT system, there could have been direct routes between all of the corridors, removing a significant transfer time penalty, increasing frequency and, hence, ridership. This sort of operational flexibility is a very attractive option for U.S. BRT systems where urban density is generally quite low and bus frequency is also too low to congest the busway.

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BRT Competitors

Naturally, light rail and metro interests are threatened by the proliferation of cheaper, more flexible BRT systems. Rail interests in the United States, and particularly companies from France, Germany, and Japan, are financially threatened by the rapid proliferation of BRT. Japan's technical cooperation agency, JICA, and to a lesser extent the French and German governments, have been active around the world promoting their rail companies by disseminating misinformation about the limitations of BRT systems. They finance feasibility studies that tend to exaggerate the projected ridership and financial feasibility of proposed light rail or metro systems.

The current fiscal crisis creates a political opportunity to demand better transit system performance for less taxpayer funds. The United States could develop world-class BRT systems, with speeds, capacities, and levels of service comparable to the best metro and light rail systems, but costing far less. New, performance-based contracting could be used to get better quality of service for a lower price, while protecting unionized workers.

In exchange for fresh infusions of funds, transit authorities could be required to invest their capital in ways that most directly improves speed and quality of service, while reducing operating costs. Transit authorities could be required to perform an alternatives analysis, subject to public scrutiny, comparing alternative mass transit options for reaching a desired service standard for any new mass transit system. The gravity of the current fiscal crisis in many of our transit authorities calls for greater experimentation. If different mass transit options were actually forced to compete on a level playing field, in many cases, BRT would prove to be highly competitive. **em**