

# Inserting bus rapid transit into an existing transportation system: the Mexico City experience

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## Abstract

In 2005, Mexico City introduced MetroBus, a single BRT line along Avenida de Insurgentes, the main north-south artery through the capital. The line has been well received, attracting more than a quarter million riders every weekday. This single line has connections to suburban trains, the metro system and both the public and private bus systems. This paper reports on a survey of BRT passengers that focused on how MetroBus trips have been integrated with other transportation modes, how the cost of MetroBus compared with total trip costs, general service quality, and desired new routes. It also highlights how BRT can be used in conjunction with other mass transit options to facilitate travel in even the most congested cities, contributing to a more sustainable urban environment.

*Keywords: bus rapid transit, sustainable transportation, urban transportation.*

## 1 Introduction

Since it was first introduced in the city of Curitiba, Brazil in 1968, the concept of bus rapid transit (BRT) has attracted the attention of planners and public officials in countries around the world. As of April 2008, it is estimated that twelve Latin American, three Australian, seven US, and eight Asian cities have BRT systems with more currently under construction [1]. BRT is characterized by dedicated lanes, pre-payment of fares and frequent headways to provide service levels that are comparable to rail systems (although serving slightly fewer riders) but at



much lower capital costs [2]. The original system in Curitiba has reduced automobile trips per year by 27 million, saved about 27 million liters of fuel annually, allows residents to spend only about 10% of their income on travel (below the national average), and has contributed to the city enjoying one of the lowest rates of ambient air pollution in Brazil [3].

In 2005, Mexico City introduced MetroBus, a single BRT line along Avenida de Insurgentes, the main north-south artery through the capital. The 20-kilometer system was the result of a partnership between EMBARQ, the World Resources Institute's Center for Sustainable Transport, the Government of Mexico, and the Centro de Transporte Sustentable de Mexico (CTS-Mexico) [4]. The line has been well received, attracting more than a quarter million riders every week day. This single line has connections to suburban trains, the metro system and both the public and private bus systems. This paper reports on a survey of BRT passengers that focused on how MetroBus trips have been integrated with other transportation modes, how the cost of MetroBus compared with total trip costs, general service quality, desired new routes, and potential substitution for personal automobiles. It also highlights how BRT can be used in conjunction with other mass transit options to facilitate travel in even the most congested cities, contributing to a more sustainable urban environment.

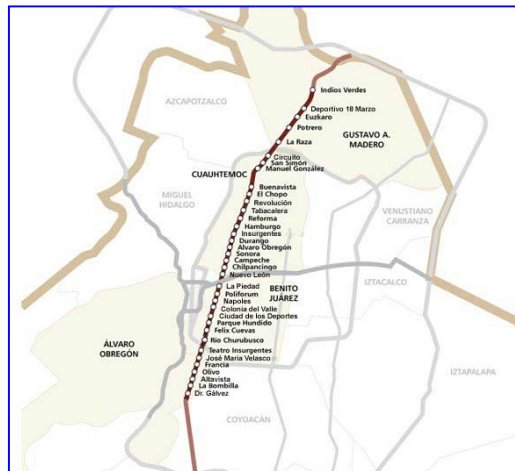


Figure 1.

## 2 Bus rapid transit

BRT use has expanded across the globe since its introduction in Brazil. The nature of implementation varies widely, however: infrastructure costs have ranged from under \$1 million per kilometre to over \$10 million [5]. Often BRT is seen as a cost-effective option to other forms of mass transit such as light rail

[6]. Total infrastructure costs (stations, lane separations, signage, fare collection system) in Mexico City have been estimated at \$31,160,000 US dollars: total costs of buses for the initial route was \$18.41 million US dollars [7].

Cost and effectiveness vary by the nature of the BRT system implemented. “Operationally, BRT applications can include buses running on exclusive rights-of-way with dedicated stations and preboarding fare payments, or buses operating in mixed traffic lanes.” [8] It appears that a particular package of elements leads to the greatest benefits in terms of ridership, time and cost savings, and traffic (and hence pollution) reduction. A complete system would include: dedicated bus lanes, pre-boarding fare collections, level bus boarding from raised platforms in stations, large capacity articulated and bi-articulated wide-door buses, overlapping system of bus services, and signal priority for buses, (all of which have been implemented in Mexico City except the last, likely due to the very heavy traffic volumes) [9]. Where BRT systems have been less than successful (Jakarta for example), it appears that poor or incomplete implementation of basic elements are to blame [10]. Many US systems began as dedicated lanes on freeways and most have been reduced to simple high occupancy vehicle lane arrangements, limiting their contribution to sustainability [11]. Integrating BRT into already developed urban centers provides the greatest ridership and hence opportunity for pollution and congestion reductions.

## 2.1 Assessments of Mexico City’s BRT

Several initial studies were done of the MetroBus, the most comprehensive a cost benefit analysis conducted in 2006, which suggested a number of long run benefits, although predictive validity may suffer somewhat because full ridership potentials had not been reached. It was estimated that over the 10 years between 2005 and 2015 the MetroBus would: significantly reduce air pollution (total hydrocarbons, oxides of nitrogen, fine particulate matter, and sulfur dioxide), and costs associated with travel time for riders at an economic value of \$1.3 million US dollars [12]. In large part due to demand and success of the initial Insurgentes system, two new corridors are currently under construction: Insurgentes Sur (a southern extension to the original line of 9 KM, 10 stations, and an expected demand of 50,000 passengers per day) and Eje 4 Sur (20 KM, 35 stations, and expected demand of 110,000 per day). Two new lines are currently in the engineering development stage: Eje 3 Oriente and Periferico Oriente; an additional two lines are planned annually for the balance of the decade.

## 3 Mexico city experience

### 3.1 Methodology

The MetroBus assessment presented here is based on a face-to-face survey of 300 riders implemented in June and July of 2006. The surveys were conducted in the nine MetroBus stations with the highest use levels including all areas of



the route and the two terminus stations: Doctor Galvez, Felix Cuevas, Polifirum, Chilpancingo, Insurgentes, Reforma, Revolucion, Buena Vista and Indios Verdes. Surveys were conducted by a team of five students in the Masters of Urban Studies program at El Colegio de Mexico as part of a research capstone practicum. All students used the same script containing both open and closed-ended questions. Surveys were conducted at a variety of times of day and on different days of the week to best capture the breadth of MetroBus ridership. Obviously the design is not a random sample, however, the use of representative stations and various times and days provides a relatively accurate picture of the population of MetroBus riders.

The questionnaire asked respondents to assess a number of aspects of the MetroBus including cost, route coverage (including desired new routes), safety, and general service quality, and included a number of questions about riding profiles, use of other transportation options (cars, subway, microbuses), and other demographic and lifestyle questions.

### 3.2 Respondent characteristics

Most riders use the MetroBus five days a week (38%) which matches normal job and school commuting patterns; however, an additional 28% ride the MetroBus more frequently (see Table 1). The large majority are employed (78%) and an additional 15% are students: most riders are using the MetroBus to get to work or school (similar to the 70% of Curitiba riders that are commuting to work) [13]. Few riders use the MetroBus for recreational purposes such as to go out with friends or to go shopping. The most common types of employment of respondents are salespersons, merchants, secretaries, and chauffeurs. The majority of riders are childless (57%) and tend to be between the ages of 21-40. Likely because of the high employment level of riders, incomes tend to be relatively high: the most common incomes were between 4,201 and 14,000 pesos per month (slightly at odds with other studies indicating that the individuals most likely to benefit from BRT systems would be those in the lowest income categories) [14]. Finally, 34% of MetroBus riders have a car at home (a rate higher than an earlier survey in 2006 indicating only 4.6% of riders leaving a car at home and higher than the 28% found in Curitiba) [15]. Overall the sample of MetroBus passengers suggests a predominantly young and working ridership base. Extensive use of the system by the researchers suggests that this is a relatively accurate profile of overall users.

### 3.3 Trip profile

On average it took respondents just over a half hour in travel time to reach the MetroBus station where they began their journey. Most respondents got to the MetroBus via microbuses (32%) and most (74%) got to their final destination by walking after leaving the MetroBus. Nineteen percent had no costs to the point of embarkation: the median cost to reach the MetroBus station was 3 pesos. The mean travel time for MetroBus users (to get to their desired destination) was 69 minutes with a total cost of 11 pesos. Both time and monetary costs are lower



than before the MetroBus was an option: average travel times were 87 minutes and average cost, 33 pesos. Sixty percent of respondents indicated that their travel times had been reduced after the institution of the MetroBus. The reduction in travel time in particular could emanate from several sources. Clearly it seems that the MetroBus is a faster means of transportation than commonly used options. It is also likely that the availability of the MetroBus has reduced traffic somewhat making all alternative forms of transportation (taxis and minibuses for example) faster.

Table 1: Profile of respondents.

Gender	Male 60% Female 40%		
Age	16-20 10% 21-30 36% 31-40 22% 41-50 16% 51-60 10% 61-80 6%	Education	None 1% Primary 4% Secondary 11% Preparatory 24% Technical/business 11% Professional 42% Post-graduate 5%
Monthly Income in Pesos	< 1,400 6% 1401-2800 7% 2801-4200 17% 4201-7000 23% 7001-14000 20% > 14001 10%	Job Status	Employed 78% Retired 3% Unemployed 3% Students 15% Housewife 2%
Number of Children	None 57% One-two 36% Three or more 7%	Purpose of MetroBus Use	Go to work 78% Go to school 15% Other 7%
Weekly Use of MetroBus	One to three days 25% Four to five days 46% Six to seven days 28%	Have a Car at Home?	Yes 34% No 66%

Based on trip data, it appears that riders generally use the MetroBus for relatively short trips. Half the respondents typically pass through eleven stations or less on their commutes: the most common total is six to ten stations (28%). The large majority of riders reside in the federal district and most commonly live in Ecatepec or Gustavo A. Medero. Destinations are most commonly in Cuauhtemoc. More specifically, the stations at which riders are most likely to



embark are Doctor Galvez and Indios Verdes (the south and north terminus of the line at the time of the survey) with the most traffic at the northern terminus. These data are similar to a previous ridership survey conducted earlier in 2006 [16]. The Indios Verdes station corresponds both to the border with the State of Mexico and with a subway station. Clearly, the MetroBus is assisting residents of the State of Mexico to get to work in the federal district. Most common stations of disembarking are Insurgentes and Poliforum. There is greater variation in where riders get off than in points of embarkation.

Because one of the main objectives of the MetroBus (particularly for international funders) was to reduce the number of cars on the road and hence automobile emissions, riders with cars at home were of particular interest (see Table 2). These respondents were asked why they were using the MetroBus rather than their cars. The most frequent response (34%) was that it took less time to commute on the MetroBus (evidence of the very high traffic volumes in the city). Other common responses were that the MetroBus was less costly (28%) and that someone else needed to use the car (12%). Obviously the latter response suggests that the MetroBus is not getting cars off the roads for these families. Only three individuals indicated that they were not driving their cars because of local legislation requiring older vehicles to remain off the roads one

Table 2: Trip profile.

Most Common Municipalities of	<b>Origin</b> Federal District 72% State of Mexico 26% Ecatepec 13% Gustavo A. Medero 13% Cuauhtemoc 11% Benito Juarez 9%	<b>Destination</b> Cuauhtemoc 47% Benito Juarez 28% Alvaro Obregon 10%
Most common station for	<b>Boarding</b> Indios Verdes 23% Doctor Galvez 13% Buenavista 9% Chilpancingo 8%	<b>Unloading</b> Insurgentes 14% Poliforum 13% Reforma 7% Doctor Galvez 7% Chilpancingo 7%
Travel to MetroBus	Average time 34 min	Average cost 3 pesos
Average Trip Time	Pre- MetroBus 87 min	Post-MetroBus 67 min
Average Trip Cost	Pre-MetroBus 33 pesos	Post-MetroBus 11 pesos
Previously used subway	Yes 71% No 28%	
Transport to MetroBus	<b>To:</b> Walk 18% Truck 12% Subway 25% Combi 8% Car 4% Microbus 32% Taxi 1%	<b>From:</b> Walk 74% Truck 1% Subway 6% Combi 1% Car 2% Microbus 14% Taxi 2%



day a week suggesting that this congestion and pollution reduction program might not be as effective as it might be.

Most respondents indicated that they had alternatives to riding the MetroBus with the most common the subway (49%), cars (13%), minibuses (10%), and taxis (6%): only 5% indicated that they had no other alternatives. Given that most riders had options including personal cars, it appears that the time and cost savings of the MetroBus is a major draw in its favour. Indeed, 71% of the MetroBus riders stopped riding the subway when the MetroBus became available.

### 3.4 Satisfaction with the MetroBus

One of the primary concerns of the survey was to measure rider satisfaction with the MetroBus. Overall, respondents are very positive about the MetroBus (see Table 3): 64% indicated that general service was good (56%) or very good (13%). An additional 23% indicated that service was average. Similarly, most riders feel that the price of the MetroBus is appropriate to the service they are getting (60%), 21% think it is over-priced and 17% feel it is under-priced. Indeed, 58% indicated that they would be unwilling or unable to pay more. However, 22% indicated that a price increase to four pesos would not be unreasonable.

Table 3: User satisfaction.

Overall Service	Overall Price
Very good 13%	Inexpensive 17%
Good 56%	Appropriate 60%
Average 23%	Expensive 21%
Poor 5%	
Very poor 2%	

Table 4: Correlates of service and price satisfaction.

	Service Satisfaction	Price Satisfaction
Frequency	.04	-.04
Gender	-.08	.01
Have car	.14*	-.09
Education	.00	-.08
Salary	-.07	-.02
Age	-.02	.21**
Children	.00	.02
Occupation	-.06	.01
Total commute time	.05	-.05
Total commute price	.02	-.07
Total time before MB	-.04	.04
Total time after MB	-.08	.09

\* significant at .05 \*\* significant at .01



None of the common demographic, economic or trip characteristic variables included in the survey explain the variation in either overall service or price satisfaction (see Table 4). Having a car and choosing to leave it at home is the only indicator significantly correlated with service satisfaction: those with cars are more satisfied. Age is the only variable significantly correlated with price satisfaction: older respondents are more comfortable with the current MetroBus price.

One concern of the research was to estimate the price elasticity of the fares. A direct assessment was not possible due to concerns from MetroBus administrators about asking such questions. Several proxy measures were developed that suggest most riders would accept a fare increase if

- the total trip cost is high and the MetroBus proportion is small;
- substitute services with lower prices than the MetroBus do not exist;
- riders believe that the current fare is a bargain; or
- the fare price is low relative to the rider's income.

On the other hand, sensitivity to price increases is most pronounced among those with shorter trips and transportation options. Based on these measures, it was estimated that a substantial majority of riders would accept a modest increase in fares without reducing their ridership.

### 3.5 Service improvements

Respondents were also asked what actions are needed to improve MetroBus service. Again, although overall satisfaction ratings were quite high, riders did have some suggestions for improvement. Because this was an open-ended question response rates are lower. The most common response (16%) was the first one below; the need for more bus units during peak times. Suggestions included:

- A greater number of busses during peak times and in the stations where the demand is very high: Poliforum, Chilpancingo, Indios Verdes, and Insurgentes.
- Improvement in ticket machines to clarify the card recharging process and ensure that they are providing correct change.
- Changing the rate structure to relate to trip distances so that shorter rides cost less, as is the case with the subway.
- Improving station signage and queuing systems.
- Improving bus ventilation
- Providing more time for boarding and embarkation during peak times.
- Providing training to MetroBus drivers to ensure that they leave appropriate space between the unit and the platform.

Preferences for additional routes correspond to the areas of the Federal District where most trips are made and where many respondents begin their commutes: the delegations of Benito Juárez and Cuauhtémoc. Additional demand could be addressed by reinforcing the current system with another parallel line.





More specifically, respondents were most likely to request new lines along Reforma (7%), Eje Central (3%), Eje Viales and the Periferico (3%). Ten percent wanted an extension in some area not included in the survey, and the majority of respondents (74%) did not have an answer (Table 5). Based on current and planned development of new lines it appears that MetroBus administrators are accurately matching rider demand for extensions.

Table 5: Preferred future routes.

Avenues	Frequency	Percentage
Ignacio Zaragoza	10	1.1
Insurgentes (extension)	11	1.2
Tlalpan	11	1.2
Revolucion	19	2.1
Periferico	26	2.9
Ejes Viales	27	3.0
Eje Central	28	3.1
Reforma	60	6.7
Other	92	10.2
No preference/response	624	74.0

#### 4 Conclusions and policy implications

The main motive of the MetroBus trip is access to work or school. In general, respondents have good perceptions of service quality (69%) and price (60%). Nevertheless they identified opportunities to improve service, primarily increasing the units in peak hours, improving card vending machines and differentiating price based on route. Overall economic factors have little impact on willingness to pay: a combination of forces is more critical (income, perception of price, travel options, and length of trip).

The ability of the MetroBus to reduce car usage was an important theme of the survey. A high percentage of users left their car at home to utilize the MetroBus (34%). However, traffic reduction effects are likely reduced because other family members tended to use the car instead. Overall, the institution of MetroBus service appears to have reduced total commuting time and cost, thus improving the quality and ease of commutes for riders. Impacts on road congestion are likely limited because of the substitution effect of available cars.

Based on this ridership survey, as well as recent cost-benefit analyses, it appears that the MetroBus has increased urban sustainability in Mexico City by decreasing travel times in a cost effective and desirable manner. It also appears that air emissions have been reduced. There are still challenges, however. The tendency for the cars of riders to still be on the roads is cause for concern. Buses are clearly congested at peak times with negative effects of crowding, particularly for women (although female-only cars have recently been instituted).

The MetroBus may in time prove to be an effective means of addressing a common problem faced by public transit providers in developing countries. The efforts to keep fares low while limiting public subsidies often results in



underinvestment and deteriorating service and equipment. As a result, those who are financially able to change from public to private transit do so; frequently switching to private automobiles. The result is an increase in both congestion and air pollution. If the MetroBus is able to retain its middle income riders by continuing to provide them with acceptable service, it may provide a way out of this dilemma.

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