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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.

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 provid offer an alternative to driving that can mitigate the seri 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 per 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 Only Lanes

Within normal arterial streets, a lane on either the right hand side, or in the me 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 times. Low floor buses, raised platform stations and wide doors make boarding faster and easier.

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 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]

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 th

- 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 for9598p2 324.3719079p3w 12 0 0 12 306BDj1212 0 0 12 319.

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 wh

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 ons,ss g g

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 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 grow

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 can

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.

Exclusive Busways

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

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 stil

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]

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 sig 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 dram 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 be642 e(m)Tj12 0 0 1e5si47 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 investm

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 syste2 380.75188 488.92178 460.55981 Tm85 12 0 0 12 149.3.1

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 aver

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 me

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

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

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 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 onl

Fast Boarding/Station Design

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 ridj10.01.4lh3n stations ar5it

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 me

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 ma

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

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 availabl 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 Lin

- 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 L

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 theree the to7 T tim to7 T tim0 12 104.58487 243.882891 57(to7 T timea

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 rath

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

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