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Bus Rapid Transit
Ridership Analysis

June 2005

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13. ABSTRACT (Maximum 200 words) **CALSTART surveyed select BRT communities across the country compiling data that identifies how the implementation of BRT service and, in particular, stylized vehicles affects bus ridership in the respective communities. This report reflects *what the transit properties are saying* regarding the effect of BRT vehicles on ridership. Specific issues addressed include 1) whether the vehicles are branded and/or styled differently than the communities' regular buses, 2) whether the BRT vehicles themselves were responsible for changes in ridership levels and 3) the effect of the vehicles on community acceptance of the BRT system. The survey results indicate that ridership levels increased after BRT system implementation, and, in some cases, up to one third of the new riders came were new to transit and an additional third were riding more often. An appendix in the report identifies and quantifies the benefit that these increased ridership levels have on vehicle miles traveled (VMT). An example of the estimated emissions and fuel consumption reduction corresponding to a BRT corridor ridership growth is presented. BRT can be an important option for reducing national use of petroleum based fuels as well as cost-effective and easily implemented from a public investment and policy perspective.**

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The Federal Transit Administration (FTA), Office of Mobility Innovation, sponsored the report. CALSTART would like to acknowledge the contributions that made this report possible. The study was conducted through telephone interviews, and questionnaires as well as review of public documents, information from websites and other public sources and refined based on interview data. The authors would like to express their sincere appreciation to the many people that made time in their busy schedules to provide their insights, data and observations that are the heart of this report.

The participants included FTA officials, community transit representatives, and other industry stakeholders. All participants contributed valuable information, ideas, suggestions, viewpoints and perspectives on BRT ridership performance. CALSTART paraphrased comments, aggregated data and compiled a perspective on BRT ridership growth. CALSTART also appreciates the reviews and clarifications provided by the participants.

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INTRODUCTION

From Los Angeles to Boston, communities across the country are implementing Bus Rapid Transit (BRT) systems and dispelling the perception that buses are an inferior way to travel. BRT is a potentially cheaper alternative to other major transportation investments that is presented as a new concept, or "mode," in bus travel and attracts new riders through the use of unique service and design characteristics.

Playing a primary role in this presentation is the BRT vehicle itself. Styling and aesthetics are one of many things that differentiate BRT systems from other bus systems and assist in the creation of a distinct BRT "brand." As rail vehicles often demonstrate, sleek designs can provide riders with the feeling of riding on a modern, upscale form of transit. Complimenting this updated exterior is a more functional interior that is itself "rail-inspired." Incorporating interior design features such as a large number of wide doors, an optimized floor height, and wider aisles facilitates easy and rapid passenger boarding and seating that reduces dwell times at passenger service stops. Another popular BRT vehicle feature is that of advanced propulsion systems powered by clean alternative fuels.

As BRT system implementation increases, more transit authorities are opting for vehicles with these advanced features. For instance, 60 percent of BRT community participants in WestStart-CALSTART's 2004 BRT Vehicle Demand Analysis Update used words like "sleek," "modern," "futuristic," and "rail-like" as adjectives to describe the types of vehicles they seek.[1] These participants also indicated that they prefer over 40 percent of an anticipated 5,210 vehicles for potential delivery between 2004 and 2013 to be powered by advanced technologies and almost 40 percent to be powered by alternative fuels such as natural gas.[2] Yet, if the bottom line for transit is to move people out of their cars and increase ridership, the question has to be asked whether BRT is accomplishing this, what role the vehicle has in accomplishing this goal, and what is the overall business case for manufacturers to pursue strongly designed vehicles. This report examines these issues.

EXECUTIVE SUMMARY

BRT systems are extremely effective in increasing transit ridership levels. These gains are documented in studies and surveys completed by various transit agencies that are operating BRT systems, as well as by onboard passenger counters. In Las Vegas, the RTC's "MAX" system is responsible for at least a 35 to 40 percent increase in ridership along its corridor of operation. AC Transit, based in northern California, the Boston based MBTA, and two Los Angeles MTA BRT routes experienced 65.8, 84, 27, and 42 percent increases, respectively, in ridership by switching their limited routes to BRT lines. In AC Transit's case, this increase in ridership came at a time when its overall ridership declined, thereby propping up the corridor's overall ridership numbers. In the MTA's case, the introduction of BRT service drove up local service ridership as well. Part of these increases can be attributed to the fact that both routes reduced running times by between 17 and 29 percent. The RTC's MAX service indicates the same, as the overwhelming majority of MAX riders state a reduced travel time as compared to their previous transportation mode, with a full 40 percent state reduced travel times by greater than 15 minutes. Furthermore, 32 percent of AC Transit's trips, 67 percent of the MTA's trips, and 24 percent of the RTC's MAX trips on their BRT routes came directly from new transit travel, indicating that their services attract a large number of "choice" riders.

Anecdotal evidence collected for this report illustrates the popularity of advanced vehicle designs and features, the emphasis that communities are placing on procuring these vehicles, the public's expressed desire to ride these vehicles, and the role of the vehicle in increasing the use of BRT and transit services. In fact, one can infer from this evidence that a strong design is a necessary BRT vehicle component for it significantly increases the system's potential to increase ridership and thereby achieve the overall goal of BRT system implementation.

Taking their cue from Europe, where bus ridership is high and people are eager to ride sleek new vehicles, transit executives, such as Roger Snoble from the MTA, are directing their communities to place emphasis on the design and features of the BRT vehicle itself and only procure and implement modern, rail-like carriages with aerodynamic designs, sleek shapes, and quiet, clean, well lit, and spacious interiors. These directives are working as people line up to gawk at and ride advanced stylized vehicles. In Phoenix and Los Angeles, members of the public and transit riders are filling up park-and-ride lots, bypassing other vehicles, and waiting longer at bus stops for a shot at riding a 45 foot NABI CompoBus. They photograph the vehicle, inquire about where they can catch a ride, and complain when they are forced to take one of the older "shoebox" styled buses. In Phoenix, 33 percent of RAPID riders never rode a Valley Metro bus before the introduction of the CompoBus.

The public's reactions to other stylized buses are at least equally as positive as those of the CompoBus. Passengers onboard the MTA's BRT-60, which has yet to enter regular service, rave about the vehicle's modern appearance, roomy interior, and quietness. Transit users, non-transit users, and local business owners in Eugene, Oregon indicated an overwhelming preference for streamlined, "cool" looking buses as well as those with clean propulsion systems and ease of entering and exiting over other conventional designs. In Cleveland, the GCRTA's decision to implement a stylistic vehicle, which is the vehicle that Eugene ended up opting for as well, was cemented by the public outpouring of attention, praise, amazement, awe, and declarations of ridership preference the authority received while demonstrating a stylized Irisbus Civis. In Las Vegas, the only community in America operating the Civis, the vehicle serves as a tourist attraction and was so successful at helping re-brand city transit that many regular riders fail to recognize that it is a form of transit bus.

Altogether, while BRT system characteristics demonstrate a capacity to expand transit ridership, the popularity of stylized BRT vehicles illustrates the potential to attract even more riders in the future as increasing numbers of manufacturers shift toward and build these rail-like vehicles. Altogether, while BRT system characteristics demonstrate a capacity to expand transit ridership, the popularity of stylized BRT vehicles illustrates the potential to attract even more riders. The additional growth in ridership can also further provide a quantifiable benefit in the communities by reducing emissions including greenhouse gas emissions and reducing fuel consumption as illustrated in Appendix A as increasing numbers of manufacturers in the future shift toward and build these rail-like vehicles.

CONTACTED COMMUNITIES

In order to examine the questions posed by this analysis, seven BRT communities around the country were contacted and interviewed. Although there are many more communities that either have BRT systems in place or are planning BRT systems, other contacted agencies, such as Miami-Dade and King County Metro, implemented only a few elements of true BRT systems in their cities. The seven selected communities were included because they have sufficient experience and operational data with BRT systems and/or stylized vehicles that illustrate the affect on transit ridership.

The communities included in this analysis are as follows:

- Massachusetts Bay Transportation Authority (MBTA)
- Lane Transit District (Eugene)
- Alameda-Contra Costa Transit District (AC Transit)
- Valley Metro (Phoenix)
- Greater Cleveland Regional Transit Authority (GCRTA)
- Regional Transportation Commission of Southern Nevada (RTC)
- Los Angeles County Metropolitan Transportation Authority (MTA)

These agencies and the others were initially contacted to see if they would be willing to participate. After they agreed, an open-ended questionnaire was sent out and an interview time was scheduled further discussion. Each interview lasted approximately an hour and covered the questions listed as well as those that emerged as relevant through discussion. A list of the survey questions can be found in the Appendix B.

Some of these agencies provided more insight and information than others. For instance, those communities that are operating with modern BRT-designed vehicles were able to provide rider responses to the vehicles as well as changes in ridership levels. In fact, four of the agencies provided quantified survey data on changes in ridership levels since BRT system implementation. On the other hand, as was mentioned above, some communities were not able to provide any input for this study because, upon investigation, they were determined to be inappropriate for inclusion.

CHARACTERISTICS OF BRT VEHICLES IN SURVEYED COMMUNITIES

The communities that are included in this analysis use a wide variety of vehicles, ranging from modern and stylistic vehicles with every desired BRT amenity and branding, to older buses that bare little distinction between themselves and those operating on non-BRT routes, aside from the distinct branding. The vehicles used in each community are as follows:

Massachusetts Bay Transportation Authority (MBTA)

The MBTA uses the Neoplan AN 460 LF for its "Silver Line" BRT service. While the vehicle has a conventional "boxy" transit bus design, it has modern BRT features such as a full low floor interior and a distinct paint scheme. It is also an articulated bus, which is uncommon in Boston.

MBTA: Neoplan AN 460 LF

The Silver Line was implemented in July 2002 on Washington Blvd. in Boston, replacing the conventional bus route 49. It is a limited stop service and has dedicated lanes for 80 to 90 percent of its route.

Greater Cleveland Regional Transit Authority (GCRTA)

When Cleveland begins its phased implementation of BRT service in late 2007, it will use the New Flyer Model DE60-BRT, an adaptation of the DE60LF that is more stylized and is specifically designed for BRT service. In addition to the vehicle's advanced rail-like design, it also has doors on both sides, a low floor, space for onboard bike storage, a distinct paint scheme, and an advanced hybrid system with "hush mode" operation that allows it quietly and smoothly accelerate up to 50 miles per hour solely on electric power. Also, three quarters of the vehicle's seats face forward, all of which combine to give passengers a very rail-like ride and experience. GCRTA purchased 26 vehicles with options for another 50.

GCRTA: New Flyer Model DE60-BRT

Lane Transit District

Although Eugene, Oregon was one of the first communities in the nation to begin discussion about implementing BRT in its community as well as creating plans to actually do so, BRT service will not actually begin until 2006. When service does begin, it will be along a one mile route and the vehicle used will be the same New Flyer Model DE60-BRT that will be used in Cleveland. This vehicle is also planned for use along a six mile BRT route in Springfield beginning in 2009. Five of these vehicles were purchased on an order piggybacked off Cleveland.

Lane Transit District: New Flyer Model DE60-BRT

Alameda-Contra Costa Transit District (AC Transit)

When AC Transit began BRT service in late 2003, it desired a vehicle with three doors and a continuous low floor in order to ease the movement of passengers on and off the vehicle and to meet handicap passenger requirements. Since no domestic bus manufacturer could meet these requirements, the agency opted for the Belgium built Van Hool Model A330, the winner of the 2003 European Bus of the Year award.

This 41 foot stylized vehicle has multiple amenities that riders prefer, from the aforementioned doors and floor, to its spacious feel, ample oversized windows on all four sides, distinct brand and paint scheme, and interior route map. AC Transit currently operates this vehicle on its 72R route and hopes to implement it on two new BRT lines in the future.

AC Transit: Van Hool Model A330

The agency also has 20 Van Hool Model A300 articulated buses in BRT service as well. Similar in styling to the A330, the A300 has a continuous low floor design and large, open standing areas that improve passenger circulation. Also, unlike most other articulated buses, the A300 has four sets of opening doors, easing boarding and exiting, both of which add to the vehicle's rail-like feel.

AC Transit: Van Hool Model A300

Los Angeles County Metropolitan Transportation Authority (MTA)

The Los Angeles County MTA is an important BRT community to examine because not only has it been operating its "Metro Rapid" system since 2000, but it has two different vehicles in BRT operation, and soon it will have three.

The first vehicle that entered into BRT service was the NABI 40-LFW. This vehicle has many BRT amenities, such as a low floor and distinct paint scheme, but it has a traditional boxy bus design and is not specifically designed for BRT use. In fact, the vehicle is not even unique to BRT service within Los Angeles and can be commonly found operating on traditional transit routes without the Metro Rapid branding.

Los Angeles MTA: NABI 40-LFW "Rapid" Bus

In 2003, the MTA received its first of 30 NABI CompoBuses, which it entered into service on its highly traveled Vermont and Wilshire/Whittier corridors, and will have 100 total by mid 2005. The vehicle is distinctly BRT, with all of the amenities of the 40-LFW that it replaced, including Metro Rapid branding and an alternatively fueled propulsion system, but it also has an advanced lightweight design, modern style, and larger size.

Los Angeles MTA: NABI CompoBus 45C-LFW

In the fall of 2005, the MTA plans to place the first 30 of 200 new NABI 60-BRTs into service on its Orange Line in the San Fernando Valley. This vehicle has the ultimate rail-like appearance, with a shapely aerodynamic body and covered rear wheel wells. The initial vehicles, which the MTA branded its "Metro Liner", will also be operating on its own designated busway, thereby adding to its rail-like feel. Since this vehicle is not yet in operation, ridership levels are unknown and not presented in this analysis. However, information on the decision to buy and implement this vehicle as well as initial rider impressions from the vehicle's limited public exposure is included.

Los Angeles MTA: NABI 60-BRT

Valley Metro

Like the current MTA fleet, Phoenix is an important BRT community to examine because it also has two different BRT vehicles in service. Also like the MTA, Phoenix is operating the NABI 40-LFW and the CompoBus. The city began its BRT service in July 2003, running on 12 40-LFWs and only two CompoBuses. However, when the city added two more corridors in early 2004, it implemented all CompoBuses for a total of 32 vehicles in all four corridors. A primary difference between Phoenix's vehicles and those of the MTA is that the MTA's run on compressed natural gas while Phoenix's run on liquefied natural gas.

RTC: NABI CompoBus 45C-LFW

Regional Transportation Commission of Southern Nevada (RTC)

The RTC operates what is arguably the most distinct and rail-like of all BRT vehicles. The Irisbus CIVIS is a European designed full low floor 60-foot articulated bus that attracts the attention of BRT communities around the nation with its shapely aerodynamic body, covered wheel wells, large panoramic windows, spacious interior, and level boarding platforms at all doors. The bus also has advanced vehicle features such as an optical guidance system and lightweight fiberglass body panels.

RTC currently has 10 vehicles in operation (only six of which run concurrently at the present system frequency) serving the Las Vegas Boulevard North corridor as part of the city's "MAX" system. There are plans to implement 6 or 7 more BRT routes, one of which is already approved and scheduled to be operational by 2007. However, funding restrictions prevent the agency from purchasing additional CIVIS vehicles because it is not domestically produced. Therefore, the RTC is looking into "pursuing a Civis-type" vehicle.

RTC: Irisbus Civis

STUDY RESULTS: THE EFFECT OF BRT SERVICE AND VEHICLE CHOICE ON TRANSIT RIDERSHIP

The results of the questionnaire and interviews with the transit authorities indicate that the implementation of BRT service in these communities has not only attracted significant levels of riders to BRT lines, but to transit as a whole. In other words, BRT is attracting "choice riders", i.e. those that don't have to ride transit because they have other means by which to travel but choose to ride transit nonetheless. In addition, discussions revealed that riders greatly prefer the modern rail-like BRT vehicles over traditional vehicles, and transit agencies are buying these vehicles in order to satisfy this preference and attract new riders to transit.

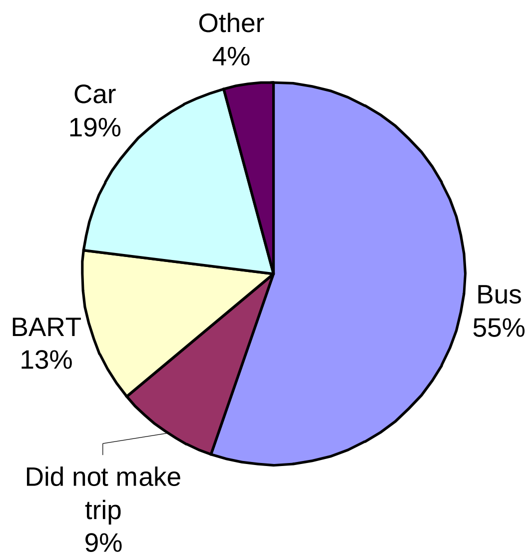
The Effect of BRT Service on Transit Ridership

After 10 months of BRT operation, AC Transit commissioned a "data collection effort and system performance overview" for its three route 72 lines, the so-called "San Pablo Corridor", one route of which is the agency's BRT line. This route, the 72R, replaced the agency's 72L line, which was a "limited-stop" peak only service. Even though the data was collected less than a year after the implementation of the 72R and, therefore, did not allow adequate time for the new service to mature and become completely established within the bus system, this data indicated that the 72R not only reduced running time by 17 percent, but it also increased ridership by 204.2 percent over the 72L. However, this number is slightly misleading since the 72R runs all day while the 72L only ran during peak hours. Still, comparing ridership levels during the same spans of time during the day reveals that the 72R increased ridership on the route by 65.8 percent.[3]

This increase in ridership is even more impressive because it came at a time when AC Transit's overall ridership declined. In fact, along the San Pablo Corridor, the local non-BRT routes experienced a 14 percent decline in ridership over the same timeframe.[4] Yet, once the Rapid's ridership increase is figured in, the corridor experienced a 7.2 percent growth in ridership, meaning the Rapid was responsible for a 21.2 percent rise in ridership on the corridor.[5]

Another impressive aspect of this ridership increase is that a significant portion of the ridership gains made by the 72R came from so-called “choice” riders, those that have other means for traveling to work but instead choose to take transit. A full 32 percent of those taking the Rapid bus either traveled by car, by another non-transit form of transportation, or did not make the trip altogether before Rapid service began.[6]

Mode Used Before the Introduction of Rapid Bus



Source: Nelson\Nygaard Consulting Associates

AC Transit was not the only agency that experienced ridership gains and attracted riders from outside of transit due to BRT implementation. The Los Angeles MTA performed a similar study that focused on its Metro Rapid Wilshire/Whittier and Ventura Demonstration Program.

The Metro Rapid Demonstration Program was initiated in March 1999 in response to a visit by MTA and City of Los Angeles officials to a city well known for its innovative BRT system, Curitiba, Brazil. The feasibility study recommended that the MTA, in partnership with the City of Los Angeles, conduct a demonstration along two-to-three major arterials that have strong ridership and unique characteristics to provide broad actual experience regarding the feasibility of full-scale deployment of BRT within the MTA system.[7] The two Metro Rapid lines that comprised the Demonstration Program, one along Wilshire/Whittier and another along Ventura Blvd., were implemented on June 24th 2000.

The study was completed by Transportation Management and Design, Inc. and was based on ridership surveys administered in September 2000, 90 days after BRT service implementation. It indicated that these two Metro Rapid routes were extremely successful at reducing passenger travel times and increasing transit ridership. On the Wilshire/Whittier corridor, travel times were reduced by 29 percent, while on the Ventura corridor, travel times were reduced by 23 percent. These decreased travel times resulted from the Metro Rapid program's introduction of several attributes specifically designed to improve service operating speeds including bus signal priority, level boarding/alighting with low-floor buses, headway rather than timetable-based schedules, fewer stops, far-side intersection location of stations, and joint active management of the service operation from the Transit Operations Supervisors (TOS) in the field and the MTA Bus Operations Control Center (BOCC).[8]

These faster travel times combined with other Metro Rapid features such as clean bus interiors, reliable service, and easy bus identification to drastically improve riders' perception of bus service. In fact, as the study points out, riders perceived a "quantum leap in service performance and quality," the magnitude of which is "rare, particularly over a relatively short time frame."[9] Furthermore, the study states that the "MTA has essentially raised the bar significantly in terms of service quality for its riders" through the Metro Rapid program.[10]

The reduced passenger travel times and improvement in bus service resulted in significant increases in ridership along both corridors. Along the Wilshire/Whittier corridor, ridership increased by 42 percent while along the Ventura corridor, ridership increased by 27 percent. While 1/3 of this increase was due to existing transit riders changing their routes, one-third was from existing riders who rode more often and, of particular significance, one-third came from brand new transit riders.[11] This means that two-thirds of the increased ridership came directly from new transit travel. In addition, along the Wilshire/Whittier corridor not only did express service ridership increase, as measured by the comparison between limited-stop service and the Metro Rapid service that replaced it, but local service ridership did as well as people made adjustments for appropriate stop locations and used local buses to connect to and from Rapid service.

In other studies, Boston's MBTA indicates that replacing its standard route 49 with the Silver Line BRT route increased ridership from 7,625 riders per day before July 2002 to over 14,000 in early 2005 on Washington Blvd, indicating an approximately 84 percent increase. Furthermore, while the RTC didn't have a study commissioned to examine ridership levels, its automated passenger counters (APCs) onboard vehicles keep regular tabs on ridership levels. These APCs indicate that ridership along the Las Vegas Boulevard North corridor, which includes both the Civis MAX service and the non-BRT Route 113, is up 35 to 40 percent in early 2005 from the level it was at in early 2004, before the implementation of the MAX. It's important to note that these ridership gains are conservative percentages, for the APCs only function properly on vehicles with three doors, yet the Civis has four doors.

The Effect of BRT Service on Transit Ridership

Transit Agency and Corridor	Percent Increase in Ridership Levels	Percent Increase in Choice Riders
AC Transit – 72R	66	32
Los Angeles MTA		
Wilshire/Whittier	42	67
Ventura	27	67
Boston MBTA – Silver Line	84	
Las Vegas RTC – MAX	>35-40	24
Phoenix RAPID	N/A	33

Another important note is that while the APC data shows that ridership on Route 113 took a small dip, this dip is not entirely responsible for all MAX ridership, which means the MAX is attracting additional riders to the corridor. In fact, a MAX corridor study completed in March 2005 by Strategic Solutions illustrates that 24 percent of surveyed MAX riders are new to transit, indicating they are “choice” riders because they traveled by a non-transit form of transportation before MAX began operating.[12] A key factor in attracting these choice riders is the fact that 90.7 percent of surveyed MAX riders state faster travel times as compared to previous transportation modes, while a full 40 percent state reduced travel times by greater than 15 minutes.[13]

The Effect of Vehicle Design on BRT Ridership

According to Jon Twitchell, Service Development Manager at AC Transit, the role of the vehicle in the ridership gains experienced by AC Transit, the MTA, and those who observed but haven't quantified these gains is due at least in part to the vehicle. "It's part of the overall package," he said. While Twitchell is modest in describing the link between vehicle and ridership, other transit agencies are more outspoken and direct in their demand for stylized vehicles and the attribution of actual and potential ridership gains to the vehicle used. Inside information and anecdotes confirm the strong link as well.

The Los Angeles MTA's goal with designing and implementing the Metro Rapid program was to maximize BRT system capacity and ridership. The MTA observed that this was being accomplished in Europe through the operation of advanced vehicles with aerodynamic rail-like designs and features. These features were popular with the public, which made clear its desire to travel on these vehicles and led to increased ridership. Therefore, when the MTA set about implementing its vision of a 21st century bus system in the Metro Rapid program, it looked to Europe for inspiration and direction regarding the look, style, and feel of the vehicle.

Roger Snoble, CEO of the MTA, issued an order to his staff that new vehicle designs should be sleek, rounded, and rail-like. "Roger and I were on the 25th floor of the MTA building looking out the window onto our bus yard," says Richard Hunt, General Manager of the San Fernando Valley Service Sector for the MTA. "Roger pointed to the buses and said 'See those boxes down there? Don't bring me another bus that looks like that. No more shoeboxes!'" Snoble's order placed a very high priority on not only the exterior, but also on a rail-like interior with various amenities such as padded seats, larger windows, larger doors, and a more spacious and well lit interior. Limited focus group work confirmed Snoble's sentiments as group members consistently chose sleek vehicles over boxier counterparts and stated those were the vehicles they were more inclined to ride.

The MTA worked closely with NABI to design both its non-articulated bus and its articulated bus, which would first be used on its Orange Line busway, to implement these priorities. This joint effort paid off with the 45-foot CompoBus and the BRT-60 articulated vehicle. With half of its planned fleet of 100 in service from the end of 2004, people are lining up to ride the CompoBus. “We have people waiting at the Rapid stop for the next bus if they think it will be a 45 footer,” said Hunt.[14]

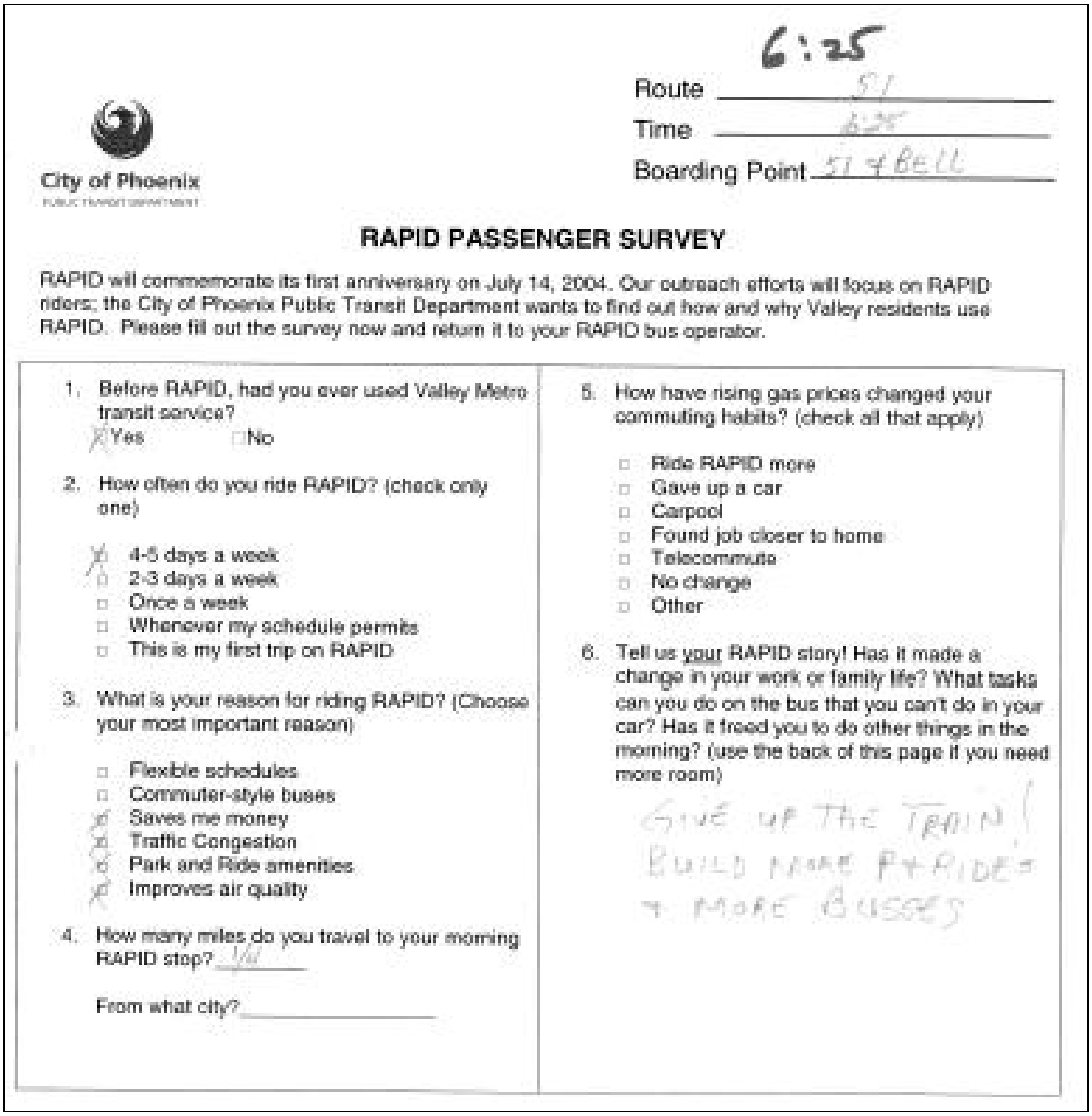
The response to the 60-BRT, which is not yet in regular service, is similarly enthusiastic. In limited rides, the response from stakeholders, policymakers, and the public is consistently overwhelmingly positive. Passengers onboard the 60-BRT were overheard commenting that the vehicle looks like “a train on tires” and raved to the MTA about the vehicle’s looks and quietness, which, at 78db, is forty percent lower than that of a typical articulated bus (the only internal noise is from the ventilation system).

BRT-60 “Rail-Like” Interior

The CompoBus is also used as part of the Rapid Express program at Valley Metro in Phoenix, where it is receiving a similar tremendous response as Los Angeles. “I talked up the sleek look of the vehicle to convince the agency of its worthiness," says Reed Caldwell, Phoenix Transit Department Facilities Division Deputy Transit Director. In the end, "the city was drawn towards the CompoBus because of its style and capacity."

The decision to go with this vehicle turned out to be a wise one. While the agency has not completed an analysis on transit ridership levels before and after the implementation of the CompoBus, it does monitor park-and-ride lots, which are how a significant number of metropolitan Phoenix commuters travel to and from bus stops. Between July 2003 and January 2004, these lots averaged 60 vehicles per day. However, after the introduction of the CompoBus into daily service, demand for park-and-ride spots surged. In February 2005, the Park and Ride lots were averaging 468 vehicles per day. "The CompoBus brought riders in hordes," says Caldwell. People are even seen photographing the bus, while those from out of town often question how they can find and catch routes that operate the buses. Riders that receive the steel NABI 40-LFW instead of the CompoBus are often displeased and voice this displeasure to the city in letters.

A recent Rapid Express passenger survey indicated not only that there are more than 13,500 passenger boardings on RAPID buses each week, but that nearly 33 percent of riders never rode a Valley Metro bus before. In the additional feedback section, surveys also consistently displayed demand for more CompoBuses and appreciation for its style and amenities.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Route 51

Time 6:25

Boarding Point 51 + BELL

City of Phoenix
PUBLIC TRANSIT DEPARTMENT

RAPID PASSENGER SURVEY

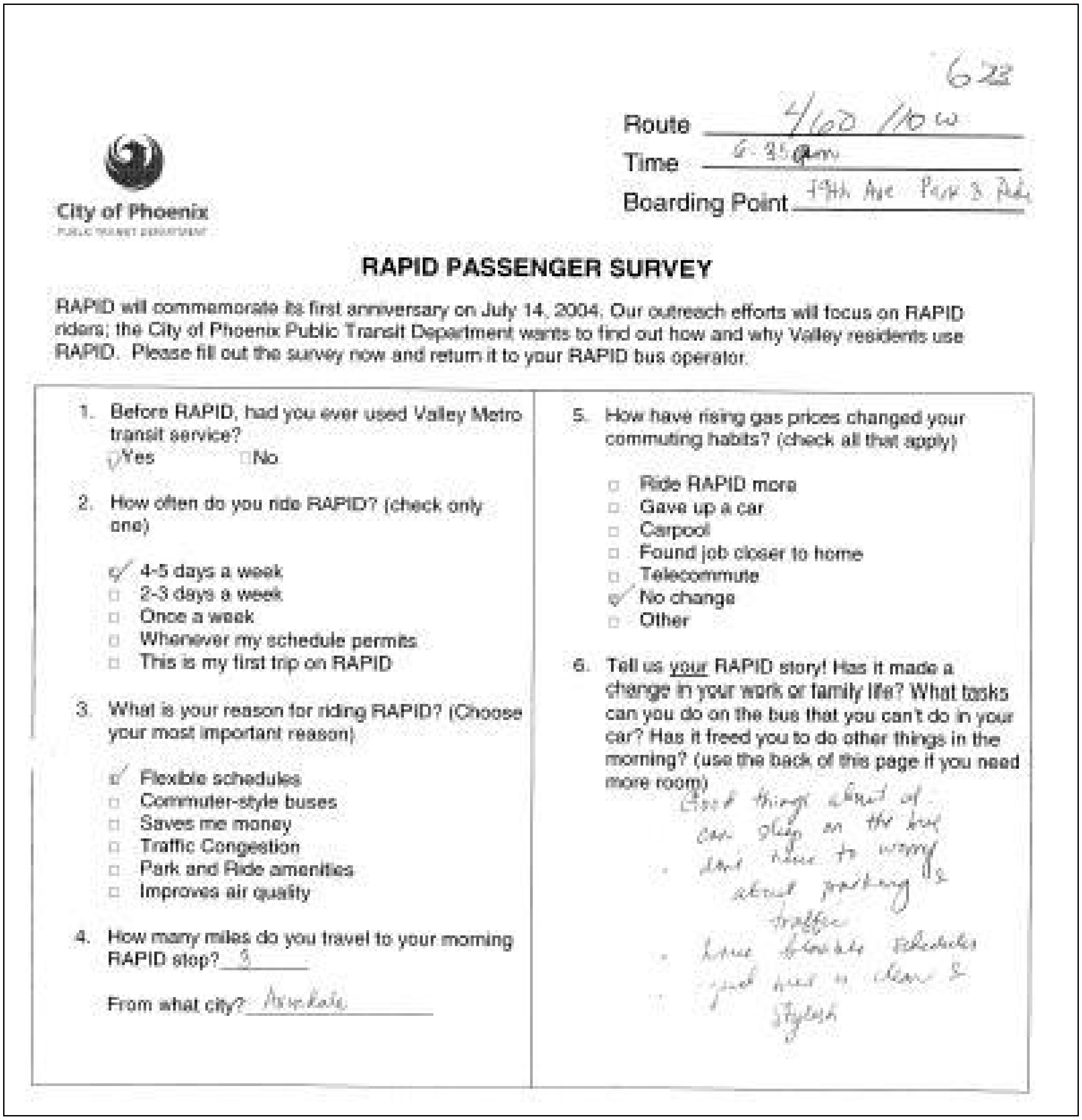
RAPID will commemorate its first anniversary on July 14, 2004. Our outreach efforts will focus on RAPID riders; the City of Phoenix Public Transit Department wants to find out how and why Valley residents use RAPID. Please fill out the survey now and return it to your RAPID bus operator.

1. Before RAPID, had you ever used Valley Metro transit service?
   - [X] Yes
   - [ ] No
2. How often do you ride RAPID? (check only one)
   - [X] 4-5 days a week
   - [ ] 2-3 days a week
   - [ ] Once a week
   - [ ] Whenever my schedule permits
   - [ ] This is my first trip on RAPID
3. What is your reason for riding RAPID? (Choose your most important reason)
   - [ ] Flexible schedules
   - [ ] Commuter-style buses
   - [X] Saves me money
   - [X] Traffic Congestion
   - [X] Park and Ride amenities
   - [X] Improves air quality
4. How many miles do you travel to your morning RAPID stop? 1/4

   From what city? ______
5. How have rising gas prices changed your commuting habits? (check all that apply)
   - [ ] Ride RAPID more
   - [ ] Gave up a car
   - [ ] Carpool
   - [ ] Found job closer to home
   - [ ] Telecommute
   - [ ] No change
   - [ ] Other
6. Tell us your RAPID story! Has it made a change in your work or family life? What tasks can you do on the bus that you can't do in your car? Has it freed you to do other things in the morning? (use the back of this page if you need more room)

   GIVE UP THE TRAIN! BUILD MORE P+RIDES + MORE BUSSES

Survey Urging the Production of More Buses



City of Phoenix
PUBLIC TRANSIT DEPARTMENT

Route
Time
Boarding Point

RAPID PASSENGER SURVEY

RAPID will commemorate its first anniversary on July 14, 2004. Our outreach efforts will focus on RAPID riders; the City of Phoenix Public Transit Department wants to find out how and why Valley residents use RAPID. Please fill out the survey now and return it to your RAPID bus operator.

1. Before RAPID, had you ever used Valley Metro transit service?
   - ☑ Yes
   - ☐ No
2. How often do you ride RAPID? (check only one)
   - ☑ 4-5 days a week
   - ☐ 2-3 days a week
   - ☐ Once a week
   - ☐ Whenever my schedule permits
   - ☐ This is my first trip on RAPID
3. What is your reason for riding RAPID? (Choose your most important reason)
   - ☑ Flexible schedules
   - ☐ Commuter-style buses
   - ☐ Saves me money
   - ☐ Traffic Congestion
   - ☐ Park and Ride amenities
   - ☐ Improves air quality
4. How many miles do you travel to your morning RAPID stop? 3

   From what city? Avondale
5. How have rising gas prices changed your commuting habits? (check all that apply)
   - ☐ Ride RAPID more
   - ☐ Gave up a car
   - ☐ Carpool
   - ☐ Found job closer to home
   - ☐ Telecommute
   - ☑ No change
   - ☐ Other
6. Tell us your RAPID story! Has it made a change in your work or family life? What tasks can you do on the bus that you can't do in your car? Has it freed you to do other things in the morning? (use the back of this page if you need more room)

   Good things about it
   - can sleep on the bus
   - don't have to worry about parking & traffic
   - have flexible schedules
   - and bus is clean & stylish

Survey Complimenting the CompoBus' Style

In 1996, when Lane Transit District was in the initial planning stages of its BRT system, it commissioned an exploratory research report that examined how various system features registered with the public. These features were proposed to focus groups comprised of transit users, non-transit users, and local business owners, and the reactions of the group's participants were recorded.

One examined system feature was vehicle design. The focus group was shown three distinct looking vehicles: an aerodynamic electric powered bus, a non-articulated 45-foot bus with four sets of double doors, and a standard "shoebox" designed 60-foot articulated bus. The aerodynamic, styled bus was "favored by the vast majority of focus group participants" and was "praised for its…attractive 'cool' appearance."[15] Group participants made such comments as "I like the shape of it", "I think it's cool…It looks streamlined", and "I like the design…The design is good."[16]

The focus group also commented on other BRT system features such as clean fueled propulsion. In fact, "several participants in each group expressed favorable comments about using alternative sources of energy for the transit system."[17] While the 45-foot bus was not at all close to the aerodynamic bus' high rating, the ease of entering and exiting the vehicle was praised and noted as the primary benefit of the design. "I like all the doors on it," participants were quoted as saying. "You're going to be able to get on and get off." The influence of these sentiments by the public involving vehicle style, propulsion system, and ease of entry and exit, were evident when Lane Transit decided on the New Flyer Model DE60-BRT, a stylized vehicle with a clean propulsion system and multiple double doorways, for its BRT system.

The GCRTA received similar feedback about stylized vehicles from residents when it was planning its BRT system. The authority needed to distinguish BRT from normal bus operation and make it a higher quality service that is in line with rail in order to attract riders. It believed a key component in accomplishing this was through the use of stylized vehicles. This belief was confirmed in late 2001 during a month long period when the authority operated an Irisbus Civis, displaying the vehicle in front of several public meetings and providing limited rides to the community, both in an effort to obtain public feedback on the vehicle.

Reaction to what many consider to be the most stylized, rail-like bus in production was overwhelmingly positive. The public, through a large amount of testimony, made it clear that if the city was going to make this improvement to its bus system, riders preferred to travel on these stylized new vehicles instead of the normal old ones. Members also stated that they were more likely to ride a vehicle if it is stylized and looks better than a standard bus.

Perhaps the primary factor that led the transit authority to decide on implementing a stylized vehicle was the visual reactions it garnered by driving around town. “People stopped in their tracks to check this vehicle out,” said Michael Schipper, Deputy General Manager of Engineering and Projects. Speaking about a time when he and leading GCRTA decision makers and board members rode in the vehicle as it cruised around the public square, Schipper said “The looks on the publics’ faces were telling…They were in amazement and awe. Seeing these reactions was very influential.” In fact, it was so influential that when the transit authority learned that it couldn’t use the Civis itself because of federal “Buy America” procurement requirements, it had to justify the decision to go with another vehicle to members of the public and even the Board. “The Board said ‘After all this, you’re *not* bringing the Seattle bus here.’ That’s why we decided on the DE60-BRT…It’s a stylized version of the Seattle bus.”

In Las Vegas, which due to a Buy America waiver is the only city in the United States where the Civis operates in regular service, public response was and continues to be overwhelming. The Civis vehicle operates along Las Vegas boulevard, making it as much of a tourist attraction as the city’s casinos. The overwhelming majority of local residents state that they found out about the vehicle and the MAX service simply by seeing the attention-grabbing vehicle pass by.[18] As June DeVoll, the Transit Operations Manager of the RTC states, the Civis was so successful in helping the agency create a new brand of transit that MAX service riders often state that “[they] don’t ride buses, but [they] do ride that,” while pointing at the MAX vehicle.

Comments on BRT Vehicle Design		
Name and Affiliation	**Comment**	**Vehicle Design Category**
Roger Snoble, CEO of the MTA	• "No more shoeboxes!"	Non-angular, "rail-like design", rebranding
MTA focus group	• Preference for sleek vehicles over boxier counterparts	Non-angular, "rail-like design"
Richard Hunt, General Manager, MTA	• "We have people waiting at the Rapid stop for the next bus if they think it will be a [CompoBus]"	Size, comfort, large windows
MTA stakeholders, policymakers, and the public	• The 60-BRT looks like "a train on tires"; raved about the vehicle's looks and quietness	"Rail-like" appearance
Reed Caldwell, Director, Valley Metro	• "I talked up the sleek look of the [CompoBus] to convince the agency of its worthiness"	General aesthetics
	• "The CompoBus brought riders in hordes"	General aesthetics, size
Rider surveys, Valley Metro	• Demand for more CompoBuses and appreciation for its style and amenities	Style, size, comfort, large windows
Focus Groups, Lane Transit	• "I like the shape of [the aerodynamic electric powered bus]", "I think it's cool…It looks streamlined", and "I like the design…The design is good."	"Rail-like" appearance
	• Favorable comments about using alternative sources of energy for the transit system	Alternative (clean) fuels
	• "I like all the doors on it… You're going to be able to get on and get off"	Ease of entry and exit
Public Testimony, GCRTA	• The public stated that it was more likely to ride a vehicle if it is stylized and looks better than a standard bus	General styling, increased ridership
Michael Schipper, Deputy General Manager, GCRTA	• "People stopped in their tracks to check this vehicle out." "The looks on the publics' faces were telling…They were in amazement and awe. Seeing these reactions was very influential"	Non-angular, "rail-like design"
June DeVoll, Transit Operations Manager of the RTC	• The Civis was so successful in helping the agency create a new brand of transit that MAX service riders often state that "[they] don't ride buses, but [they] do ride that," while pointing at the MAX vehicle	Non-angular, "rail-like design", rebranding

CONCLUSION

Throughout the United States, an increasing number of communities are implementing BRT systems and advanced, stylized vehicles as ways to increase transit ridership. This effort is paying off as BRT is proving to be extremely effective at increasing transit ridership levels.

As other studies identified, these new, modern transit systems are significantly reducing running times. These reductions are combining with new, stylized, rail-like vehicles to provide a level of service previously unimaginable. Not only is the exterior of these vehicles drastically improved over previous "shoebox" designs, but interiors are offering a wealth of modern and popular amenities such as a large number of wide doors, an optimized floor height, and wider aisles, thereby facilitating easy and rapid passenger boarding and seating that reduces dwell times at passenger service stops. Clean and quiet propulsion systems complete the picture of a modern "rail-car on tires" and raise the bar for public transit satisfaction and popularity. Future research should be directed at gathering additional data to verify these conclusions. In addition, research should examine prices that transit agencies are willing to pay for these stylized vehicles in order to help justify the hard investment decisions manufacturers must make. For example, one vehicle mentioned herein is no longer available because transit properties determined current prices to be too high.

With this drastic redesign of the traditional bus system and vehicle, it's no surprise that BRT communities across the country are experiencing significant ridership gains. In many cases, the increase in ridership occurs not just on the route that BRT serves, but to transit as a whole as choice-riders elect to use the service. These gains are only bound to increase as transit planners and executives, based on the results they observed in Europe and in other domestic communities such as Los Angeles and Las Vegas, realize that the vehicle *does* matter and is a crucial part of the effort to attract more ridership. The public clamors for advanced vehicles, waits extended periods of time at bus stops for chances to ride one, photographs them, writes complimentary letters to transit agencies about them, and complains when forced to take one of the older box-styled buses. With such reactions and sentiments, and with an increasing number of manufacturers lining up to produce stylized vehicles, the potential for BRT to be a lower-cost, efficient and effective transit system has never been better.

Although not part of the survey work, Appendix A quantifies the environmental benefits of the ridership growth in terms of emissions reduction in communities and also an energy savings benefit. Both of these quantifiable benefits accrue from the transport of people collectively, in public Bus Rapid Transit, and not by private vehicles.

Based on LACMTA Metro Program ridership and revenue miles data, forty miles of BRT corridor operating 40’ CNG buses can result in close to a 75 percent savings in GHG and a dramatic reduction in NOx. In addition to emissions reduction, public transit also reduces our consumption of fuel. In the example 40 miles of corridor, annual savings are estimated at 19,070 barrels of crude oil. This could place BRT, if widely implemented, among the top fifteen options for reducing national consumption of petroleum based fuels and one of the most cost-effective and easily implemented options from a public investment and policy perspective.

APPENDIX A - EMISSIONS REDUCTION AND FUEL SAVINGS BENEFITS OF BRT RIDERSHIP GROWTH, AN EXAMPLE

The substantial ridership growth reported in the body of this analysis document suggests a question: Are there any other benefits that can be quantified and related to these increases? The answer is a resounding yes as suggested by the following analysis. This appendix estimates a measure for the environmental benefits in terms of emissions reduction in communities and also an energy savings benefit. Both of these quantifiable benefits accrue from the transport of people collectively, in public Bus Rapid Transit, and not by private vehicles.

Background

APTA commissioned an oft quoted report[1] by Robert J. Shapiro et al that quantifies the role of public transportation in conserving energy and reducing vehicle emissions in the private sector by attracting ridership to transit. The principles for the pollutant and greenhouse gas (GHG) emissions calculations developed in the reference report are adapted for use in this Appendix to estimate the benefit of documented or projected growth in ridership in BRT implementations.

The Shapiro technique is to postulate a world without public transportation and estimate how much additional emissions would occur if current users of public transit had to rely instead on private automobiles. Using a similar technique, WestStart-CALSTART calculated the environmental benefits and energy savings for a typical 40-mile BRT corridor based on the LACMTA Metro Rapid demonstration data. Transit agencies can estimate actual or projected benefits by using local data and the example method presented in this Appendix.

One way to accomplish this is to first estimate the pollution caused by public transportation. Next, calculate the pollution emitted if current public transportation needs had to be met by a distribution of private passenger cars, SUVs, and light-duty trucks. Finally, the difference between the emission levels associated with the current use of public transportation, and the higher levels of emissions by the greater number of light duty vehicle trips required to replace public transit, provides an accurate measure of the environmental benefits of public transportation.

The adaptation for a BRT corridor application involves calculation of the added emissions attributable to the BRT vehicles based on before and after statistics for a specific corridor implementation. Those same statistics also can identify the growth in passenger miles that we can hypothesize might be replaced with private vehicle trips. Calculating the pollutant and GHG emissions for the private vehicle trips and subtracting the BRT emissions on an annual basis provides a quantification of the environmental benefit of BRT ridership growth.

[1] Conserving Energy and Preserving the Environment: The Role of Public Transportation, Robert J. Shapiro, Kevin A. Hassett and Frank S. Arnold, July 2002.

Both public transit and private automobiles emit both criteria (regulated) pollutants and GHG into the environment which include particulate matter, nitrogen oxides, carbon monoxide, and carbon dioxide. For the purpose of this example calculation, emissions will be estimated for NOx and GHG. For various classes of vehicles, emissions from their propulsion systems with specific fuels can be determined on a grams-per-vehicle-mile-traveled basis, which then is multiplied by the total miles traveled by the vehicles to calculate the total emissions produced by them.

BRT Methodology for Emissions Calculations

Applying the Shapiro report methodology, the first step is to gather data on the growth in BRT vehicle miles and the corresponding growth in passenger miles traveled in the local or metropolitan area for a particular BRT implementation. Since ample early "Metro Rapid" statistics were gathered by LACMTA[2] on two corridors, as shown in Table 1 and that data will be aggregated for use in these example calculations.

Table 1 Ridership Growth

Ridership

Total Unlinked Ridership	Wilshire/Whittier Corridor		Ventura Corridor	
	Before	After	Before	After
Local	39,700	50,000	13,500	8,100
Limited	23,800			
Metro Rapid		40,300		9,000
Total Ridership	63,500	90,300	13,500	17,100
Net Increase		26,800		3,600
% Increase		42.2%		26.7%

% Corridor Ridership				
Local	63%	55%		47%
Limited/Metro Rapid	37%	45%		53%

The LACMTA Metro Rapid experience on the Wilshire and Venture corridors resulted in a total weekday ridership growth from 77,000 (the before) to 107,400 (the after).[3] These

[2] Los Angeles Metro Rapid Demonstration Program, Final Report, LACMTA, March 2002.
[3] Los Angeles Metro Rapid Demonstration Program, Final Report, LACMTA, March 2002.

are shown in Table 1 resulting in a net weekday corridor gain of 30,400 riders! The service growth involved more vehicles traveling at higher speeds which increased the vehicle miles traveled for the BRT buses as well as a substantial growth in passenger miles traveled.

BRT Vehicle Emissions

Statistics on BRT vehicle miles traveled were not directly available from LACMTA report data. However, before and after values were available for "Revenue Miles" as shown in Table 2. Note that Table 2 was from an earlier version of the Final Report (2001 versus a 2002 version) and does not have the complete ridership number shown in the previous Table 1. However, the Peak Vehicles and Revenue Hours are quite similar, providing a certain confidence in quoting the Revenue Miles. Another issue is that the distance traveled from the bus facilities to the routes are not in the revenue miles. Still the "revenue miles" are deemed a reasonable proxy for the "vehicle miles traveled" by the BRT buses. The weekday revenue miles before is 17,578 and 23,508 is the after resulting in a net weekday gain of 5,930 miles traveled. Annual BRT vehicle miles are estimated by multiplying by five days per week and 52 weeks per year to result in 1,541,800 annual BRT vehicle miles.

Table 2 Growth in Revenue Miles
Weekday Corridor Service[4]

Corridor	Ridership			Peak Vehicles			Revenue Hours			Revenue Miles		
	Pre-Rapid	Post-Rapid	% of Change	Pre-Rapid	Post-Rapid	% of Change	Pre-Rapid	Post-Rapid	% of Change	Pre-Rapid	Post-Rapid	% of Change
Wilshire-Whittier												
Lines 18/318	32,082			45			517			5,472		
Lines 20/21/22/320/322	31,405			77			727			7,767		
Line 18		27,066			34			400			3,949	
Lines 20/21		28,880			44			503			4,057	
Metro Rapid 750		28,207			64			619			7,877	
Combined Corridor	63,487	84,153	32.6%	122	142	16.4%	1,244	1,522	22.4%	13,239	15,884	20.0%
Ventura												
Lines 424/425/522	10,800			37			285			4,339		
Lines 150/240		4,650			31			353			4,486	
Metro Rapid 750		9,000			20			211			3,138	
Combined	10,800	13,650	26.4%	37	51	37.8%	285	564	98.1%	4,339	7,625	75.7%
Total Demonstration	**74,287**	**97,803**	**31.7%**	**159**	**193**	**21.4%**	**1,528**	**2,086**	**36.5%**	**17,578**	**23,508**	**33.7%**

Conceptually, we estimate the growth in NOx and GHG emissions by multiplying the vehicle miles traveled by the BRT buses during a year by the emissions for a particular bus configuration on a grams per mile basis. This is identified in Table 3 showing gram

[4] Final Report Los Angeles Metro Rapid Demonstration Program July 2001 (early website version).

per mile emissions for a 40 foot CNG bus powered by one type of CNG engine with and without exhaust after treatment (an Oxidation Catalyst – OC) plus a different CNG engine also with an OC after treatment. The annual emissions represent the product of 1,541,800 annual BRT vehicle miles and the indicated grams per mile.

Note that the emissions for even similar propulsion systems with similar emission control devices can vary, sometimes substantially, when tested under different drive cycles. The data here is not meant for comparing differences in propulsion systems but rather the comparison of benefits of BRT transport relative to private vehicle trips. Consequently, even the calculated annual emissions will be averaged when that comparison is presented.

Table 3 Emissions for 40' CNG Bus

Emissions in Grams per Vehicle Mile			
	Propulsion	**NOx**	**CO_2**
BRT with CNG 40' Bus[5]	CNG - 1	18	2,150
	CNG - 1 w/OC	14	2,000
	CNG - 2 w/OC	13.5	2,150
Annual Emissions (x 1,000 lbs)			
	Propulsion	**NOx**	**CO_2**
BRT with CNG 40' Bus	CNG - 1	61.1	7,301.5
	CNG - 1 w/OC	47.5	6,792.1
	CNG - 2 w/OC	45.8	7,301.5

BRT Passenger Miles

The original operating concept for the LACMTA demonstration was to provide existing and potential customers with equal amounts of local and Metro Rapid service and allow them to choose that which best met their needs. This operating plan was implemented in June 2000. From the initial week of operations it was clear that many customers were choosing the Metro Rapid service. This led to overloading on both Metro Rapid lines initially (only the Wilshire/Whittier line continues to have under-capacity problems) and continuing underutilization on two of the three local services (i.e., Lines 20/21 and 150/240).

While overall performance in terms of service effectiveness and efficiency improved on the Wilshire/Whittier corridor with the introduction of Metro Rapid, performance on the Ventura corridor declined significantly despite the 25 percent increase in riders. This was

[5] "CNG and Diesel Transit Bus Emissions in Review", Alberto Ayala, Norman Kado, Robert Okamoto, Michael Gebel, and Paul Rieger, California Environmental Protection Agency, Air Resources Board, 9th Diesel Engine Emissions Reduction Conference, August 24 - 28, 2003, Newport, Rhode Island

principally due to the very large increase in Ventura local service compounded with an over 50 percent rider switch from the local to Metro Rapid service.

For this example, the data from both corridors will be combined for a net growth number. In Table 4, the weekday growth in passenger miles is 127,609, the difference between 508,999 (post-rapid) and 381,390 (pre-rapid). Multiplying by 5 days per week and 52 weeks per year, the result is a growth to 33,178,340 annual passenger miles.

Table 4 Growth in Passenger Miles

Weekday Corridor Service

	Unlinked Passengers			Passenger Miles			Peak Vehicles			Revenue Hours		
Corridor	Pre-Rapid	Post-Rapid	% Change	Pre-Rapid	Post-Rapid	% Change	Pre-Rapid	Post-Rapid	% Change	Pre-Rapid	Post-Rapid	% Change
WILSHIRE-WHITTIER												
Lines 18/318	32,100			94,695			45			517		
Lines 20/21/22/320/322	31,400			162,495			77			727		
Line 18		25,000			65,000			33			397	
Lines 20/21		25,000			93,750			42			410	
Metro Rapid 720		40,300			237,770			71			705	
Combined Corridor	63,500	90,300	42.2%	257,190	396,520	54.2%	122	146	19.7%	1,244	1,511	21.5%
VENTURA												
Lines 424/425/522	13,500			124,200			37			285		
Lines 150/240		8,100			40,929			28			317	
Metro Rapid 750		9,000			71,550			21			198	
Combined	13,500	17,100	26.7%	124,200	112,479	-9.4%	37	49	32.4%	285	515	80.9%
TOTAL DEMONSTRATION	77,000	107,400	39.5%	381,390	508,999	33.5%	159	195	22.6%	1,528	2,027	32.6%

Private Vehicle Miles to Replace the Growth BRT Passenger Miles

The calculation of the private vehicle miles necessary to replace the BRT growth passenger miles depends on the number of these riders per private vehicle. An assumption is made that multiple passengers in the car are all would-be BRT riders and that they would reflect the national tendencies for number of occupants in a vehicles. Table 5, quoted in the Shapiro report[6], reflects the distribution of vehicle trips that typically occur with the corresponding number of occupants. For example, typically 70 percent of vehicle trips involve the driver alone.

Table 5 Distribution of Occupants in Private Vehicles

Private Vehicle Occupants	Share
Driver Only	70 percent
Driver + 1 passenger	19 percent
Driver + 2 passengers	6 percent
Driver + 3 or more	5 percent
Total	**100.0 percent**

It is also assumed that the total passenger miles are the same whether the riders take BRT buses or private vehicles. This allows 33,178,340 annual passenger miles to be

[6] Conserving Energy and Preserving the Environment: The Role of Public Transportation, Robert J. Shapiro, Kevin A. Hassett and Frank S. Arnold, July 2002.

distributed as in Table 5 to approximate the number of vehicle miles traveled with the various number of occupants. The result is as shown in Table 6. The total of the equivalent total private vehicle miles then is 27,455,076 on an annual basis to replace the growth in BRT travel along the total 40 miles of BRT corridor.

Table 6 BRT and Equivalent Private Vehicle Miles

Vehicle Occupants (Number)	Public Share (Percent)	BRT Passenger (Miles)	Equivalent Private Vehicle (Miles)
Driver Only	70 percent	23,224,838	23,224,838
Driver + 1	19 percent	6,303,885	3,151,942
Driver + 2	6 percent	1,990,700	663,567
Driver + 3	5 percent	1,658,917	414,729
Totals	**100 percent**	**33,178,340**	**27,455,076**

Private Vehicle Emissions from Replacing BRT Passenger Miles

Approximating the vehicle miles to replace BRT passenger miles is only part of the task in estimating emissions from the private vehicles. The type of vehicle is important as well as the age of the vehicle. As an example, Table 7 shows the U.S. national estimate for annual vehicle miles by autos and a combination of SUVs and light trucks, as quoted in the Shapiro report[7].

Table 7 Annual Vehicle Miles Driven by Vehicle Type

Type of Private Vehicle	Annual Miles Driven
Automobiles	1,546,000,000,000
Sport Utility Vehicles and Light Trucks	866,000,000,000

Data estimates on the age distribution of vehicles and use of computer tools can result in an estimated annual number for emissions in terms of grams per mile. Table 8, shown on the next page, provides average values that can be used in conjunction with the private vehicle miles to estimate the emissions for the private vehicle trips.

[7] Conserving Energy and Preserving the Environment: The Role of Public Transportation, Robert J. Shapiro, Kevin A. Hassett and Frank S. Arnold, July 2002.

Calculation of an estimate for the annual emissions produced if private vehicles replaced BRT is accomplished by multiplying the equivalent private vehicle replacement miles from Table 6 by the weighted-average emissions for private vehicles, in grams per vehicle mile, from Table 8. The result is shown in Table 9.

Table 8 Private Vehicle Emissions in Grams per Mile		
Vehicle Type	**Vehicles Emissions (NTD) grams/mile**	
	NOx	**CO_2**
Automobiles	1.41	415.49
SUVs & Light Trucks	1.84	521.63
Weighted Average	1.56	452.92

Table 9 Emissions from Private Vehicles Replacing BRT Growth Trips		
Emissions in Grams per Vehicle Mile		
Private Vehicle Replacement Trips[8]	**NOx**	**CO_2**
	1.56	452.92
Annual Emissions (x 1,000 lbs)		
Private Vehicle Replacement Trips	**NOx**	**CO_2**
	94.3	27,389.8

Comparison of Emissions from BRT and Private Vehicle Replacement Trips

Now the emissions from the additional BRT passenger miles and the estimated emissions of the private vehicle trips necessary to replace those passenger miles are compared in Table 10. The first row marked "Private Vehicles" reflects the emissions from the private vehicle trips necessary to replace the growth in passenger miles resulting from the success of BRT implementation. The second row is the average of the BRT corridor annual emissions shown in Table 3 resulting from the different CNG engine configurations for a 40 foot bus. Two additional rows are

Table 10 Comparison of Emissions 40' CNG BRT Bus and Private Vehicle Trips		
Vehicle Type & Vehicle Comparison	**Annual Emissions (x 1,000 lbs)**	
	NOx	**CO_2**
Private Vehicles	94.3	27,389.8
BRT with CNG 40' Bus (Average)	51.5	7,131.7
Annual Savings (x 1,000 lbs)	42.8	20,258.1
% BRT Emissions Reduction	45 %	74 %

[8] Conserving Energy and Preserving the Environment: The Role of Public Transportation, Robert J. Shapiro, Kevin A. Hassett and Frank S. Arnold, July 2002.

also included. The first shows the annual difference in emissions in thousands of pounds and the last row shows that same data as a percentage difference.

Forty miles of BRT corridor operating 40' CNG buses can result in close to a 75 percent savings in GHG and a dramatic reduction in NOx. For other BRT corridor implementations with before and after data, similar calculations can be made using this appendix as an example and using data from the original references.

Since some transit properties plan to use diesel or ultra low sulfur diesel fueled buses, the following example uses the same passenger miles from the LACMTA data reports but substitutes an average of the Shapiro data for diesel bus emissions and the results of CARB emissions tests. Other data sources that reflect the appropriate fuel and propulsion system can also be selected for comparisons for selected transit BRT operations.

Table 11 Emissions for 40 ' ULSD Bus

Emissions in Grams per Vehicle Mile		
	NOx	**CO_2**
BRT with ULSD 40' Bus[9],[10] (average from sources in footnote)	21.5	2,450.
Annual Emissions (x 1,000 lbs)		
	NOx	**CO_2**
BRT with ULSD 40' Bus	73.0	8,320.1

Table 11 shows the emissions per vehicle mile and the annual emissions for ULSD fueled bus. Table 12 is a comparison again to private vehicle replacement trips. As a general note about PM emissions, although not part of these estimates, testing suggest that ULSD buses equipped OC after treatment appear to have similar PM performance to that from CNG buses. But the results vary substantially with drive cycle. NOx emissions are generally lower from CNG buses than from OC equipped ULSD buses, but can show a wider range of variability. Again, the example here is not meant as a comparison of propulsion systems but rather the benefits from BRT by attracting ridership away from private vehicle trips.

Table 12 Comparison of Emissions - 40' ULSD BRT Bus vs Private Vehicle Trips

Vehicle Type & Vehicle Comparison	Annual Emissions (x 1,000 lbs)	
	NOx	**CO_2**
Private Vehicles	94.3	27,389.8
BRT with ULSD 40' Bus	73.0	8,320.1
Annual Savings (x 1,000 lbs)	21.3	19,069.7
% BRT Emissions Reduction	23 %	70 %

[9] Conserving Energy and Preserving the Environment: The Role of Public Transportation, Robert J. Shapiro, Kevin A. Hassett and Frank S. Arnold, July 2002.
[10] "CNG and Diesel Transit Bus Emissions in Review", Alberto Ayala, Norman Kado, Robert Okamoto, Michael Gebel, and Paul Rieger, California Environmental Protection Agency, Air Resources Board, 9th Diesel Engine Emissions Reduction Conference, August 24 - 28, 2003, Newport, Rhode Island

Energy Reduction Benefits of BRT Corridors

In addition to emissions reduction, public transit also reduces our consumption of fossil fuels. The benefit of BRT, with the dramatic increases in ridership, can make a substantial contribution to fuel-use reduction.

Calculating the fuel-use comparison is similar to the emissions calculation example. A comparison is made between the additional energy necessary to provide the growth in BRT service and the energy used to transport the same growth passengers if shifted to private vehicles.

As in the emissions example, gather data on the number of **passenger miles and vehicle miles** traveled in the BRT Corridor. In the example BRT corridor, the weekday revenue miles before is 17,578 and 23,508 is the after resulting in a net weekday gain of 5,930 miles traveled. Annual BRT vehicle miles, assuming they can be approximated by revenue miles, are estimated by multiplying by five days per week and 52 weeks per year to result in 1,541,800 annual BRT vehicle miles.

Also for this example, the data from the BRT corridor shows the weekday growth in passenger miles is 127,609, the difference between 508,999 (post-rapid) and 381,390 (pre-rapid). Multiplying by 5 days per week and 52 weeks per year, the result is a growth to 33,178,340 annual passenger miles.

Next, **calculate the energy use** by the local BRT corridor by multiplying the annual vehicle miles for BRT by the Btus per-vehicle-mile for buses (41,338 Btu/vehicle mile) provided in Table 10 in the Shapiro report[11]. The product of the approximate 1,541,800 annual BRT vehicle miles by 41,338 Btus per vehicle mile results in 63,734,928,400 Btus annually for 40 miles of BRT corridor.

Now the amount of fuel necessary if private vehicles replaced the BRT is calculated by multiplying the corridor's total BRT passenger miles by 5,254.8, the Btu per-passenger-mile for "replacement" vehicles from Table 13 in the Shapiro report[12]. The fuel used, in terms of Btu, is the product of 33,178,340 BRT Passenger Miles and 5,254.8 Btu per passenger mile which results in a total of 174,345,541,032 Btu annually.

Table 13 Example of Annual Energy Savings from BRT Corridor

Parameter	Energy (Btu)
Energy needed by private vehicles	**174,345,541,032**
Energy needed by BRT buses	**63,734,928,400**
Energy Savings from BRT Ridership Growth	**110,610,612,632**

[11] Conserving Energy and Preserving the Environment: The Role of Public Transportation, Robert J. Shapiro, Kevin A. Hassett and Frank S. Arnold, July 2002.
[12] Conserving Energy and Preserving the Environment: The Role of Public Transportation, Robert J. Shapiro, Kevin A. Hassett and Frank S. Arnold, July 2002.

The estimated energy savings benefit from the use of BRT in the example corridor is calculated by subtracting the energy used by BRT (**63,734,928,400**) from the energy needed if private vehicles replaced public transit (**174,345,541,032**) as shown in Table 13.

Using 5,800,000 Btus as the energy content of one barrel (42 U.S. gallons) of crude oil, the example 40 miles of corridor annually saves approximately 19,070 barrels of crude oil. In perspective, 2,100 miles of BRT corridor nationwide, if performing similarly in terms of ridership growth, passenger and vehicles miles, could result in an annual savings of about one million barrels of crude oil. LACMTA is planning over 400 miles of Metro Rapid corridors although not all corridors may perform as well as the Wilshire/Whittier and Ventura. Other cities are implementing BRT and performance evaluations will soon be available.

Another way to characterize the impact of a growth in BRT implementations is by estimating the savings in terms of gasoline gallon equivalent (GGE). The concept of gallon equivalents using a gallon of gasoline compared to another fuel is one that allows for a comparison of energy content based on British thermal units (BTUs). Since Table 13 provides a BTU estimate for fuel savings for 40 miles of BRT corridor, the savings in terms of gallons of gasoline equivalent annually is approximately 970,000 GGE.

This means that with no new technology and with a similar ridership growth from other BRT corridors, if L.A. builds the planned network of 29 routes totally about 450 miles the annual fuel savings may by 10.7 million GGE. If 50 corridors such corridors are implemented across the nation by 2009, the annual fuel savings could be almost 50 million GGE. California alone is contemplating development of close to 100 BRT corridors by 2009 (not all necessarily 40 miles total length) in communities including Los Angeles, San Francisco, Oakland, Sacramento, San Diego and others. If 200 similar 40 mile corridors (or the equivalent in total corridor miles) are implemented nationwide by 2020, the annual fuel savings could be on the order of 200 million GGE. This could place BRT among the top fifteen options for reducing national consumption of petroleum based fuels and one of the most cost-effective and easily implemented options from a public investment and policy perspective.

Applications to Other BRT Corridors

Although many assumptions are necessary to estimate the emissions benefits and energy savings from the BRT implementations, the modified methodology from the Shapiro report[13] applied in this appendix might be useful in communicating BRT benefits in any metropolitan area. Local transit properties or planning organizations can estimate the savings and benefits of their BRT corridors by adapting the approach of the Shapiro study to their own communities. For convenience, the example adapted methodology discussed in this appendix is summarized in Table 14 on the next page.

[13] Ibid.

Table 14 BRT Emissions Reduction and Energy Savings Calculations[14]

BRT Corridor Data

1. Gather data on the growth in the number of passenger miles and BRT vehicle miles traveled in the BRT corridor(s) from before and after data.

Calculating Emissions Benefits

2. Calculate the emissions produced by the growth in ridership in the corridor by multiplying the vehicle miles from Step 1 for BRT vehicles (buses) in the corridor by the selected vehicle emissions in grams-per-vehicle-mile that represent the vehicle propulsion/fuel used for BRT service.
3. Calculate the emissions that would be produced if the growth BRT passenger trips were shifted to trips in private vehicles replaced public transit. This is done by multiplying the BRT corridor(s) passenger miles by 0.826 (the ratio of the private vehicle replacement miles to the public-transit passenger miles being replaced, from Table 19 in Shapiro[15]), and multiply by the weighted-average of emissions for private vehicles, in grams/vehicle mile, from Table 18[16].
4. Estimate the emissions benefits of the BRT service corridor by subtracting the emissions due to the growth in the BRT corridor (step 2) from the emissions that would be produced if private vehicles replaced the BRT passenger trips (step 3).

Calculating Energy Savings

5. Calculate the energy use by the BRT service implementation by multiplying the growth in vehicle miles created by the service by the Btus per-vehicle-mile for buses provided in Table 10[17].
6. Calculate the amount energy used by private vehicles to replace passenger trips by the growth in BRT ridership. This is accomplished by multiplying the growth in passenger miles in the BRT corridor by 5,254.8, the Btus per-passenger-mile for "replacement" vehicles from Table 13[18].
7. Estimate the energy savings from the BRT corridor(s) by subtracting the growth in energy used by for the BRT service (step 5) from the energy needed if private vehicles replaced the growth in BRT passenger trips (step 6).

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[14] Adapted for BRT Corridor calculations from "Conserving Energy and Preserving the Environment: The Role of Public Transportation, Robert J. Shapiro, Kevin A. Hassett and Frank S. Arnold, July 2002."
[15] Conserving Energy and Preserving the Environment: The Role of Public Transportation, Robert J. Shapiro, Kevin A. Hassett and Frank S. Arnold, July 2002.
[16] Ibid.
[17] Ibid.
[18] Ibid.

APPENDIX B: LIST OF SURVEY QUESTIONS

BRT Ridership Analysis
Survey Questions

Prepared by Matt Peak, WestStart-CALSTART
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Dear Survey Participant,

Thank you for agreeing to take part in WestStart-CALSTART's BRT Ridership Analysis. Below is the list of questions that I would like to discuss with you during our arranged interview time. Written answers are not required in order to participate in this survey. In order to make our time as productive as possible, please review these questions and collect all relevant information before our interview. If you have any questions concerning the meaning of the questions, please contact me. I will be happy to clarify them for you.

Sincerely,
Matt Peak
Project Manager
Clean Transportation and Policy Analyst
WestStart-CALSTART
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1) Which **year** was your BRT system implemented?

2) How many BRT **routes** did you operate when your BRT service was implemented?
    a. Since BRT service implementation, how many routes have you added?
    b. How many BRT routes do you currently operate?
    c. What is your plan for expanding BRT service and/or increasing the number of routes?

3) **How many transit buses** do you have in service, on both BRT and non-BRT routes, that are:
    a) How many are specifically BRT-designed vehicles:
    b) How many are specifically non-BRT-designed vehicles:

4) What was your ***overall*** transit bus **ridership level** before and after BRT service implementation?

5) For ***specific*** transit bus routes that were converted to BRT service, what were the **ridership levels** before and after conversion?
    a. What does this say about how many choice riders your BRT system attracted?

6) Which **makes and models** of BRT vehicles do you currently have in service?
    a. How are these vehicles "branded" with regard to BRT amenities (i.e. unique vehicle paint schemes, low-floor interiors, rail-like designs, alternative-fuel propulsion, etc.)
    b. Have these BRT amenities been present in your BRT service operation since service implementation?
    c. For BRT routes that replaced general transit buses with BRT specific buses, how were ridership levels affected?

7) If there is ridership growth after BRT service implementation, what do you attribute to this growth?
    a. Is there raw data that you can provide? Focus groups, anecdotal information, rider surveys? Quantified ratings of elements relating to vehicles?
    b. Was growth simply due to travel time savings, or were riders influenced by the bus interior? If so, what specific parts of the interior (seats, windows, lighting, sound level, etc.)?
    c. Were exterior elements at least partially responsible for increased ridership? (signage, paint scheme, advertising)?
    d. How far are these new choice riders riding? What are the reasons for the new trips (work, recreational activities, etc.)?
    e. What time of day did ridership growth occur?

8) Did the specific **look and amenities** of the BRT vehicle assist or impede the system's acceptability by local communities?

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