Exploring Bus Rapid Transit in Los Angeles

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Executive Summary

This paper is an exploration of Bus Rapid Transit (BRT) with an eye towards implementation of BRT features in Los Angeles. Through the use of runningways that give buses priority over other vehicles, or remove them from traffic completely, advanced station designs and payment methods, and intelligent transportation technologies such as signal preemption, bus service can become faster and attract more riders. Taking the best attributes of rail and applying them to a bus system can create high quality transit, at a fraction of the cost of rail. By examining other cities' experiences with BRT, most notably the use of different types of runningways and different station designs, the paper concludes that Los Angeles should implement BRT features, especially bus only runningways, wherever possible.

Introduction

Los Angeles is the car capital of the world. Like no other metropolitan area, Los Angeles is designed around automobile use.[*] The car has become synonymous with the region; like skyscrapers and New York. The car, while offering perceived freedom to its users, actually limits the quality of life for Los Angeles residents. Whether stuck in traffic, breathing polluted air, or immobilized by a lack of adequate public transit, Angelinos are disadvantaged by its city's obsession with the automobile. City and regional leaders must become more aggressive in attacking the car and ending its

[*] For the entirety of this report, Los Angeles will refer to the County of Los Angeles, because the Metropolitan Transit Authority is a countywide agency and its policies affect the County of Los Angeles.

stranglehold on the Southland. The first step of such an effort is to improve transit options in order to improve mobility for those without cars and to attract new riders to the transit system, so that they leave their cars at home.

A first class bus system is the best way to provide mobility for all Angelinos, and to attract drivers out of their cars and onto public transit. Aboveground light rail and subway are often viewed as the most advanced and effective options for upgrading public transit and increasing mobility. However, in Los Angeles, these forms of transit are not appropriate. The sprawling, decentralized nature of L.A. is simply not conducive for use of high volume trains. With a complicated network of freeways and dispersed residential and employment patterns, Los Angeles does not have the typical residential, commercial and job centers found in many cities. A region like L.A. needs a more flexible and lower capacity system, which can be implemented more cost effectively than high priced rail systems.

Bus rapid transit (BRT) may be the answer. It is an innovative new approach to upgrading bus systems to the point where they are both adequate for the transit dependent and attractive and convenient enough to get drivers out of their cars and onto public transit. This paper will argue that BRT is an option that may be suitable and cost effective for Los Angeles. By looking at other cities' experiences with BRT, the costs and benefits of BRT projects, Los Angeles should be able to assess the desirability of the implementation of specific BRT features based on their potential costs and benefits.

Snapshot of Los Angeles

With a population of 9,761,037[1], Los Angeles is one of the largest counties in the country. The region is very decentralized, with no clear job centers and dispersed residential patterns. The average worker commutes 29.2 minutes to his or her job, above the national average of 24.7 minutes.[2] Downtown L.A., which is the main hub of public transit, and largest job center, only provides jobs for 6.6% of the county's employees.[3] However, downtown Los Angeles is still a major commercial and business center, providing some 280,000 jobs. Instead of just one major employment center, there are many major nodes of employment in the county. L.A.'s residential patterns are also spread yet are often segregated from places of work. Other destinations such as healthcare, education, and recreation sites are scattered throughout the county, requiring fairly long distance travel for many activities. With a disconnect between where people live and work, transit must be flexible and thorough. Traditional transit systems, such as high capacity rail oriented towards downtown, which are set up to bring suburban residents to downtown in large volumes at peak hours, are not appropriate for Los Angeles.

Los Angeles, with its geographical layout, is extremely dependent and disadvantaged by the automobile. L.A. consistently ranks as the most congested and most polluted city in the United States. On average drivers spend an additional 93 hours per year in their cars, simply due to congestion, the most in the country.[4] Los Angeles also ranks as the most polluted metropolitan area in the U.S. by most measures, including short-term and long-term particle pollution and ozone pollution.[5] Improving public transit can potentially provide fair and adequate access to the transit dependent and can also offer an alternative to driving that can mitigate the serious problems that auto use has caused. Reducing auto dependence can also help to address the issue of climate change by reducing tailpipe emissions of greenhouse gases.

Public Transit Use in Los Angeles

Creation of the Car Capital

Although Los Angeles today is an auto centric metropolitan area, it did not always feature freeways, smog and congestion. In fact, the transit system in L.A. was quite extensive, featuring a major network of transit options.

In 1837, the Los Angeles City Council passed an ordinance, which permitted the laying of rail in order to run streetcars pulled by horses and mules. This gave birth to the transit system of Los Angeles. At first the services provided were minimal, with just a few lines running very infrequently, but the system grew into a formidable option for transportation.

The early era of transit featured private capital as the only source of investment. Many competing and complementary transit companies invested in streetcar tracks, cars and even a cable car system. In 1911, the Pacific Electric railway emerged as an incorporation of several of these companies. Through the 1920's the system expanded offering service ahead of its time. This era of transit is known as the "red car" system, which featured over 1,500 miles of tracks.

Private investment in the transit system soon declined due to lack of economic sustainability. By the 1930's, as the public sector became more involved in transit, attention shifted to road building. In the 1940's the city began building freeways, sometimes with tracks in the medians, resulting in a multimodal system of roadways.

By the 1950's "unimodalism" came to the forefront, as city officials stopped including transit in new infrastructure. The age of the automobile took Los Angeles and spurred a rejection of transit. Mass transportation became stigmatized as a product for the underclass. Middle class Angelinos avoided transit as soon as they could afford a car, and a stayed away from transit at all costs. As a poor person's mode of transport, the rail system became a political pariah, with little will for expansion of the system. In addition to this cultural and political shift in Los Angeles, state and federal government funded road and freeway construction at will, made possible by gasoline tax revenue that was earmarked for such projects. National City Lines, a private transit company which had an eye towards bus transit began acquired the railway and began converting the streetcar system to buses. Hoping to take advantage of the high levels of road construction, they viewed buses as a business venture that would replace the streetcar and even surpass it, as it could access the newly built freeways. The ensuing bus system never matched the streetcar system, as city officials rejected proposals for busways and bus subways, instead continuing to focus on freeways and roads.[6]

While some people point to market forces for prompting the removal of the trolley system, some blame the powerful highway lobby and General Motors. Government attorney Bradford Snell, in a 1974 report to congress brought the theory to the forefront. According to his theory, GM bought up and destroyed trolley systems all over the country. Allegedly, GM illegally used its role in shipping as leverage in negotiations with rail companies. They threatened to divert freight to rival carriers unless they converted their streetcar systems to buses, which at the time could not match the service that rail provided. The shift to inferior transit options gave people incentive to buy cars. GM also used financial influence by depositing bribes in rail companies' bank accounts, in exchange for compliance with its anti rail plan.[7]

Whether or not GM used foul play to dismantle the transit system and promote cars, Los Angeles had entered an era of auto centricity. With no adequate transit options, a boom in road construction and a cultural obsession with the car, Los Angeles continued to grow and develop as a place where the auto was a focus of social life. The region is still trying to recover from this development and overcome some of the crippling effects of the automobile.

While the trolley was once the focus of transit in the region, it is unlikely that rail can be as effective in L.A. as is once was. The rise of the automobile resulted in a landscape connected by freeways with single use neighborhoods separated from places of employment. The spatial layout today is very much influenced by these developments and makes rail a difficult option to implement. Bus transit, while was a factor in creating the car haven of L.A., is likely the best immediate option to break the car's stranglehold on the region.

Transit Today

Los Angeles' status as a metropolitan area addicted to the auto is supported by the disparity between residents who use public transit and those who drive. Only approximately 6% (254,091 total) of workers commute by public transit to work daily, while 86% (3,296,964 total) drive to work, for the most part alone in their car.[8] The main determinant of this high rate of car ownership and driving is due largely to the layout of the area and poor performance of public transit. Although the percentage of population that rides is low, the total ridership of the transit system is quite significant. On an average weekday, the MTA utilizes 2,245 buses and 1,282,920 boardings occur on the 191-line bus system. Another 275,593 boardings take place on the 73-mile rail and subway system.[9] The ratio of bus riders to rail riders is 4.65 to 1. Despite this huge difference favoring the bus system, the MTA disproportionately funds the rail system. Of total MTA funding, 49.7% goes to the bus system and 20.0% is allocated to the rail system.[10] This is only a 2.5 to 1 ratio of bus to rail funding. In years of rail construction this disparity is amplified. Such funding and ridership mismatch is a major source of contention in Los Angeles between bus and rail supporters.

Although the spatial layout of the county seems to favor bus service for its low capacity and flexibility, there are many advocates for the use of rail. Their primary argument is that buses are not clean, quiet, environmentally friendly and comfortable enough to attract significant drivers out of their cars and create a first class transit system. They argue that only trains can achieve such a goal.[11] The advent of modern, clean, comfortable and environmentally friendly buses, however, has narrowed the gap between trains and buses, and has rendered this argument invalid and outdated. The second major argument of rail advocates is that buses cannot compete with rail in terms of volume of passengers. This argument might work for many cities, but it does not hold water in L.A. Angelinos do not follow traditional travel patterns, instead moving throughout the region to and from diverse locations. These movements do not usually necessitate such high capacity transit lines. As can be seen by looking at rail ridership, trains do not offer benefits over buses in terms of attracting riders or carrying capacity. For example, Gold Line rail ridership (15,769 daily passengers), which opened in 2003, does not match the ridership of the Orange Line, a bus rapid transit route that opened in 2005 (18,242).[12] This disparity shows that buses have the ability to attract riders just as well as rail does, and that a high capacity rail line does not necessarily translate into high ridership.

In order to improve the bus system in Los Angeles, public officials must think creatively about how to improve service and attract riders, bus rapid transit is an up and coming method for such improvements and might be a valuable means toward creating a better transit system in L.A.

Bus Rapid Transit

Bus rapid transit (BRT) is a possible approach to improving Los Angeles' public transit system. The Federal Transit Authority (FTA) defines BRT as a rapid mode of transportation that combines the quality of rail transit and the flexibility of buses"[13] A more detailed definition, developed under the 2001 FTA sponsored TCRP A-23, calls BRT a "flexible, rubber-tired rapid transit mode that [combines] stations, vehicles, services, running ways and intelligent transportation system (ITS) elements into an integrated system with strong positive image and identity. In brief, BRT is an integrated system of facilities, services and amenities that collectively improves the speed, reliability and identity of bus transit."[14]. Although BRT is often viewed as a comprehensive type of bus system, incorporating many improvements to form a better system, it can also utilize individual features where appropriate. For the purpose of this report, BRT will be an inclusive term that allows for flexibility and implementation of individual features as well as entire system overhauls.

The Components of Bus Rapid Transit[15]

Running Ways

The central and most important BRT feature is the running way. Instead of utilizing normal roads, BRT gives priority to buses so that they are not subject to traffic caused by other vehicles. There are various options for creating bus priority with runningways.

Bus Only Lanes

Within normal arterial streets, a lane on either the right hand side, or in the median can be designated for buses and turning vehicles only. This gives buses preferential treatment, increasing travel time, speed and efficiency. In addition, bus only lanes can improve traffic for autos due to decreased lane changing and merging by buses. Safety for both cars and buses can increase, as they do not have to interact and compete for the same road space.

Median Bus Only Lanes

A bus only lane can be placed in the left hand, or median lane, of a street separated from automobile traffic with either raised median or a solid or double yellow line. A raised separating median ensures that other vehicles, such as cars cannot interfere with the bus lane and makes the right of way privileges more permanent. Even if only a line separates the median bus lane from other traffic, there will be less interference from auto traffic than in curbside lanes, which are usually used for right turns for all traffic.

Freeway Bus Only Lanes

A single lane on a freeway can be dedicated for bus or high occupancy vehicle uses. This lane is usually in the median much like a carpool lane. In a city such as Los Angeles, where freeway travel is such a vital means of transit, giving buses access is a logical step to improving travel time of public transport.

Exclusive Busways

A busway is a street that only buses can use. There are two ways to create an exclusive busway. An entire street can be blocked off to all vehicles except buses, or a new bus only street, or tunnel can be constructed. Such busways are often constructed on former railroad rights-of-way, as capital costs will be lower. Busways are a way to create a separate right-of-way for buses, eliminating interference from autos, improving speed and cutting down travel time.

Bus Stations/Stops

Bus stops can be improved to resemble actual stations, offering comfort and convenience. Adequate shelter, seating and comfort should be included, as well as features such as clear, easy to use schedules and maps, automated countdowns with updates on approaching buses and their estimated times. Stops can also be equipped with video boards offering transit information, news or even entertainment. Such bus stop improvements are aimed to make the entire process of using the bus rival the traditional train station experience. BRT stops should be spaced far enough apart so that buses can reach high speeds. Stop spacing ranges from 1,000 to 7,000 feet for most BRT bus lines, depending on the nature of the line.

Faster Boarding

There are multiple options for increasing the speed of boarding passengers. One is to require prepayments upon entry into a station/stop area. This can be implemented with turnstiles or other automated payment machines. This allows boarding to occur on all doors of the bus. A self-service and proof of payment system would also allow boarding on multiple doors, but poses significant enforcement and freeloading costs. With such a system, passengers purchase tickets from an automated machine and present them as proof of payment to transit officials. Another option is a prepaid smart card that could be swiped upon entry to the bus. Station and bus design are also important in reducing dwell times. Low floor buses, raised platform stations and wide doors make boarding faster and easier.

Intelligent Transportation System (ITS) Elements

Buses can be given preference in traffic signaling by using sensors that detect approaching buses. These sensors can trigger either the lengthening of green lights or the prompting of a signal change to green light. Signal priority is very effective when implemented in conjunction with bus only lanes or busways, as the signal changes have less impact on autos. Buses can also be given priority on toll plazas, freeway onramps and controlled bridge or tunnel entrances. ITS also includes passenger information systems that can give locations of approaching buses and approximate travel times to passengers or on bus announcements of approaching stop/stations. This information can be available on video boards at stations, on the internet, or by phone.

Service Patterns

BRT service patterns often overlay express service with local service to give access between express stops. In other words, a BRT system can be implemented along the same or similar route as a normal local route. The local bus should be timed to provide quick transfers between BRT and local systems.

Traffic Management Improvements

There some minor infrastructure improvements that can increase traffic flow and mobility and efficiency of buses. These include bus turnouts, bus-boarding islands and curb realignments. These changes can decrease the required maneuvers that a bus must make, thus increasing speed and efficiency.

Vehicles

BRT vehicles can range from conventional diesel buses to the most modern and clean burning vehicles. Some of the features of new and innovative designs include, various types of clean burning fuels or more efficient engine types such as low sulfur diesel fuel, compressed natural gas (CNG), diesel-electric hybrid; low floor buses to make boarding easier for disabled and senior bus riders; more doors and wider doors to facilitate boarding and disembarking; and distinctive, recognizable vehicles dedicated to BRT to improve visibility and marketability.

On Bus Improvements

To improve the experience of bus riders, improvements can be made to the amenities on a bus. Comfortable seating and cleanliness are the most basic of such features. More advanced features include offering reading materials, and other forms of entertainment and information such as video boards.

Benefits of BRT

BRT can offer increased speeds for buses and lower travel times for passengers. It can cut down on transfer and waiting times by speeding up the payment and boarding processes. It can also improve the general bus riding experience, through enhanced station amenities and more accommodating vehicles. BRT has the potential to attract new riders as well as improve access for the transit dependent. Offering an alternative to light rail, BRT can be slick and attractive enough to persuade drivers to abandon their cars. By attracting new riders, BRT can help to reduce automobile use, mitigating public health problems and global warming. BRT can facilitate infrastructure improvements, making a city more aesthetic, walkable, friendly to development and more livable in general. BRT is flexible and is appropriate for all different types of cities. Depending on the specific needs, demographics, geography and identity of a city, different features of BRT can be utilized. Through research and planning, BRT systems can be tailored to fit the exact specifications of a region, city or neighborhood.

BRT, while offering a competitive alternative to light rail, can be implemented at a fraction of the cost. Initial investments, such as infrastructure construction and bus purchasing are much lower compared to the required investments of light rail, which is inflated due to the high cost of laying rail and purchasing light rail vehicles (LRVs). Operational costs for BRT are also lower than LRV operation, making BRT more cost effective in both the short and long-term.[16]

External Costs of BRT: Environmental Impact

BRT vehicles have come a long way since the diesel powered dirty buses of a generation ago. Specifically, environmental impacts have been significantly reduced. Bus propulsion technology is rapidly advancing with the advent compressed natural gas (CNG) engines, and the prospects for more advance fuel cells such as hydrogen. Currently, there is conflicting information about which mode of transit, light rail or BRT emits more pollutants. [17] A study by Vincent and Walsh compares the two modes in Washington DC and the in the Pennsylvania, New Jersey, and Maryland region. The authors find that a BRT system can emit substantially less pollution than electricity generation for either a light rail or subway system, on a per passenger mile basis.[18] Christopher Puchalsky on the other hand, conducted a study based U.S. national averages for power plant emissions and tries to take into account additional costs associated with transport of bus fuel. He concludes that light rail offers lower emissions than BRT on a per passenger mile basis. [19]This study assumes the use of diesel fuel and the costs associated with transporting it. However, most BRT lines now use CNG and such costs are likely different. Such conflicting information suggests that regardless of which mode of transportation pollutes less, the difference is likely quite small.

Even if total levels of pollution are identical, the nature of the pollution between the two modes varies. For buses, pollution is in the form of tailpipe emissions, meaning that pollutants are concentrated along transit corridors. For light rail, on the other hand, pollution occurs at power plants. Such pollution can result in hot spots of very high pollutant concentration near power plants. This adversely affects some communities and workers much more than others, yet does not affect the general population as much as bus pollution. Bus pollution impacts everyone who travels the transit corridor, and bus riders who wait for buses and directly breathe emissions.

When comparing the two modes, it is unclear which is more environmentally friendly. It is clear, however that public transit use is a very positive thing for the environment, reducing pollution and fuel use. There is clear indisputable evidence that, per passenger mile, public transit, compared with private vehicle use, uses about half the energy and produces only 5% as much carbon monoxide, less than 8% as many volatile organic compounds, and nearly half as much carbon dioxide and nitrogen oxides.[20] With such dramatic benefits exhibited by public transit over the auto, increasing the number of passenger miles traveled on public transit and reducing the total by private vehicle should be the top priority. Because relative pollution levels between BRT and LRT are ambiguous, external costs based on pollution should not factor into decisions about which mode is more cost effective.

BRT in Los Angeles

Los Angeles is not unfamiliar with BRT. Currently, the MTA utilizes some BRT features. The Orange Line utilizes an exclusive busway. The Metro Rapid lines are express buses coupled with local service on some of the busiest corridors. Both of these lines utilize distinctive bus and station designs that differ from the normal bus system. They also use ITS in the form of traffic signal preemption to give their vehicles longer and more frequent green lights. While these two lines fall into the definition of BRT, the MTA should explore further use of BRT features to improve bus transit in LA.

By examining the costs and benefits that other cities have experienced, the MTA should be able to make specific decisions that fit the geographic and social design of L.A. County. BRT features need to be further explored in order to make public transit in L.A. a first class system. If utilized to its potential, BRT can accomplish goals ranging from increasing public transit use, improving public health, clearing traffic congestion and narrowing the transportation gap between car owners and the transit dependent. This last possible benefit of BRT is especially important to Los Angeles, as transportation is such a large obstacle to access to jobs, healthcare, education and recreation. The broad range of potential benefits, low cost and flexibility make BRT a viable option for Los Angeles.

Past Research

The most extensive study of BRT is the Transit Cooperative Research Program TCRP-90 report. TCRP was established under Federal Transit Administration (FTA) in 1992 with hopes providing guidance to local decision makers and planners on transit issues. This report is one of the most exhaustive studies on BRT. It attempts to offer a consolidated set of principles for planning designing and operating BRT projects.[21]

Summarizing the report brings out some key conclusions which should be incorporated into the basic principles of planning and implementing any BRT project.

The report offers general reasons why BRT can be a useful approach to solving transit needs. In particular, the report emphasizes BRT's desirability over rail:

- The growth of metropolitan areas, especially decentralized suburban regions, necessitates a growth in transit opportunities and access. Given the high costs of freeway construction and limiting nature of increased automobile use (e.g. financial restraints for the poor, pollution, and congestion), public transit improvements are necessary. Traditional bus systems are often slow, inefficient and unreliable, with little or no passenger information to make the journey easier. Rail, on the other hand is much more expensive to implement, costly to operate, and is unsuited for the travel patterns of many U.S. cities.
- BRT can be implemented quickly and incrementally as certain needs are identified.
- For any given distance, BRT is less costly to build and equip than rail.

- BRT vehicles are flexible, operating on streets, freeways, exclusive bus lanes, busways, arterial structures or underground. BRT can also provide a broad array of direct express, limited stop, and local all-stop services on a single facility. Rail on the other hand often forces many transfers to serve the same markets. Rail vehicles also cannot be used in interchangeable facilities.
- BRT can provide sufficient capacity for most U.S. cities. Many BRT lines in South America carry peak-hour passenger flows that surpass those on many U.S. and Canadian rail lines.
- BRT is well suited to extend the reach of existing transit lines. It can also act as a feeder to rail systems to and from areas where densities are too low to support rail.
- BRT is appropriate for, and can be integrated into, urban and suburban environments.

The report offers some general planning recommendations. These can be viewed as general characteristics that can help make BRT projects successful:

Incremental development of BRT will often be desirable.

Incremental development may provide an early opportunity to demonstrate BRT's potential benefits to riders, decision makers, and the general public while still enabling system expansion and possible upgrading. Examples of flexibility are as follows:

• BRT may be initially developed as a basic low-cost project, such as with curbside bus lanes. The running way could be upgraded to busways in the future.

• BRT may serve as a means of establishing the transit market for a possible future rail line. BRT systems should be beneficial in terms of usage, travel timesaving, costs, development effects, and traffic impacts. These benefits are greater when the system contains more BRT elements. Therefore, corners should not be cut in the development of BRT systems.

Parking facilities should complement, not undercut, BRT.

Adequate parking is essential at stations along high-speed transitways in outlying areas. It may also be desirable to limit or raise prices for, downtown parking space for employees, especially where major BRT investments are planned. This can provide incentives to use transit.

BRT should serve demonstrated transit markets.

Urban areas with more than a million residents and a central area of employment of at least 75,000 are good candidates for BRT. These areas generally have sufficient corridor ridership demands to allow frequent all-day service. BRT works well in physically constrained environments where hills, tunnels, and water crossings result in frequent traffic congestion.

It is essential to match markets with rights-of-way.

The presence of an exclusive right-of-way, such as along a freeway or railroad corridor, is not always sufficient to ensure effective BRT service. Ideally, BRT systems should be designed to penetrate major transit markets. In order for a BRT line to be successful, there must be adequate demand for transit. In addition, stations should be designed to be easily accessible by several modes such as bicycles, walking, transit, and individual automobiles.

The key attributes of rail transit should be transferred to BRT, whenever possible.

These attributes include segregated or priority rights-of-way; attractive stations; off-vehicle fare collection; quiet, easily accessible multidoor vehicles; and clear, frequent, all-day service. A successful BRT project requires more than merely providing a queue bypass, bus lane, or dedicated busway. It requires the entire range of rapid transit elements and the development of a unique system image and identity. Speed, service reliability, and an all-day span of service are extremely important. It is important to provide easy access to stations for pedestrians, bus passengers, automobile drivers and passengers, and cyclists.

BRT should be rapid.

Operating on exclusive rights-of way wherever possible and maintaining wide spacing between stations best achieve high-speed travel for buses. Spread out service patterns can be overlaid with a local service line to make up for infrequent stops.

Vehicle design, station design, and fare collection procedures should be well coordinated.

Adequate berthing capacity should be provided as well as passing lanes for express buses (on busways) and amenities for passengers. Buses should be distinctively designed and provide sufficient passenger capacity, multiple doors, and low-floors for easy passenger access. There should also be ample interior circulation space. Off-vehicle fare collection is desirable, especially at major boarding points

BRT services should be keyed to markets.

The maximum number of buses during peak hour should meet ridership demands and simultaneously minimize bus-bus congestion. Generally, frequent, all-stop service throughout the day should be complemented by an "overlay" of peak-period express services serving specific markets. During off-peak periods, overlay services could operate as feeders (or shuttles) that are turned back at BRT stations.

The report also draws conclusions about capital and operating costs of implementing BRT features, notably the range of runningways that BRT utilizes:

> Reported median costs were $272 million per mile for bus tunnels, $7.5 million per mile for busways, $6.6 million per mile for arterial median busways, $4.7 million per mile for guided bus operations, and $1 million per mile for mixed traffic or curb bus lanes. Operating costs reflect the ridership, type of running way, and operating environment. Comparisons of BRT and light rail operating costs suggest that BRT can cost the same or less to operate per passenger trip than LRT.

The report concludes that BRT is a viable option for improving transit systems in all large cities. It is a cost effective method to increase transit ridership, by creating a service that, at a fraction of the cost of rail, provides the same benefits plus further flexibility.

The United States General Accounting Office published a study on the use of federal funds for BRT projects. The “Bus Rapid Transit Shows Promise” report presents considerable data about the costs of implementing BRT projects.[22] The report highlights BRT's competitiveness with rail, showing that BRT can be implemented much more cost effectively than rail projects. It found that for almost all measures of operating costs, including cost per passenger trip and cost per vehicle revenue mile BRT was less costly to operate than rail.

This report also evaluated service and speed of BRT projects compared to rail. In almost all examples BRT outperformed rail for average speed of vehicle.

The report looks at the image problem that many bus systems face, citing the fact that it is very hard to convince choice riders, who have the option of driving, to get on a bus. There is an image associated with buses as being slow, unreliable and dirty, which is based on the traditional bus system. The report asserts that passengers’ bias against buses can be overcome by creating BRT service that equals or surpasses that of rail. With environmentally friendly, comfortable and amenable buses, in conjunction with competitive service patterns, fares and travel times, BRT gives buses the ability to attract riders that would otherwise not consider boarding.

One of the areas where BRT might not be competitive with light rail is in spurring transit-oriented development. Because rail is viewed as a permanent infrastructure investment, developers see building along a rail line as solid investment. There have been mixed results however with the development along BRT lines. This is likely due to the varying nature of BRT running ways. In Dallas, for example there has been little development correlated with freeway HOV running ways, yet in Cleveland, along an arterial corridor, there has been significant private investment in anticipation of the BRT line. In addition, complementary factors such as planning and zoning as well as the economic strength of the region, affect the level of development along a corridor.

The Paris based International Energy Agency released a report in 2002 exploring BRT, with an eye towards implementation in large cities in developing countries. While the cities examined in the report are in less developed countries and where car ownership is lower than in the U.S., they are all of similar size to Los Angeles and suffer from the same problems of traffic congestion and poor air quality. Of note is one section of the report that compares the traditional bus systems in these cities with BRT systems. Here are some conclusions that could be useful to Los Angeles:[23]

- Speeds and distances traveled:
    - Traditional buses generally travel at speeds of 5-15 km/hr depending on traffic, resulting in 100-300 km traveled per day.
    - BRT systems travel 20-25 km/hr, resulting in up to 500 km/day.
- Service frequency
    - Traditional bus systems require waits of 20 minutes or longer
    - BRT systems require waits of usually less than 10 minutes and as little as 1 minute on some systems at peak hour.

Bus Rapid Transit is an increasingly popular solution to urban and suburban transit needs. It compares favorably with rail in terms of performance and is far less costly to implement. It offers remarkable opportunities to improve on existing bus systems or to establish a new first class system. BRT seems to be successful in most large cities where there is demand for transit. Los Angeles has utilized some BRT features, although often in limited amounts. It should explore the further implementation of BRT features and expansion of current utilized features.

To further explore the future use of BRT in Los Angeles, other cities must be examined to determine costs, benefits and best practices of implementing BRT.

Case Studies

Curitiba

When examining BRT applications in other cities, one must begin in Curitiba. The Brazilian city of 1.6 million inhabitants and 2.2 million in the metropolitan area, boasts the original and the best BRT system in the world. Since 1970, the city has adhered to a master plan that has emphasized public transit and controlled growth along transit corridors. Planners have succeeded in creating city free of congestion and air pollution, where residents can count on buses to meet their transit needs.[24]

The system has about 1,100 buses, making a total of 12,500 trips and carrying 1.3 million passengers daily, 50 times the number of passengers of 20 years ago.[25] The number of bus boardings is roughly equal to Los Angeles's daily ridership, despite a population that is only about 1/4 the size and a bus fleet about 1/2 as large.

Buses in Curitiba are efficient and fast, keeping passengers waiting for only a few minutes, and on some lines for as little as 90 seconds between buses. The majority of residents utilize the system as 55% of private trips are made on public transit. The use of the automobile has greatly decreased with the development of the BRT system. Despite rapid population growth, car trips have dropped by 27 million per year since 1970, saving about 27 million liters of gasoline. Compared to other Brazilian cities of similar size, Curitiba uses 30% less gasoline per capita.[26]

The bus system has been a catalyst for transit-oriented development. Coordinated with an integrated zoning system, the bus system has shifted the residential and commercial layout of the city. From 1970-1978, the period of construction of the first three main BRT corridors, the city grew by 73%, yet the population along the corridors increased by 120%, indicating greater concentration of growth along transit corridors. In addition, the transit corridors have attracted the development of businesses, which has resulted in a linear pattern of high-density corridors. The traditional importance of downtown has been reduced as the primary focus of day-to-day transit. This results in a two-way rush hour traffic pattern, which has reduced congestion and traffic.[27]

The development of the BRT in Curitiba has been incremental and steady, with minor investments favored over large and expensive projects. The city has continually shown fiscal responsibility by choosing relatively low cost and low-tech improvements, such as simple road service improvement and curb realignments. Building a rail system in place of the BRT lines has been repeatedly considered and rejected due to high costs. The BRT lines, which total 37.2 miles, cost approximately $320,000 per mile to construct including stations, and operating costs are completely covered by fares.[28] In contrast, creating a light rail system would have cost approximately $32 million per mile.

Curitiba now features a hierarchical bus system with mini buses running through residential neighborhoods, feeding conventional buses, which circumnavigate the central city and move between districts. These lines operate around five main arteries, which are the heart of the BRT system. These arteries reach out from the city center like spokes on a wheel. These arterial corridors utilize the following features:

- Exclusive bus lanes separated by raised medians
- Signal priority for buses
- Stations designed to facilitate fast boarding and disembarkation
- Pre boarding fare collection
- Level bus boarding from raised platforms in bus stations

- Free transfers between lines
- Large capacity articulated and bi-articulated buses that can carry up to 270 passengers each
- An overlapping system of bus services

Each BRT artery is composed of a “trinary” road system, made up of three parallel streets separated by one block each. The middle street features separated median lanes for express buses, which travel at speeds of 12 km/hr and normal lanes on the outside for local access and parking. The other two streets that comprise the transit corridor are one way; featuring normal vehicular traffic next to bus only lanes for direct high-speed buses, which move 19 mph.

BRT lines feature cylindrical stations that use turnstiles for fare collection. Buses feature extra wide doors and ramps which automatically extend to meet the platform of the station, facilitating fast boarding and offering easy access to wheelchairs. These features combine to produce dwell times of 15-19 seconds.[29]

The Curitiba model for BRT is not totally applicable to L.A. The development of the bus system being coordinated with the growth of the city is the most obvious reason that the model does not apply to L.A. Los Angeles is a huge and established metropolitan area with established residential and commercial patterns. One of the reasons that Curitiba’s bus system has been so successful is that zoning and planning has created a market for the bus system. In Los Angeles, such a method will not work. However, there are already plenty of high-density corridors, with high demand for public transit. Creating exclusive busways on these corridors would likely increase speed and decrease travel times to greatly improve the quality of transportation for the transit dependent and attract car drivers.

The costs of developing BRT in Curitiba are not very applicable to Los Angeles. Brazil is a relatively poor country, with readily available labor from a population that earns about $8,400 per capita annually, about one fifth of the U.S. GDP per capita of $42,000. [30], Land is also much less expensive in Curitiba than in L.A., one of the most expensive places in the US to live. Capital expenditures will undoubtedly be much higher in L.A. than in Curitiba.

While fares cover all operating costs in Curitiba, this is an unlikely outcome for a bus system in L.A. or anywhere else in the U.S. Standards for overcrowding are much more stringent in the States, rendering riders per vehicle mile much lower. In Curitiba, buses carry up to 270 passengers although equipped with only 57 seats. In Los Angeles such a bus would only be allowed to carry up to 68 passengers. [31] Such a significantly lower level of crowding results in much lower revenues per vehicle mile and thus a lower ratio of revenue to operating costs.

While Los Angeles cannot develop BRT the same way as Curitiba (incremental and coordinated with growth), it can look at the success of the system as a model for what the outcome of BRT development should look like. It is worth noting the success of Curitiba even if the actual process may not translate to the Los Angeles experience.

Case Studies by BRT Feature

This section of the paper looks at different features of BRT and their applications in other cities. It describes the implementation of the features, the benefits in terms of travel time and ridership changes, as well as other impacts such as property value changes and reduction of congestion. It also examines the costs of implementation so as to judge which features are generally more cost effective. With each case study, attention is paid to Los Angeles, by comparing key characteristics of the cities, such as population, density, transportation trends and spatial layout.

This section focuses on the three most common runningways: exclusive busways, median separated bus lanes and bus only lanes. As the central feature of BRT service, the runningway is the most important feature in terms of determining the success of a BRT line. For this reason, this section focuses on these three runningway options.

Station design is also examined, as the design of stations is another visible and central component of BRT. Different strategies for reducing dwell times, as well as other station characteristics are very important in influencing travel times and attracting riders.

A busway is a street that only buses can use. There are two ways to create an exclusive busway. A street can be blocked off to all vehicles except buses, or a new bus only street, tunnel, or elevated roadway can be constructed. Such busways are often constructed on former railroad rights-of-way, as capital costs will be lower due to existing infrastructure. Busways are a method to creating a separate right-of-way for buses, eliminating interference from autos, improving speed and cutting down travel time. Busways, while generally removed from traffic, do have to cross normal traffic at intersections. To reduce the impact of such crossings, signal priority can give buses fewer stoppages. Busways that are built with overpasses or resemble an elevated freeway do not experience these problems, yet are often more expensive to construct. Busways can also promote traffic safety as they remove buses from the general traffic flow and reduce interaction between cars and buses. The construction of busways can have external positive benefits such as spurring investment and development through transit-oriented development.

Pittsburgh

Opened in 1977, the South Busway was the first busway designed and constructed solely for transit use.[*] The busway system has since expanded to include two more lines, the Martin Luther King Jr. East Busway, which opened in 1983 and was extended in

[*] All previous busways were part of highway infrastructure or paved over trolley or light rail tracks.

2003, and the West Busway, which opened in 2000. In total, the busways are 18.4 miles in length.[32]

The South Busway was built to bypass the heavily congested Liberty Bridge Tunnel. It was built next to existing rail tracks to take of advantage of a previously landscaped and virtually flat grade. The busway serves multiple routes, which access downtown Pittsburgh and the South Hills neighborhoods. The busway also connects with rail stops to make intermodal transportation easier.[33]

Daily ridership is approximately 13,000, with about 400 bus trips made per direction per day. The buses operate at relatively high speeds of 30 mph for all stop service and 40 mph for express service. Bus trips are 6-11 minutes shorter on the busway than by previous service, with savings of 1.4 to 2.6 minutes per mile.[34]

The cost of the South Busway was $27 million in capital costs for a $6 million per mile average. Maintenance costs of the busway are $475,000 per year, an average of $110,000 per mile.[35]

The second of Pittsburgh's busways is the Martin Luther King Jr. East Busway, which totals 9.1 miles after incremental expansion in 2003. This busway was built as a means to alleviate traffic on the Penn Lincoln Parkway, which experienced traffic backups of up to seven miles at peak hours. The construction of the busway was a compromise after plans to rebuild and expand the parkway were rejected due to the expected disruption and long construction time. The busway was constructed on an existing railroad right-of-way that is still in use. The busway and railroad operate adjacent to each other, separated by a dividing wall.[36]

The MLK Busway, which connects downtown Pittsburgh with the eastern suburbs of Allegheny County is utilized by 36 separate bus lines. This busway is the most heavily ridden, serving some 30,000 weekday passengers. Bus speeds are 30 mph for all-stop service and 40 mph for express service. Time savings have been significant. For the most significant routes that utilize the busway, travel time has been reduced, compared to previous non-busway service. For the EBA (East Busway A) route, the old 51-54 minute trip now takes only 30 minutes a 41-44% improvement, which has resulted from saving 3.1 to 3.5 minutes per mile. Other routes experience similar times saved compared to local non-busway service.[37]

Capital costs of the MLK Busway for the original portion were $113 million, for an average of $16.6 million per mile. The extension cost $69 million, an average of $30 million per mile. This busway was more costly to build largely due to higher real estate expenditures, which totaled almost 15% of total costs. Operating costs of the original portion of the busway is an annual $724,000, which translates to $107,000 per mile.[38]

The West Busway, Pittsburgh's third and final exclusive busway is 5 miles long and features two to four lanes, allowing buses to pass along certain intervals. The busway connects downtown Pittsburgh with western Allegheny County suburbs, Oakland and the Pittsburgh International Airport. Fourteen bus routes operate along the busway and connections can be made to light rail lines.[39]

Ridership for an average weekday is about 9,000. Bus speed has increased, up from 19 mph before the busway to 30 mph. Trips on the morning inbound route are 25-26 minutes long compared to 50 minutes before the busway, representing a time-savings of almost 50%. The busway has led to savings of 5 minutes per mile.[40]

The West Busway was much more expensive than the other busways in Pittsburgh, costing $275 million ($55 million per mile). This huge expenditure is due to the hilly terrain that the busway is built on and the renovation of a rail tunnel, which the busway passes through.[41]

Overall, Pittsburgh's busways have increased the speed and reliability of bus service. The ridership of the busway routes has increased due to new riders, many of who previously drove cars. A survey conducted in 1984, after completion of the South and MLK Busways, found that 11% of riders on new routes and 7% on diverted routes are new riders that previously used a car for their commute showing the ability of BRT to attract new riders.[42]

Total capital costs for the busways has been $415 million and average of $25.8 million per mile. [43]Operating costs have been significantly reduced along the busways. For example, on the East Busway, cost per passenger is $0.95, compared with $2.55 for the rest of the bus system and $3.22 for the LRT/streetcar service. On this same busway, operating subsidies were reported at $0.52 per passenger, compared with $1.13 for the rest of the bus system and over $2.00 for the rail transit lines.[44]

Community and economic benefits have also been experienced, as landscaping and improved lighting have helped to beautify the neighborhoods along the busways. These improvements have made investment in the areas more attractive and development has increased. The MLK busway, from its opening in 1983 through 1996 experienced high levels of transit oriented development. $302 million worth of investment was made within 1,500 feet radii (about a 6 minute walk) of bus stations. A diverse array of developments occurred, including retail, office, residential, and medical facilities.[45]

Pittsburgh's experience with exclusive busways is very useful to Los Angeles. With a population of 2.4 million, the metropolitan area is significantly smaller than L.A., but it is still a major city. Allegheny County is nearly comparable to Los Angeles in terms of population density with over 1,700 people per square mile, close to Los Angeles County's 2,100. On average, Allegheny residents commute 25.3 minutes to work daily utilizing public transit for 10.5% of trips and drive 82.1% of the time. These numbers, compared to Los Angeles (29.4 minutes, 6.6% public transit, 85.5 drive), indicate a slightly shorter travel time and greater tendency to use public transit.[46] While these cities are not] identical in their nature, Pittsburgh and Los Angeles should expect similar results with the development of BRT. The positive results that Pittsburgh has experienced provide a good example of potential benefits of BRT for Los Angeles. The use of busways in Pittsburgh provides a valuable model of successful BRT that Los Angeles can learn from.

Miami

The South Miami Dade Busway opened in 1997. The busway is a two-lane two direction exclusive runningway for buses that was constructed on a former railroad right-of-way.[47] The busway is 8.2 miles long and crosses traffic at several intersections.[48]

Approximately 12,000 weekday riders utilize the busway, yet ridership has increased since the busway was opened. Over the first five years of operation, from 1997 through 2002, weekday ridership has risen by 71% and weekend ridership by 130%. Almost half of all riders on the busway were not previous transit users. Bus speeds for express service reach 18 mph and for all stop service are 12-14 mph. The busway has provided little in terms of time saving. The busway is subject to cross street traffic and signals, which significantly reduce the speed of buses. Upon opening the busway, signal priority was used for traffic crossings. However, high occurrence of automobile and bus accidents prompted the discontinuation of the signal priority. The busway cost $59 million to construct with a per mile average of $7.2 million.[49]

The South Miami Dade busway is an example of using BRT to increase ridership without offering any real improved service. With travel times virtually unchanged from previous service, the increase is ridership is likely due to marketing and ease of use of the busway. Significant outreach and education prior to the opening of the busway and during the first few months was conducted to attract riders. In a 2001 survey, the most popular aspect of the busway was its safety. Riders also indicated satisfaction with travel speed, which they perceived as faster than normal bus service in the area.[50] This result is somewhat surprising considering that travel times have barely changed with the busway.

Miami-Dade County is a large metropolitan area with a population of 2.3 million and population density of 1,158 people per square mile.[51] It is significantly smaller and is less dense than Los Angeles. The average worker lives approximately 30 minutes from his or her place of work, almost identical to Los Angeles. Miami-Dade County residents utilize transit even less frequently than Angelinos and drive more often. To get to work, only 5.2% use transit and 88.4% drive, compared to 6.6% and 85.5% in L.A., indicating similar tendencies in terms of transportation between the two cities.[52] Los Angeles can learn a few things from the South Miami Dade Busway. The biggest lesson is that travel-time savings from a busway can be almost totally forfeited by interaction with cross traffic if signal priority is not used. Another lesson is that positive image can be a valuable tool to increase ridership even if service is not significantly improved. Effective marketing, coupled with a clean and safe experience can increase ridership. These factors can attract riders even in cities where transit is a tiny share of total trips.

Brisbane

The Australian city of Brisbane currently has two functioning exclusive busways. The first of these busways is the South East Busway, which opened in 2000 and was expanded in 2001. The 10.5-mile busway is located next to the South East Freeway and consists of dedicated two-way roadway, which includes tunnels, underpasses and overpasses. Special attention was paid to using environmentally friendly and reused materials and to using native plants for landscaping at stations and along the busway, so that the project would blend in with surrounding environs. The South East Busway connects the central business district (CBD) to southern suburbs. There is one line that runs the length of the busway, yet many other routes utilize the busway for smaller stretches. There is also express service from outlying stations to the CBD. These lines often start out in suburban neighborhoods on normal streets, and then use the busway to get downtown without stopping on the way. Standard buses, like on the rest of the Brisbane system, run along the busway.[53]

With the busway in place, speed and ridership has increased along the route. The Busways is very heavily used, providing transport for 71,000 passengers daily.[*] This represents a growth in ridership along the corridor of 88%, with 26% of passengers

[*] This is a simple average, which underestimates weekday ridership and overestimates weekend ridership. Ridership on the busway is very high partly due to the fact that many bus lines only utilize the busway for short stretches.

switching from car to bus.[54] Overall car use in the city has decreased as with the rise in popularity of the busway. In it the first three years since the busway opened, there have been 375,000 fewer car trips per year. [55] Dropping from 1.4 billion trips per year in 2001.[56] While the percentage decrease in car use is only about 0.02%, the total reduction in cars on the road is significant in terms of pollution and congestion reduction. In a 2002 survey passengers listed increased travel speed as the number one advantage of the busway, followed by reduced congestion.[57] Featuring only 10 stations, spaced about a mile apart, buses can reach relatively high speeds of 50 mph. This has led to dramatic timesaving. The 18-minute trip from the Eight Miles Plains suburb to the CBD, used to take 60 minutes on previous service, representing 42 minutes saved and a decrease in travel time of 70%.[58] An external benefit of the busway has been an increase in property value along the busway of about 20% despite the fact that busway runs next to a freeway.[59]

The cost of the South East Busway was approximately $256 million, for an average of $25.3 per mile.[60]

With a population of 1.8 million and population density of 1,000 people per square mile Brisbane is significantly smaller and less dense than L.A. Brisbane has a strong CBD, comprising a large share of the city's jobs.[61] Such a layout is quite different than Los Angeles, which multiple job centers. This layout feature is a large contributor to the success of the South East Busway. Los Angeles would likely not experience such a large increase in ridership as Brisbane, as its downtown is less of a focus for the metropolitan area. L.A.'s downtown does however provide some 240,000 jobs making transit needs very high. Peak hour/direction traffic in Los Angeles is very congested making time saved from such a busway potentially high, as the Brisbane example has shown.

Conclusions

Exclusive busways have been an effective tool for increasing bus speed and ridership. Travel times from the above case studies were reduced by as much as 70% and ridership increased by as much as 88%, with as many as 26% of riders switching from car to bus use. Not all examples show this rate of success. Busways may not improve speed at all, if stations are too close together or if intersecting traffic causes interference. The use of signal priority, or the use of overpasses, underpasses or tunnels, can mitigate this factor.

The example of Brisbane has shown that BRT can attract riders even without fancy modern vehicles. Many experts believe that vehicle is choice is the deciding factor in determining ridership, yet this example proves that just improved service can be effective at attracting riders.

All of the busways examined here connect residential neighborhoods to downtown. This fact might prove these examples difficult for Los Angeles to base predicted results. All of the examined cities have a more downtown oriented economy than Los Angeles. However, the size of L.A.'s economy should provide markets for BRT to provide access to many areas, not just downtown as there are numerous high-density areas of employment and commercial activity.

Park and ride lots work well with exclusive busways, especially in low density and sprawling suburbs, of which L.A. has many. Personal auto use can be used as the feeder to BRT lines, which can then bypass congestion and reduce the number of cars on the road.

The cost of constructing exclusive busways is the highest of all types of BRT running ways. Cost per mile is highly variable ranging from $6 million up to $55 million. Operational costs, compared to light rail transit (LRT) or even standard bus service, as shown by the Pittsburgh example can be quite low, reducing the size of subsidies and allowing lower fares. This is achieved through lower infrastructure costs compared to LRT and by increasing ridership relative to cost increases, which makes BRT exclusive busways more cost effective than standard bus service. Overall, busways are a good investment relative to LRT and can be the most effective type of runningway if sufficient funding is available.

Median Bus Lanes

A bus only lane can be placed in the left hand, or median lane, of a street separated from automobile traffic with either a raised median or a solid or double yellow line. A raised separating median ensures that other vehicles cannot interfere with the bus lane and makes the right-of-way privileges more permanent. Even if only a line separates the median bus lane from other traffic, there will be less interference from auto traffic than in curbside lanes, which are usually used for right turns for normal traffic. Median bus lanes offer the opportunity for island style stations, which are more visible than traditional bus stops.

Bogotá

Bogotá, Colombia's TransMilenio BRT system, opened in 2000, is comprised of 23.6 miles of four lane busways, separated from normal traffic flows by a raised median. Buses utilize signal priority to make interaction with intersecting traffic smoother. The system is currently under construction to expand by another 23 miles.[62]

Buses travel at average speeds of 13-19 miles per hour, depending on the service pattern, which include all stop, limited-stop and express services.[63] By comparison, previous buses on the same corridors featured average speeds of only 1.24-7.45 miles per hour, depending on the bus line. Overall, travel times have been reduced by 32%.[64]

This increase in bus speed has made the system more attractive to residents, leading to a daily weekday ridership of 950,000 and up to 45,000 riders per hour.[65] In a recent survey, 83% of respondents stated that they ride TransMilenio because of its fast service. Seventy eight percent rated the system as a whole "good" or "very good". Thirty seven percent said that they actually spend more time with their families as a result of the system improvements.[66]

In addition to increased faster service, increased ridership and improved mobility for residents, the TransMilenio system has been positively correlated with numerous other benefits that have occurred since the opening of the system. Air quality has improved dramatically, with a 40% drop in air pollutants, most notably SO_2, NO_2 and particulate matter. Traffic safety has improved dramatically; with 89% fewer traffic related fatalities and 83% fewer injuries. Noise pollution has also dropped by 30%. These positive trends are likely due in part to other measures taken by the city, which have been implemented in conjunction with the bus system investments. Programs such as limiting the number of cars on the road at peak hours, and the construction of over 200 miles of bicycle lanes, have likely played major roles in producing the aforementioned results[67]

The initial cost of the new bus lanes was approximately $184 million, or $7.8 million per mile.[68]

With a metropolitan population of over 7 million, Bogotá is a large urbanized area comparable to Los Angeles. Bogotá however is much denser than Los Angeles at over 11,000 people per square mile.[69] With such a higher density, comparing the two cities is difficult. However, the TransMilenio busways have helped cut through very congested areas, reducing travel times. The reduction in air pollutants, while not solely due to the bus lanes, is something that Los Angeles should consider when making transit improvements. By improving transit and bicycle mobility, while placing limitations on cars, Bogotá's air has improved. As the United States' most polluted and congested city, Los Angeles can learn from Bogotá's success.

Seoul

Seoul recently implemented a massive overhaul of its bus system, implementing a BRT system featuring median busways and bus lanes. Seoul is a fast growing and dense city with 9.9 million residents in the city and 22.5 million in the metropolitan area. The spatial layout of Seoul requires long travel between residencies and workplaces from suburb to city center or from suburb to suburb, which is becoming more common as businesses have been locating outside of the city. The city has experienced a rise in car use and extreme traffic congestion as the population has grown. The construction of the BRT system in 2004 coincided with an increase in regulation of private bus companies, which had previously been almost totally unregulated, setting their own schedules, routes and prices. In addition, the bus system changes were congruent to projects for the beautification of the city and improvement of infrastructure, which included developing pedestrian walkways, bicycle lanes and waterfront open spaces.[70]

The median bus lane portion of the system is 46.5 miles long, covering six corridors. It is being expanded and is set to reach 118.4 miles across 16 corridors by 2008. Buses travel an average of 12.4 mph. This represents increases in speed of 38%-85% during peak morning hours and 75%-99% during peak evening hours.[71]

The system has performed well with an 11.2% increase in total bus use, which represents 700,000 new daily riders, a significant increase[72] There has also been a net gain in trips made by public transit of 7.1%, an increase of almost one million passengers daily.[73]

There has been a decrease in traffic related accidents along the BRT corridors, with 26.9% reduction in accidents.[74] This drop-off is mostly due to removing buses from the main traffic flow, which allows cars to more easily navigate without having to deal with buses stopping and changing lanes. This decrease is also likely a result of the decrease in auto use in the city.

The cost of constructing the median bus lanes along the first BRT corridor was $71 million over 9 miles, for an average cost of about $8 million per mile. Some of the higher capacity BRT lines have experienced much higher capital costs, rising to as high $24 million per mile.[75]

The example of Seoul may not be entirely useful for Los Angeles because the market for public transit was already in place at the time of BRT implementation. In 2002, just two years before BRT was introduced, 59.5% of all trips in the city were made on public transit, 33.3% by rail and 26.2% by bus. Only 27.5% of all trips were made by private car.[76] In Los Angeles conversely, 85.5% trips are made by car and 6.6% by public transit.[77] Seoul is much less a car-centered city than Los Angeles. However, significant gains in ridership should not be overlooked, as BRT development has coincided with a decrease in car use and an increase in transit use. The travel time reduction in Seoul is likely applicable to any city, especially Los Angeles, that experiences high levels of congestion and relatively long commutes.

Orlando

The Lynx Lymmo, which opened in 1997, is a free bus service in downtown Orlando, Florida. It offers transportation along bus lanes, which are separated from traffic by a raised median or reflective, raised ceramic markers. It replaces the old Freebee service, which operated in the normal flow of traffic. The goals of the Lymmo line were to aid the economic development of downtown, mitigate parking issues, improve mobility and provide an aesthetic and pleasant pedestrian and transit environment. Stretching 2.3 miles,[78] the busway is distinctively paved to contrast normal lanes. Despite the fact that the route is 25% shorter, there are 19 stops/stations along the route, an increase from the previous service.

There has been no difference in travel time between the old and new service, as buses cannot reach high speeds, and have more total dwell time, due to the increased number of stops. In addition, buses stop at every stop whether or not passengers have requested a stop.[79]

Ridership on the route has increased by 33% since implementation, with 91,000 boardings per month, about 3,000 per day.[80] These increases are clearly not a result of a more efficient ride, but likely stem from the busway and stations' modern design and good marketing. For example, buses along the Lymmo line feature artistic themes, and advertising was used to educate potential riders about Lymmo service.

The project cost $21 million, a $9.1 million average per mile. Operating costs are $1.2 million annually, or $1.14 per boarding.[81]

Orlando's metropolitan area has a population of 1.6 million and density of almost 2,000 people per square mile. Residents of the city have an average commute time to work of 27 minutes, traveling 90.1% of the time by car and 4.1% by public transit, even more car oriented than L.A.[82] Despite this tendency, and no gains in travel efficiency, the Lymmo line was able to attract new riders. This proves the viability of a slick BRT line and busway to increase ridership. The Lymmo line teaches a valuable lesson that increasing the number of stops can force a reduction in speed.

Conclusions

Benefits of reduced travel time experienced in the median busway case studies above ranged from no time saved to increasing speed by 99%. Most service however, was in the 30% reduction of travel time range. The most successful examples utilized spaced out stations so that buses could achieve high speeds and placed busways in places where congestion had previously seriously hindered transit. The least successful example in terms of travel time, Orlando, increased the frequency of stations, forfeiting the express nature that characterizes many BRT lines.

Ridership increased as a result of median busways, rising by up to 33% on median busway corridors and helping to improve transit ridership overall by as much as 7.1%. Median busways provide an effective way to reduce travel time and increase ridership. Other benefits from median busways include traffic congestion reduction and air and noise pollution mitigation. Costs of median busways were closely bunched, ranging from $7.8 million to $9.1 million per mile. Los Angeles should look into utilizing median busways along multi lane corridors with high congestion and a market for transit, as they are an effective method for improving mobility, attracting riders and reducing congestion and pollution.

Within normal arterial streets, a lane, usually on the right hand side, can be designated for buses and turning vehicles only. This gives buses preferential treatment, increasing travel time and efficiency. In addition, like any of the bus runningways, bus only lanes can improve traffic conditions for autos due to decreased lane changes and merging by buses.

Boston

Boston's Silver Line opened in 2001, with Phase I of III completed. This portion of the route operates on right hand side bus only lanes on Washington St., from Dudley St. to downtown Boston. The bus lane is also used for right turns by other non-bus vehicles. The bus only lane stretches only 2.45 miles and is being expanded to include a tunnel that will link another portion of the Silver Line with the Washington St. service. The Silver Line along Washington St. replaces the old route 49 bus line.[83]

About 14,000 people ride the Silver Line daily, which is an 84% increase from previous route 49 service along Washington St.[84] Ridership per vehicle mile has increased by 45% indicating that the ridership increase is not due to more service, but riders per mile traveled has increased as well.[85] Many of the riders, are new to public transit, as 16.6% of riders are new to the system. However, only 1.8% of the new riders previously drove alone.[86] This is likely due to the nature of downtown Boston, which features high congestion and parking prices. The Silver Line is faster than previous service, but time saved varies greatly depending on the hour of operation. The total trip is reduced by only 1% in morning peak hours, but as much as 25% in the early morning before peak hours, midday and evening peak hours. Standard deviation of travel time decreased as well, indicating an increase in consistency and reliability of service.[87]

The cost of implementing Phase I of the Silver Line was $27 million, for an average of $11 million per mile. About half of the cost was for vehicles and the other half was for roadwork, signage and stations. The costs directly associated with the busway totaled about $13 million, or $5.3 million per mile.[88]

While Boston and Los Angeles are very different cities in nature, the Silver Line can provide valuable lessons for L.A. Most notably, it shows how bus only lanes can decrease travel time and increase ridership. The Boston metropolitan area is home to about 3 million residents. It is a very dense area with 2,100 people per square mile, identical to Los Angeles.[89] Boston's large and dense downtown provides approximately 240,000 jobs,[90] almost as much as LA's 280,000. Identical to L.A. is the average travel time to work 29 minutes. Residents of Suffolk County are much more likely to use public transit than those from Los Angeles: 30.9% use public transit, 11.9% walk to work and 53.7 % drive.[91] These tendencies indicate that Bostonians will be more likely to utilize new public transit services. For this reason, Los Angeles cannot expect as high ridership increases as Boston does. Much like L.A., traffic congestion is a major issue and is something that a bus only lane can attempt to bypass for public transit. However, it also presents some major limitations for bus only lanes. During periods of heavy traffic, bus lanes are not as effective as when there is little traffic. Turning cars, delivery vehicles and illegally parked or driving vehicles at peak hours often render bus only lanes not ineffective in reducing travel time. The Washington St. Silver Line supports this as its peak morning running times are significantly longer than non-peak hours and peak evening hours.

Phoenix

In 2003, the RAPID BRT line opened in Phoenix, AZ. The route features high occupancy vehicle (HOV) freeway lanes which connect downtown Phoenix with suburban communities. With four routes, there are 75 miles of HOV lanes in the area. The routes were designed to attract freeway car commuters, by offering priority to buses over autos on freeways. Stations are placed near park and ride lots and bring passengers downtown making car-bus transfers convenient.[92] As a totally new system of HOV lanes, there is no previous service to compare RAPID to. Ridership of the system has been rising since the routes were opened. Over 13,500 boardings occur on the buses every weekday. Assuming that commuters ride both directions, 6,750 commuters utilize the bus lines, accounting for 23% of all transit riders and about 0.05% of all commuters. In the first year of operation, ridership increased by 30%. Of the riders, 33% had never ridden a bus before, marking the achievement of the primary goal of attracting new riders.[93]

The cost of implementing the RAPID lines was approximately $50 million, for an average of only $660,000 per mile.[94]

Phoenix has a population of 1.4 million with 3 million in Maricopa County, which the Valley Metro transportation agency serves. The county's population density is much lower than Los Angeles' with only 330 people per square mile. Much of the county is not urbanized reducing the average density. The city of Phoenix however, is quite dense with 2,800 people per square mile. On average, Maricopa County residents commute 26.1

minutes to work. Much like L.A., they rarely use public transit. Only 2.1% use public transit and 89.9% drive alone.[95]

Los Angeles can use Phoenix's success in targeting freeway drivers with BRT. The high use of the RAPID routes suggests that freeway HOV lanes can be very useful for attracting car drivers onto public transit. Because Los Angeles drivers utilize freeways so heavily, the model the Phoenix provides is very applicable. By giving buses priority on freeways, Phoenix has attracted freeway drivers to switch to public transit.

Kansas City, MO

The Metro Area Express (MAX) BRT line opened in July 2005. With ridership in its bus system in decline, Kansas City implemented the MAX line to reverse this trend. The line is a response to many failed attempts to implement high cost light rail. The route is 9 miles long, operating on peak hour and peak direction bus only lanes. The bus lanes operate like most curbside bus only lanes, allowing right turn traffic to utilize the lanes for up to 100 feet, but otherwise separating bus and auto traffic to give buses priority. The line also utilizes signal priority to extend green lights.[96]

Weekday ridership of the MAX line is near 4,000, a 40% increase from previous standard service along the corridor. With the implementation of the line, the total bus system experienced an increase in ridership of 5.6%, ending a three-year decline in ridership dating back to 2002. Weekend bus schedules on other lines were also expanded, influencing the increase. Bus speeds have increased with the new service, traveling 4-5 mph faster than previous standard service. Making only 19 stops along the line as opposed to previously making 40, travel times have been reduced significantly. New service takes 17 minutes to complete the trip, compared to 24 minutes previously, a 25% decrease. The project cost $21 million, for an average of $2.3 million per mile.[97]

With a metropolitan area population of 1.8 million and a density of slightly over 1,000 people per square mile, Kansas City is much smaller and less densely populated than Los Angeles. Its streets are less congested and workers commute only an average of 21.9 minutes well below L.A.'s 29 minutes. Kansas City residents are similar to Angelinos in their aversion to public transit with only 3.8% commuting in such a manner. Car use is very similar to L.A., with 90.5% of residents driving to work.[98] Despite these trends, the MAX line was able to attract riders because of its faster service and modern image. Kansas City's bus only lanes have been successful in reducing travel time and increasing bus mobility, and thus increasing ridership, the two main goals of any BRT project. There is no reason why L.A. would not experience similar results with bus only lanes.

Conclusions

For the bus only lane projects examined in this paper, travel time was reduced by as much as 25%. The largest gains in speed and efficiency were observed where traffic signal priority is used in conjunction with bus only lanes and stations are spaced far enough apart to allow buses to reach high speeds. Ridership experienced increases of between 30% and 84%. Costs ranged from between $660,000 to $5.3 million per mile, significantly less than exclusive busways and median bus lanes.

The benefits of bus only lanes in Los Angeles will likely vary compared to the results mentioned above. For one, ridership increases will likely be less than observed in these cases. One major aspect in attracting new riders is the presence of high tech modern vehicles, which the MTA already uses on its Rapid lines. The increase in ridership due solely to the bus lanes is likely smaller than the total increase in ridership. Negative side effects of implementing bus only lanes may be larger in Los Angeles. With more congestion than any other city, reducing the number of lanes for traffic could create extreme bottlenecks. This effect, while in the short term could be very harmful, would likely further increase ridership over the long run as bus priority over autos would increase. Despite these variables, bus only lanes could be an effective method for improving transit and increasing ridership in Los Angeles. They are relatively low in cost and provide valuable right-of-way privileges to buses

The bus stop/station is an important characteristic of BRT systems. They can be used to decrease dwell times,[*] make boarding easier and more convenient, improve the image and marketability of a BRT system or to simply provide a more comfortable waiting area. Here are a few examples of innovative station designs.

Bogotá

Bogotá's TransMilenio BRT lines features 61 enclosed stations along its 23.6 miles of median busways. Buses feature four double-width doors, which are synchronized with station doors to allow easy and predictable boarding. The stations have high platforms that line up flush with the floor of the bus. Stations are 16.5 feet wide and range from 80 to 623 feet long, depending on the stop. Payment method is a pre payment at electronic turnstiles, which utilize smart cards, upon entry into the station. The result of the station and bus design is an average 25 seconds of dwell time.[99] The cost of the stations was approximately $29 million, for an average of $470,000 per station.

Pittsburgh

Pittsburgh's busways do not feature stations designed specifically for fast boarding. However, some of the more suburban stations are constructed in conjunction with large parking lots as part of an effort to attract riders who have the option of driving to utilize the system. The park and ride project provides 2,340 free parking spaces at BRT stops. This type of project is useful for alleviating the impacts of driving on a central city.

[*] The amount of time a bus waits while passengers board and disembark

By combining driving with bus transit, riders can enjoy the flexibility of personal car use, yet do not have to deal with driving and parking downtown, reducing congestion on city streets and freeways leading to downtown. By lowering the number of cars downtown, air pollution can be reduced in areas with high levels of foot traffic, mitigating potential serious health risks, such as respiratory diseases like asthma and lung cancer. It can also make commercial areas more pedestrian friendly and aesthetic, which can help business and make the area more economically prosperous. While the improvement of any transit system and the reduction of auto traffic can have these effects, a park and ride project specifically targets potential bus riders who have the option of driving into downtown and commuters who are not directly served by the transit system. This approach is especially appropriate for low-density suburban areas, which lack the density to merit extensive transit service. This is particularly applicable to Los Angeles which experiences very high congestion in its business centers, and has large outlying low-density areas, which are not served by transit.

Orlando

Along the 2.3-mile Lynx Lymmo median busway, there are 19 stops/stations. The service is free, making advanced payment methods unnecessary. The stations are state of the art, with high technology amenities such as expected bus arrival times and a guided precision docking system, which makes boarding easy and fast. However, total travel times have increased due to the high number of stations. By increasing the number of stops along the line, buses cannot reach high speeds and have a high aggregate dwell time over the course of the route. This example can teach an important lesson about the use of stops and stations. No matter how high tech and designed for fast boarding a station is, if there are too many stops, speeds will be low and travel time high.

Conclusions

Station design is an important factor in determining dwell times and thus time of travel for a bus. Various methods exist for reducing dwell times through station design. Enclosed stations with turnstiles, pre payment and proof of purchase receipts, smart card systems are all options that can speed up the payment process while buses are not present. These types of payment allow boarding to occur on all doors of the bus, making boarding faster. To implement such a system however, the station area must be enclosed and will likely be larger and costlier than a traditional bus stop. Another option is to have pre payment machines in open stops. This method, compared to an enclosed station, is less costly in terms of infrastructure, yet requires some type of on-bus monitoring, by an agent or driver. If it were the driver's duty to check receipts, the dwell time reductions from pre payment would mostly be squandered. If there were another agent on board, labor costs would rise and if they only monitor random buses it could also lead to revenue losses as some riders could avoid payment of fares. However, these losses could potentially be recouped through revenue from fines.

Low floor buses, raised platform stations and wide doors on buses can increase boarding and disembarking speeds. These measures should be further researched to determine their actual benefits in terms dwell time reduction. Their costs should also be analyzed to determine the most cost effective method.

Park and ride stations do not have an impact on dwell times, yet they do provide more accessibility and convenience for drivers. They can be effective in attracting new choice riders and reducing the number of cars on the road.

Station spacing plays a major role in determining bus speeds. Too many stations close together forces buses to drive slowly, eliminating travel time reductions from other factors such as a bus lane or reduced dwell time. However, spacing stations too far apart can reduce access to the bus route, putting a ceiling on ridership levels.

As part of the Metro Rapid project, the Los Angeles MTA has stated that it wants to test out the use of pre payment machines to reduce dwell times.[100] However, the MTA has not taken this step and alternate payment methods remain almost totally unused on the L.A. bus system. All standard and Metro Rapid buses utilize on bus payment methods. The only example of alternate payment is on the Orange Line, where in station payment machines give receipts, which act as proof of payment. This allows boarding to occur through all doors of the vehicle, reducing dwell time. MTA agents randomly monitor vehicles for passengers without proof of payment. Fines of $250 dollars are administered to violating passengers.

Metro Rapid

The Metro Rapid lines were introduced in 2000, in an effort to create a more express and limited stop service along some of the busiest corridors in Los Angeles. The premise of the Rapid service is that stations are spaced farther apart and buses stop only at intersections where crossing bus or rail service stops. The Rapid lines have been overlaid upon local service that is already in place to provide a layered service pattern of local and limited stop to give riders options without decreasing service. The new Rapid vehicles are compressed natural gas clean burning buses, featuring low floor boarding and a distinct branded red design and logo. Stations are coordinated to the buses with matching logos and coloring, making Rapid stations and buses easy to see and recognize.

The Rapid service features the use of signal priority and automatic vehicle location (AVL) technology. The use of these technologies allows bus schedules to be run based on headway rather than timetables, making wait times more consistent and buses more evenly spaced out. Rapid buses feature sensors, which prompt traffic signals to change to green for approaching buses or to stay green for longer than usual so that buses can pass through the intersection before the signal changes. Buses are given priority at signals depending on their relation to other buses along the line. This attempts to keep buses evenly spaced throughout the entire route. The headways that the Rapid line attempts to maintain range from 3-10 minutes, depending on the hour and line.[101]

Using data from the Rapid Demonstration Program,[*] the Rapid lines reduced passenger travel times by as much as 29% on the Wilshire/Whittier corridor and 23% on the Ventura corridor. Ridership increased, with gains of 42% on the Wilshire/Whittier line and 27% on the Ventura line. One third of the riders were passengers who changed routes, one third were passengers who rode the system more often, and one third were brand new transit riders. Along the Wilshire/Whittier corridor, local service experienced an increase in ridership as well; as passengers adjusted their travel plans to connect with the Rapid line.[102]

The implementation of Metro Rapid lines has been a major success for the public relations of the MTA. Creating a more modern network of bus service has done a lot to improve the image of the agency. The previous decade saw the MTA taken to court for neglecting the bus system and inner city and minority riders. The Rapid lines have greatly improved the image of bus service making it more attractive and seem more high tech, like rail. It has been successful in providing express/limited stop service and reducing travel times, primarily for long distances. These improvements have led to increased ridership.

The Rapid system is not perfect however. If it were an attempt at BRT, some would argue that it is a failure. The centerpiece of BRT projects is the runningway. To achieve BRT status, buses need to experience some sort of runningway priority over other vehicles. Instead, Rapid simply is a repackaging of limited stop service, which has been utilized in Los Angeles long before Rapid. Limited stop service was traditionally a

[*] Two corridors were used as pilot projects beginning in 2000 to assess the feasibility of Rapid service and further BRT use. Based on the success of the Demonstration Program, the Rapid system has been expanded.

tool to relieve overcrowding on local lines by only stopping at intersections that are crossed by other bus lines. The MTA simply changed their marketing style of this limited stop service and emphasized increased speed as a selling point. Rapid lines however, still must sit in traffic with autos.

Curbside bus only lanes would be the least costly way to give Rapid buses priority over cars. More costly, yet greater time saving alternatives would be to construct median busways separated from traffic by raised barriers, or exclusive busways, like the Orange Line. This alternative would be very difficult to apply to the Rapid lines as it would require rerouting the lines, creating new infrastructure parallel to current lines, or cutting off major corridors to general traffic.

One of the main advertised reasons behind decreased travel times is signal priority. The signal priority, however, has many caveats, and is often not used. For example, signal priority is overridden if it results in traffic congestion on the cross street, or if there are too many Rapid buses running at once, as is often the case on Wilshire Blvd with the 720 line. In addition, the signal extension is a set time, independent of current traffic conditions and does not guarantee that a bus can pass through the intersection. The result is that Rapids do not receive any more green lights than local lines. Signal priority is only totally effective along corridors with little traffic such as the Ventura Blvd line.[103]

Station amenities, which are a central feature of most BRT systems, are minimalist at Rapid stops. The most developed stops do not feature any type of pre payment or even seating for waiting passengers and still use on-bus payment, resulting in dwell times that are just as long as local lines. Most stops are simply metal poles with the Rapid logo at the top.

While the Metro Rapid may not be a fully developed BRT system, it can be incrementally upgraded to such a level. Bus only lanes can be implemented over time. Stations can be improved and fare collection can be changed as the political will emerges for such projects. This flexibility to develop and change a system incrementally is one of the beauties of BRT.

Wilshire Bus Only Lane Pilot Project

Los Angeles is not totally unfamiliar to bus only lanes. Along the Wilshire Blvd. Rapid 720 line, there is currently a one-mile stretch of bus only lane. Opened on March 8, 2004, the lane is a pilot project to assess the feasibility of implementing more bus only lanes, especially along the entire Wilshire corridor and for other Rapid lines. Currently, there is a political battle surrounding the future of the project with some forces advocating the expansion and others the elimination of the bus only lane.

The project, in West Los Angeles, is in one of the areas along the line with the least traffic. The results of the pilot project have been very positive, illustrating the benefits of bus only lanes.

The speed of buses has increased, cutting down the time to travel the mile by 6% in the morning peak hours and 14% in the evening. Consistency has also improved, by 27%. Without unpredictable interferences from car traffic, the time of travel for the stretch is more stable, and schedules are more accurate and closely followed. Safety has increased as a result of the project as there have been fewer accidents due to buses merging into traffic.[104]

One of the main concerns of the project and of bus only lanes in general, is that curbside bus lanes reduce available parking. On a busy and commercially active street such as Wilshire, businesses worry that the elimination of parking spots will hurt their business. This fear is largely unjustified, as parking shortages have not been an issue. Along the one-mile stretch, there has been sufficient parking available on side streets.[105] Further refuting this opposition to the bus lanes is that fact that along much of Wilshire Blvd, there is no parking allowed during peak hours anyway, when the bus only lanes is enforced.

The cost of implementing the bus only lane was $161,000 for the one-mile stretch, covering the costs of lining the lane and installing proper signage.[106] At that same price per mile, if the bus lane were to be expanded to the entire 26 mile 720 line along Wilshire it would cost $4,186,000. However this cost would likely be much higher as bus only lane construction usually coincides with road improvements, which add significant costs. If the lane were extended, such road improvements would likely be made.

To estimate the time saving benefits of expanding the bus only lane, one can take percentage of time saved on the pilot project and apply it to the whole line. The morning trip Eastbound, departing at 6:53 from Santa Monica, currently takes 55 minutes to reach 6th and Main downtown. With the 6% time saved from the bus only lane, a total of about 3 minutes could be saved. The evening trip Westbound, from downtown to Santa Monica, departing at 5:04 takes 1 hour and 9 minutes to reach Santa Monica.[107] Assuming 14% time saved, a total of almost 10 minutes could be saved. These estimated savings are likely underestimates. Because the pilot project mile experiences less traffic than the typical one-mile stretch of the 720 line, elimination of bus interaction with car traffic will likely result in greater time saved than the 6% and 14% on the one mile stretch. While time saved may be more significant, negative effects on traffic may also be more significant than observed along the pilot project. The elimination of an auto lane could cause greater traffic congestion. The combination of these impacts could provide greater incentive to ride the bus along this corridor, if bus speeds can approach, or surpass car speed. Such an outcome would be desirable for the MTA, boosting ridership and revenue and decreasing cars on the road, leading to less congestion and pollution. This increased ridership could also help to establish a greater market for transit, which could justify the future upgrade to median bus lanes.

Orange Line

The Orange Line, which opened October 2005, is Los Angeles' first attempt at an exclusive busway. The line, which spans 14.4 miles, was built on top of an old rail right-of-way. The line connects the San Fernando Valley to the Red Line and Metro Rapid lines. The busway was chosen as the best option for the area over multiple Rapid lines for the following reasons:

- The busway would generate the highest number of riders, offsetting higher capital costs, and making the busway the most cost efficient in terms of price per passenger
- Operating costs were expected to be lower than for Rapid Bus network

- The busway supported the city's land use plans to locate a mass transit project along the former railroad right-of-way and was consistent with local land use plans.
- The Orange Line would offer the most improved travel time, since the dedicated busway would not be impacted by increased traffic congestion.[108]

Like the Metro Rapid routes, the busway features traffic signal preemption and green light extensions to keep Orange Line buses from waiting at stoplights. The two-lane busway construction was accompanied by the creation of pedestrian and bicycle paths as well as landscaping with native plants. There are 13 stations along the busway, with pre payment ticket machines, real time bus arrival information, public phones, bicycle racks and seating. Five of the stations are equipped with park and ride lots accommodating over 3,000 cars. Schedules of the Orange Line are coordinated with Red Line schedules to make multi modal transit convenient.[109] The Orange Line is designed to give access to rail users, drivers, pedestrians and bicyclists.

Average weekday ridership is 18,242, with total monthly boardings at 498,023.[110] The current ridership level is about three times as large as initial expectations.[111] Ridership has been rising on the Orange Line since it opened, escalating from 15,500 in December 2005 to its current level, a 7% increase. Coinciding with this jump has been a 4% increase in bus use and an 11.6% increase in Red Line ridership.[112] One contributing factor of these increases is likely the addition of the Orange Line, which has given increased access for San Fernando residents to the rest of the system. The MTA predicts that ridership will increase to 22,000 weekday boardings by 2020.[113] Since the opening of the Orange Line congestion has been reduced on the 101 Freeway. Traffic flows during morning peak hours through south San Fernando Valley have sped up by about 7 percent, from an average 43 mph to 46 mph and the amount of time that morning commuters waste being stuck in congestion – defined as traffic slower than 35 mph – declined about 14 percent.[114]

Traveling the length of the busway takes 38 minutes, with an average speed of 22 mph. Originally buses were allowed to speed through intersections at speeds up to 30 mph, but a high occurrence of accidents with crossing autos prompted reducing this speed to 10 mph. Traffic signal timing was also adjusted, signage was added and right turn restrictions were implemented as a result of the accidents. After the 38-minute trip along the Orange Line, passengers can take a 30-minute Red Line subway trip to downtown L.A. Time saved, compared to previous bus service, as a result of the Orange Line is close to 30 minutes, or 44%.

The Orange Line cost about $350 million to construct, and average of $24.3 million per mile.[115] This figure is in line with many other recently constructed exclusive busways. It also compares very favorably to light rail construction in Los Angeles. The Gold Line, which opened in 2003, cost $859 million for an average of $62.7 million per mile which is 2.58 times the per mile cost of the Orange Line.[116]

Overall the Orange Line has been successful in providing more transit options to the San Fernando Valley. It has been cost effective compared to rail expansion and has attracted riders to the system. Further use of exclusive busways should be explored for other parts of Los Angeles County and should be considered as an alternative to rail expansion.

Policy Recommendations

Drawing form the experiences of the cities and BRT projects examined in this paper, the Los Angeles County MTA should seriously consider implementing more BRT lines and features. With the large cost savings compared to rail projects, the MTA should shift its focus from rail projects to BRT projects.

The most effective type of runningway is an exclusive busway. They show the largest gains in speed, reduction of travel time and ridership increases. However, they are the most costly of all the running ways. Exclusive busways such as the Orange Line should be considered in place of proposed rail projects. Similar infrastructure can be used, except that tracks need not be laid and vehicle costs are significantly lower. Because busways and rail rights-of-way are so similar, an exclusive busway can be upgraded to rail in the future.

Median busways are the second most effective type of runningway for decreasing travel times and increasing ridership. They are usually less expensive than busways as fewer infrastructures need to be built to implement them. Like an exclusive busway, a median bus lane can be fairly easily upgraded to rail in the future. Los Angeles should consider implementing median busways in areas where there is insufficient space for an exclusive busway or where there is a multi lane road with an established market for transit.

Bus only lanes are the least expensive of the three runningways. They can reduce travel times and increase ridership, yet not as significantly as the other two types of runningways. Bus only lanes should considered for short-term improvements, as they are not every costly and are relatively simple to implement. Specifically, the bus only lane on

Wilshire Blvd should be expanded to run the entire length of the corridor. This would be a solid first step in creating a network of bus only lanes. The MTA should look at other Rapid lines to evaluate which routes would benefit from a bus only lane. The most congested corridors would likely earn the highest returns to the investment as there is already a market for transportation options and time saved would be more significant.

As far as long-term goals, a bus only lane is a good stepping-stone on the way to more permanent and prioritized runningways. The successful implementation of bus only lanes would likely create more demand for bus transit, which would then justify larger expenditures on median bus lanes or exclusive runningways. As they are easier to implement, they are a good short-term answer while median lanes and exclusive busways are in the planning process. Overall, prioritized runningways for buses should implemented wherever appropriate.

Measures to reduce dwell times and foster easy and fast boarding should be further explored. Level boarding caused by raised platforms would be a good first step as it would make boarding faster and easier for all passengers, especially the disabled and elderly. Alternative payment methods should be further explored. A pilot project of pre payment machines would be an effective step in evaluating their feasibility and effectiveness. Choosing one Rapid line to implement the machines on is one option for such a project. Enclosed stations are another option that should be explored especially on exclusive busways such as the Orange Line. In general the MTA should try to reduce the use of traditional on-bus payment especially on the busiest lines and at the most crowded stops, where dwell times are the greatest.

As is the case in Curitiba, BRT works best when it is integrated into a large network that serves a broad geographic area and many transit functions. Most new BRT systems mainly consist of on one or two relatively small projects that serve one function such as connecting a suburb to downtown rather than a network. This model, which is similar to many rail projects, is not appropriate for Los Angeles and its spatial layout. The Metro Rapid lines serve as an example of an attempt to create a BRT network and the MTA should be commended for trying to create such a network. However, bus priority on runningways is the most effective means to improving service and creating the type of bus system that improves quality of life.

Los Angeles needs to address its dependence on the automobile. The car is choking the region, influencing the quality of life for all who live there. If nothing is done, the area will continue to suffer from the worst pollution and congestion in the country. Residents will continue to be exposed to toxins and develop respiratory diseases, driving up medical costs. Workers will continue to be unproductive, while stuck in traffic, unable to work, or even spend time with their families. Low-income individuals will continue to be disadvantaged, without access to jobs, healthcare and recreation. And the region will continue to contribute to climate change.

Something needs to be done to reorient the region away from the car and towards a more sustainable mode of transport and way of life. Rail projects, while beneficial in many ways, are not the best for option L.A., costing significantly more than bus improvements and offering a service that is inappropriate for the region. Expansion and improvement of the bus system is the best first step in changing the nature of the area.

However, conventional bus system improvements will not be sufficient to overcome the challenges that the automobile has imposed. The only way to fully take advantage of the benefits that buses can offer is to give them priority over cars. A dramatic improvement in bus service, through the use of BRT features, can get drivers out of their cars, improve mobility for the transit dependent and improve environmental conditions. Such a step is necessary for Los Angeles to be the metropolis that can and should be.

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