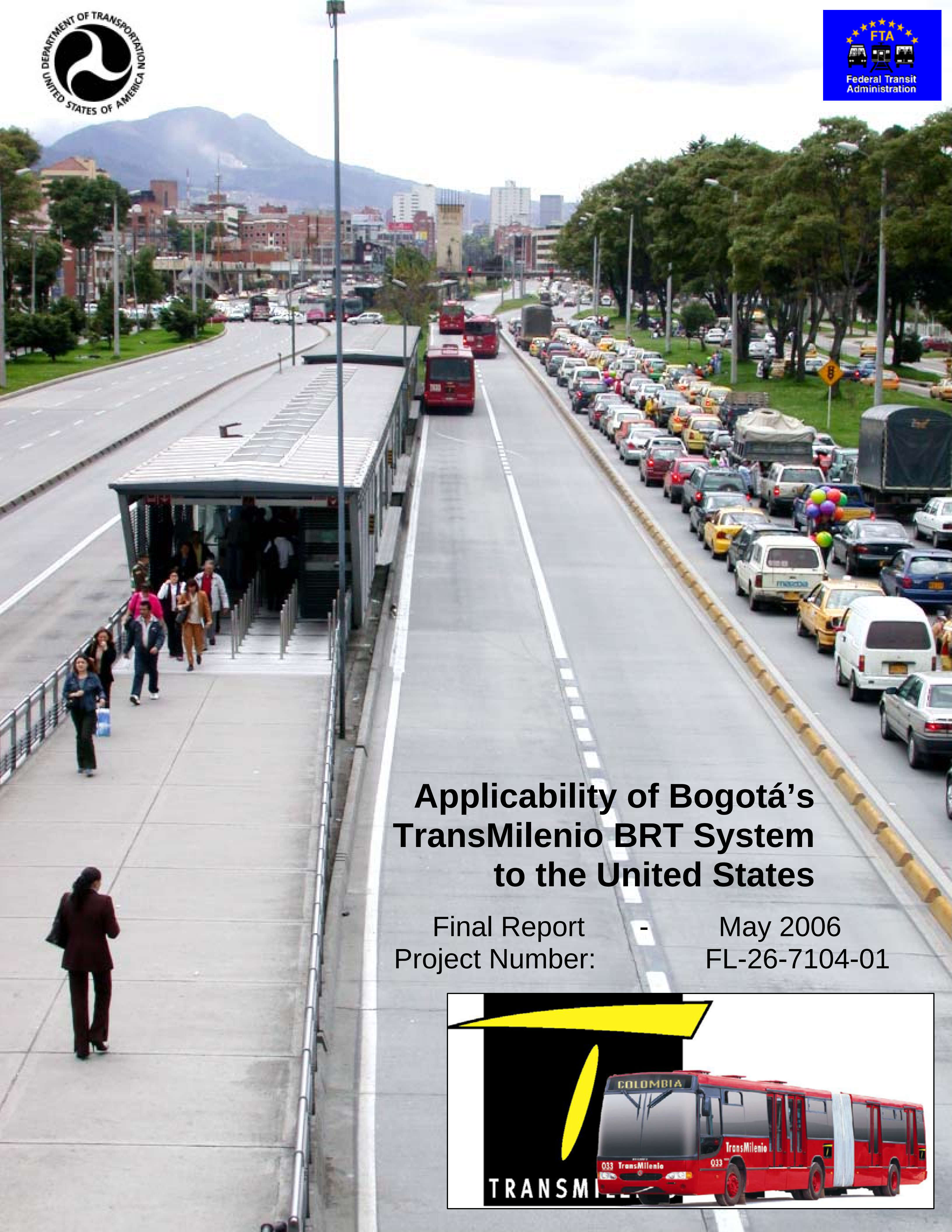

Federal Transit Administration

Applicability of Bogotá's TransMilenio BRT System to the United States

Final Report - May 2006

Project Number: FL-26-7104-01

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE May 2006	3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE
Applicability of Bogotá's TransMilenio BRT System to the United States

5. FUNDING NUMBERS
FL-26-7104

6. AUTHOR(S)
Alasdair Cain, Georges Darido, Michael R. Baltes, Pilar Rodriguez, Johan C. Barrios

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
National Bus Rapid Transit Institute (NBRTI),
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University of South Florida, CUT 100, 4202 East Fowler Avenue, Tampa, FL 33620

8. PERFORMING ORGANIZATION REPORT NUMBER
FL-26-7104-01

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Federal Transit Administration
400 7th Street, SW, Washington, DC 20590

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Available From: National Technical Information Service/NTIS, Springfield, Virginia, 22161.
Phone 703.605.6000, Fax 703.605.6900, Email [orders@ntis.fedworld.gov]
Also available through NBRTI website; http://www.nbrti.org

12b. DISTRIBUTION CODE

13. ABSTRACT
Serving the city of Bogotá, Colombia, TransMilenio is one of the world's premier Bus Rapid Transit (BRT) systems. Commencing service in December 2000, the system was carrying over one million passengers per day by early 2006 on a 40 mile network of high capacity trunk corridors, supported by feeder services that extend system coverage to peripheral areas of the city. Completion of the second phase of the project later in 2006 will add an additional ten miles of trunk corridor, and raise weekday ridership to a projected 1.4 million passengers. The city Masterplan consists of a 241 mile network of trunk corridors and supporting feeder routes that would carry an estimated 5 million passengers per day. TransMilenio is also the centerpiece of a long-term urban renewal and mobility strategy that prioritizes walking and cycling and discourages private vehicle use.

In November 2005, the National Bus Rapid Transit Institute (NBRTI) sent a delegation of U.S based BRT professionals to Bogotá to observe the operation of the TransMilenio system, attend the First International Mass Transport Conference, and meet with Colombian transportation officials. This report provides a description of the TransMilenio system and its impacts, and discusses its applicability to the U.S transit context. The report also includes a summary of potential business opportunities for the U.S Transit industry arising from Colombian government plans to invest over US$1.4 billion in TransMilenio system expansion and the implementation of similar systems in cities across the country.

Although the characteristics of Bogotá, in terms of economy, socio-political climate and urban form, are very different to those of a typical North American city, TransMilenio does demonstrate several important BRT features that are applicable to the U.S transit context. In carrying as much as 41,000 passengers per hour per direction (pphpd), TransMilenio demonstrates that BRT systems are capable of accommodating passenger volumes normally associated with rail transit. These high volumes are made possible by a wide variety of system design features, including high capacity buses, exclusive runningways, level boarding, off-board fare payment, and high service frequencies that permit headways as low as 13 seconds on busy sections of the system. Even accounting for the lower passenger loadings demanded by U.S transit users, TransMilenio demonstrates that BRT systems are capable of carrying up to approximately 28,000 pphpd in a U.S transit context, and thus should not be ruled out of alternatives analyses in favor of LRT on the grounds of insufficient capacity.

TransMilenio also demonstrates the benefits that BRT can bring in terms of capital cost effectiveness. Phase I cost a total of US$240M ($9.4M per mile) while Phase II cost $545M ($21.3M per mile). Costs are kept low partially by transferring responsibility for vehicle and fare collection costs to the private sector. The total capital cost of the 241 mile TransMilenio Masterplan, estimated at $3,320M (including vehicle and fare collection costs), is similar to the $3,041M projected capital cost of the 18 mile rail corridor proposed in Bogotá in 1997. Thus, selecting BRT offers Bogotá a city-wide rapid transit system for approximately the same cost as one rail corridor.

Other important lessons demonstrated by the TransMilenio are included in the report under the themes of "BRT and Urban Renewal", "The TransMilenio Business Model", "Politics", and "Infrastructure Characteristics". The report concludes by discussing the different issues associated with replicating the "Bogotá Model" in the U.S.

14. SUBJECT TERMS
Bus Rapid Transit, BRT, Evaluation, Colombia, Bogotá, TransMilenio

15. NUMBER OF PAGES
86

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

Applicability of Bogotá's TransMilenio BRT System to the United States

Final Report - May 2006

Funded by the Federal Transit Administration

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METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

1 inch (in)	=	2.5 centimeters (cm)
1 foot (ft)	=	30 centimeters (cm)
1 yard (yd)	=	0.9 meter (m)
1 mile (mi)	=	1.6 kilometers (km)

AREA (APPROXIMATE)

1 square inch (sq in, in^2)	=	6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2)	=	0.09 square meter (m^2)
1 square yard (sq yd, yd^2)	=	0.8 square meter (m^2)
1 square mile (sq mi, mi^2)	=	2.6 square kilometers (km^2)
1 acre = 0.4 hectare (he)	=	4,000 square meters (m^2)

MASS - WEIGHT (APPROXIMATE)

1 ounce (oz)	=	28 grams (gm)
1 pound (lb)	=	0.45 kilogram (kg)
1 short ton = 2,000 pounds (lb)	=	0.9 tonne (t)

VOLUME (APPROXIMATE)

1 teaspoon (tsp)	=	5 milliliters (ml)
1 tablespoon (tbsp)	=	15 milliliters (ml)
1 fluid ounce (fl oz)	=	30 milliliters (ml)
1 cup (c)	=	0.24 liter (l)
1 pint (pt)	=	0.47 liter (l)
1 quart (qt)	=	0.96 liter (l)
1 gallon (gal)	=	3.8 liters (l)
1 cubic foot (cu ft, ft^3)	=	0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3)	=	0.76 cubic meter (m^3)

TEMPERATURE (EXACT)

[(x-32)(5/9)] °F	=	y °C

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

1 millimeter (mm)	=	0.04 inch (in)
1 centimeter (cm)	=	0.4 inch (in)
1 meter (m)	=	3.3 feet (ft)
1 meter (m)	=	1.1 yards (yd)
1 kilometer (km)	=	0.6 mile (mi)

AREA (APPROXIMATE)

1 square centimeter (cm^2)	=	0.16 square inch (sq in, in^2)
1 square meter (m^2)	=	1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2)	=	0.4 square mile (sq mi, mi^2)
10,000 square meters (m^2)	=	1 hectare (ha) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

1 gram (gm)	=	0.036 ounce (oz)
1 kilogram (kg)	=	2.2 pounds (lb)
1 tonne (t)	=	1,000 kilograms (kg)
	=	1.1 short tons

VOLUME (APPROXIMATE)

1 milliliter (ml)	=	0.03 fluid ounce (fl oz)
1 liter (l)	=	2.1 pints (pt)
1 liter (l)	=	1.06 quarts (qt)
1 liter (l)	=	0.26 gallon (gal)
1 cubic meter (m^3)	=	36 cubic feet (cu ft, ft^3)
1 cubic meter (m^3)	=	1.3 cubic yards (cu yd, yd^3)

TEMPERATURE (EXACT)

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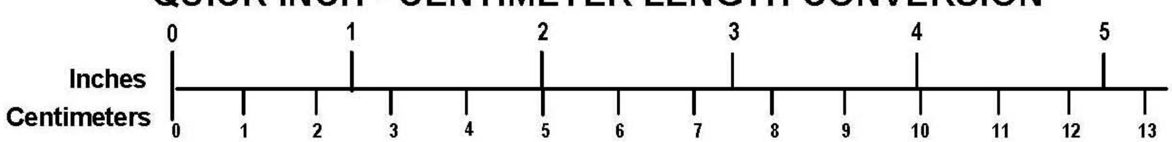
QUICK INCH - CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSION

°F	-40°	-22°	-4°	14°	32°	50°	68°	86°	104°	122°	140°	158°	176°	194°	212°
°C	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°

For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures. Price $2.50 SD Catalog No. C13 10286

Updated 6/17/98

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FOREWORD

Serving the city of Bogotá, Colombia, TransMilenio is one of the world's premier Bus Rapid Transit (BRT) systems. In November 2005, a delegation of BRT professionals from the United States was sent to Bogotá to attend the "First International Mass Transport Conference", observe the operation of the TransMilenio system, and meet with local transportation officials. This Final Report has been produced to provide an account of the trip findings, including a detailed description of the existing TransMilenio system, it impacts, and the proposals for future expansion within Bogotá and in other cities around Colombia. The report also discusses possible business opportunities related to this future expansion, and comments on the applicability of the "Bogotá Model" to the U.S transit context. The report is intended for transportation industry professionals, vendors, academics, political decision makers, and anyone with an interest in the application of international public transit experience to the U.S.

ACKNOWLEDGEMENTS

The project team wishes to thank everyone in Colombia that helped to make our visit to Bogotá both enjoyable and productive. Thanks to Vice-Minister Noero, Andres Baquero, Astrid Martínez, Raul Roa, Monica Vanegas, Angelica Castro Ortiz, Dario Hidalgo, Garrone Reck, and Arturo Ardila-Gomez, for taking the time to meet with us and share your knowledge and experience. Thanks also to Dario Hidalgo and Arturo Ardila-Gomez for reviewing initial report drafts, and special thanks to Dario Hidalgo for valuable voluntary assistance in report preparation.

EXECUTIVE SUMMARY

Introduction

Serving the city of Bogotá, Colombia, TransMilenio is one of the world's premier Bus Rapid Transit (BRT) systems. In January 2006, the system carried over one million passengers per day on a network of high capacity trunk corridors, supported by feeder services that extend system coverage to peripheral areas of the city. TransMilenio is also the centerpiece of a long-term urban renewal and mobility strategy that prioritizes walking and cycling and discourages private vehicle use. Encouraged by TransMilenio's success, the Colombian government is now embarking on a major program to construct similar systems in cities throughout Colombia. This report has been prepared to provide a detailed description of the TransMilenio system, to discuss its applicability to transit in the United States, and to summarize potential business opportunities that may exist in Colombia for the U.S transit industry.

System Planning and Operation

Construction of TransMilenio Phase I began in 1998, with initial sections opened in 2000. The full 41km (25.6 miles) were completed by early 2002, and the system was soon carrying approximately 800,000 passengers per day. Construction of Phase II, which also consists of three trunk corridors totaling 25.6 miles in length, began in 2000. Most of Phase II is now operational, and by January 2006 the system was carrying 1,050,000 passengers per day. The remainder of Phase II (sections shown in light green below) will be completed in 2006, raising ridership to a projected 1,400,000 daily passengers. Planning of Phase III is currently being carried out, which will provide more extensive system coverage within the city, and extend the service to the western suburb of Soacha. The TransMilenio masterplan consists of 388km (241 miles) of dedicated trunk corridors to be constructed over a total of eight separate phases. This is expected to take several decades, and will depend on funding availability.

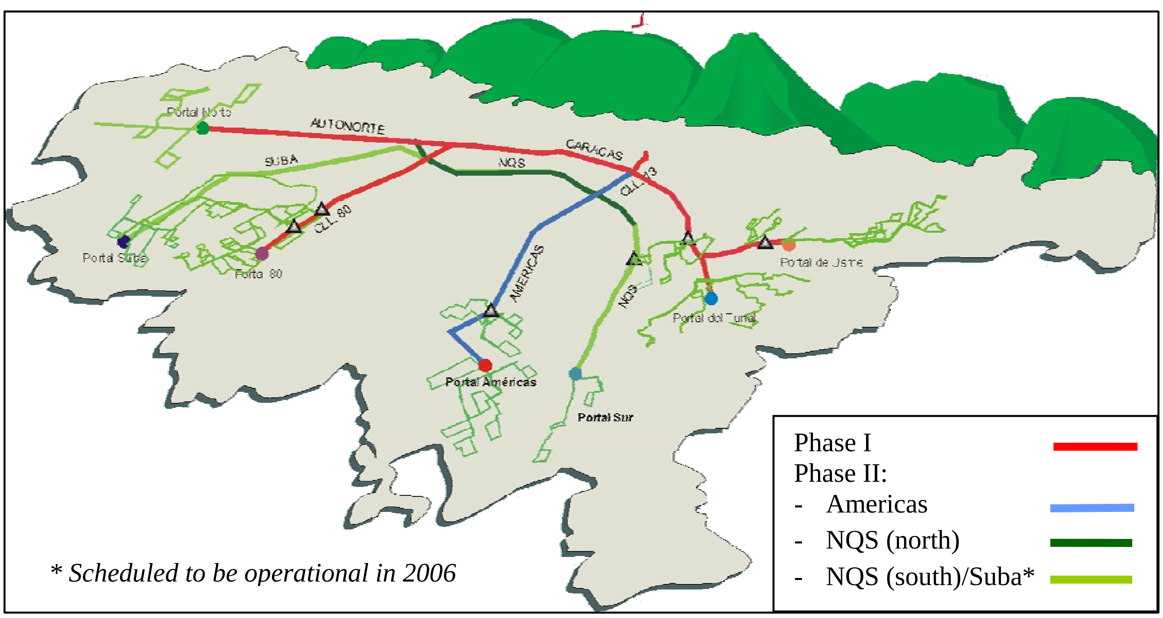

Figure EX.1 - Phases I and II of the TransMilenio System

The TransMilenio system is managed by TransMilenio S.A, a new public sector agency responsible for system planning and daily service supervision. Private contractors are responsible for fare collection and operations (including vehicle costs), through concession contract agreements. Contractors are selected through a formal tendering process and paid per service kilometer.

Phase I infrastructure costs were estimated at US$240M[1], equating to a cost per km of $5.9M ($9.4M per mile). This was financed through local fuel taxes (46%), national government grants (20%), a World Bank loan (6%) and other local funds (28%). Four different firms, formed by the traditional bus service operators, won the contracts to provide service on the trunk corridors. Phase II will cost a total of $545M, equating to a cost per km of $13.3M ($21.3M per mile). This higher cost is due primarily to increased investment in public space and associated transportation infrastructure improvements. Funding sources for Phase II were significantly different from Phase I, with funding coming from the national government (66%) and a local fuel surcharge (34%).

System Description

FIGURE EX.2 –
Typical Trunk Corridor Station

- TransMilenio's trunk services run on exclusive runningways in the median of the city's boulevards. There are currently 32km (19.9 miles) of dual carriageway and 33km (20.5 miles) of single carriageway. Single carriageway sections employ passing lanes at stations along the route.

- Stations along the trunk corridor are located approximately every 500 meters (1,640 feet) within the median, with extensive station infrastructure located at route termination and transfer points. Stations feature off-board fare payment, level boarding and automatic doors. Single stations have one to five platforms and one or two access points. They are between 25 and 190 meters (82 and 623 feet) long, depending on the number of berths, and are usually 5 meters (16 feet) wide.

- Pedestrian access is provided through overpasses, tunnels, or signalized intersections. Walkways, plazas, and sidewalks were also constructed to supply pedestrian and bicycle access.

[1] All financial information is reported in US Dollars, unless stated otherwise.

- TransMilenio uses articulated buses on trunk corridors and 40ft buses on feeder routes. The articulated buses are 19 meters long with a capacity of up to 160 passengers (48 seated). They have high floors, automatic transmission, pneumatic suspension, and anti-lock brakes. Feeder buses have a capacity of up to 80 passengers. All buses are equipped for people with physical needs, with specific seats reserved for the disabled, elderly, and pregnant. All buses run on diesel in compliance with Euro II emission standards.

- TransMilenio uses pre-paid contact-less smartcard technology. Cards are charged at nearby ticket booths and automatically debited at the turnstiles. Turnstiles are used to direct passenger flow and automatically charge the contact-less card.

- Operations are managed at a control center equipped with six workstations, each able to control 80 articulated buses. Each bus has a logic unit connected with GPS, odometer, and the door opening system. The logic unit reports the bus location every 6 seconds with 2-meter (6.6 feet) precision. Control center operators have a monitoring screen for each service in schematic display and a digital map that shows the physical location of all buses in revenue service. Optimized timing of traffic signals at intersections along trunk corridors further reduces service delays. Some more recent improvements include the placement of weight sensors in the bus suspension to prevent overload, electronic displays inside the buses for real-time service information, and an electronic taco-graph that records the daily mileage of each bus.

- Services begin running at around 4:30 a.m. to 5:00 a.m., and end at around 12:50 a.m. to 1:15 a.m., depending on the line and service. Express services stop at 40 to 60 percent of stations, while super-express services stop at less than 20 percent of stations. Both these types of "all day" service typically end at either 8:00 p.m. or 10:00 p.m. Two-minute headways are typical during peak periods for each service line, resulting in combined headways as low as 13 seconds at busy stations along the trunk corridors. Off-peak services are spaced at a maximum headway of 10 minutes.

System Performance / Impacts

Travel Time:

- TransMilenio implementation has increased average public transit travel speeds by approximately 15kph to 26.7kph (9.3mph to 16.6mph).

- This has resulted in an estimated system-wide travel time saving of 136,750 hours per day for TransMilenio Phase I, equating to a 32 percent reduction in average travel times for transit users (Yepes, 2003). This equates to an average travel time saving of around 16 minutes per trip for transit users and 13 minutes per trip for the city as a whole (Martínez, 2005).

- Travel time savings have been greatest for the city's lower-income groups that tend to be concentrated in the city periphery.

Identity and Image:

- The service is highly recognizable, with the red articulated trunk vehicles and green feeder buses all featuring the TransMilenio brand symbol. A high-profile public information campaign was conducted to coincide with system implementation.

- Over 90 percent of surveyed city residents rated the system as good or very good during the first months of operation, declining to 76 percent more recently, as the public come to accept the system as a normal part of city life.

- Travel time savings are central to public acceptance of the service – 83 percent stated that time savings were the main reason for using TransMilenio.

- An independent survey by the local major newspaper (Bogotá, *Cómo Vamos*, 2005), found that 56 percent of the respondents say that service is better than, 28 percent the same as, and 15 percent worse than the previous system. In general, the public generally perceive the system as faster and more convenient than other options.

- Public complaints center primarily on overcrowding problems during peak travel periods, safety (pickpocketing is an increasing problem), waiting times, and fare costs.

Safety and Security:

- Reduction in vehicle-vehicle traffic conflicts and pedestrian-vehicle traffic conflicts has reduced the number of collisions on the service corridors by 79 percent, which has, in turn, dramatically reduced the number of injuries and fatalities.

- The number of robberies on system corridors has also been reduced. This may relate to the significant police presence in and around TransMilenio stations.

Ridership:

- January 2006 ridership was measured at 1,050,000 passengers per day, with busy sections carrying as many as 41,000 passengers per hour per direction (pphpd). Once Phase II is fully operational, the system is expected to carry 1,400,000 passengers per day, approximately 30 percent of the city's total transit trips.

- TransMilenio, along with other actions in the transport plan, has increased transit mode share within the city from 64 percent in 1999 to 70 percent in 2005.

- The proportion of non-motorized trips has increased from around 8 percent in 1999 to around 15 percent in 2005. During the same period the proportion of vehicle trips reduced from 18 percent to 11 percent.

- Nine percent of surveyed riders stated that, before TransMilenio, they made the same trip by private car.
- Overall, these data suggest that TransMilenio has induced some additional corridor ridership and has succeeded, to some degree, in initiating a shift to non-motorized modes. However, this is also due to local car use restrictions that were imposed around the same time.

Environmental Quality:

- TransMilenio has had a positive impact on air quality in the vicinity of Caracas Avenue, with a 43 percent reduction in sulphur dioxide, an 18 percent reduction in nitrogen dioxide, and a 12 percent reduction in particulate matter.

- For the city as a whole, particulate matter has increased by 12 percent and sulphur dioxide has increased by 15 percent, while nitrogen dioxide, carbon monoxide, and ozone have been reduced. Overall, this suggests that, while TransMilenio may have induced localized reductions in air pollution, this is unlikely to have translated into citywide air quality improvements.

Business Opportunities

The success of TransMilenio has prompted the Colombian government to provide funding to extend the system within Bogotá and the surrounding area, and to build similar systems in six different cities across the country. While TransMilenio Phases I and II and Pereira's MegaBus infrastructure are either already operational or soon to be completed, a significant portion of the infrastructure in the other Colombian cities, and the planned TransMilenio expansion, remains to be constructed. A total of US$1.4M has been earmarked in either central government or local government funds for this purpose (see Appendix IV for more details). Contracts are available for both the construction of infrastructure (Works) and for Operations and Fare Collection, although explicit contract values are not known. The timing of the bids range from December 2005 to 2007, so U.S industry would have to mobilize quickly to be involved in the bidding process.

There are potential BRT-related business opportunities for U.S firms in Colombia and in other developing nations in the region (Ecuador, Peru, Panama, Dominican Republic, Nicaragua, Mexico, etc. all have BRT proposals). These business opportunities are primarily in the following areas (Hidalgo, 2005):

- Technology/ Intelligent Transportation Systems (ITS): This area offers the greatest potential for U.S transit industry involvement, capitalizing on U.S expertise in signal control, electronic fare collection, Traffic Signal Priority (TSP), passenger information systems (electronic displays, variable message signs), bus control systems (Automatic Vehicle Location [AVL], safety) and other ITS applications. Forming partnerships with local providers may be a good way to facilitate U.S industry involvement.

- Alternative fuels: The Colombian government is interested in investigating options such as Compressed Natural Gas (CNG), due to the high price of diesel that is also high in sulfur content. Large gas reserves already exist in the region. U.S. companies such as Cummins and Westport already provide such engines, which are commonly installed in Brazilian buses and used throughout Latin-America TransMilenio is currently working on an agreement with the government's Ecopetrol for fuel, and a pilot program is underway.

- Construction technology: Early deterioration of pavements and station floors show the need for better design methods (impact dynamics of high volume bus movements on paving surfaces), materials (concrete and asphalt additives) and construction methods (reduced time, better quality).

- Consulting services: Participation of U.S consultants will be useful in technology definitions. Teaming with local and regional expertise (Colombia, Brazil, Chile) may bring business to U.S-based firms.

According to Hidalgo (2005), the U.S transit industry had not been more involved in Colombia's BRT provision for the following reasons:

- Brazilian companies already have BRT expertise and products that have been utilized extensively in Colombia to date.

- Colombia cannot afford U.S consultancy fees – Brazilian companies charge much more affordable rates and provide similar services

What TransMilenio Demonstrates / U.S Applicability

Capacity

TransMilenio carries very high passenger volumes of up to 41,000 pphpd. This is made possible by a variety of system design features:

- high capacity articulated vehicles (160 passengers) with multiple doors
- high average bus occupancies (TransMilenio buses carry an average of 1,600 pax per day)
- exclusive runningways unaffected by traffic congestion, with double lanes allowing express buses to overtake local buses
- high capacity station design featuring level boarding and off-board fare payment
- centralized control of bus operations, which coordinate local and express services, reduce bunching, and improve reliability
- high service frequency (280 buses per hour per direction on busy trunk sections, resulting in a combined headway 13 seconds at busy stations)

TransMilenio's high capacity is also the result of high in-vehicle passenger loading. While the TransMilenio system was designed to carry seven standing passengers per square meter (SDG, 2000), capacity calculations in the U.S assume much lower standing passenger loads. This explains why the assumed capacities of different transit modes in the U.S context (10,000 to 12,000 for bus-based transit, 26,000 for LRT and 50,000 for HRT) (TCRP, 2003) are lower than the theoretical capacities of different transit modes presented by Vuchic (1992) (15,000 pphpd for bus-based transit, 30,000 pphpd for LRT, and 72,000 for HRT). If standard U.S passenger loadings are applied to the TransMilenio case, this would equate to a busway capacity of approximately 28,000 pphpd, similar to the assumed capacity of LRT systems in the U.S.

According to Samuel (2002), calculation of BRT system capacity in the U.S often is limited to only 10,000 to 12,000 pphpd because they do not take into account the very small headways that are possible with BRT. If these infrastructure requirements are met, it is possible to run buses at six to eight second headways (450 to 600 buses per hour per lane). This equates to a seated capacity of 27,000 to 36,000 passengers per hour. TransMilenio provides real-world proof of the validity of these calculations. The approximate tenfold headway advantage of buses over rail more than compensates for the additional capacity of a coupled rail vehicle over a single bus (Samuel, 2002).

The assumption that BRT options have limited capacity compared to LRT is often used as the justification for their being rejected early in the alternatives analysis process. TransMilenio demonstrates that BRT systems are capable of carrying the passenger volumes commonly associated with rail-based transit, even assuming U.S passenger loading standards. This demonstrates that BRT should not be ruled out of alternatives analysis in favor of LRT on the grounds of insufficient capacity.

Capital Cost Effectiveness

The history of transit planning in Bogotá provides a useful demonstration of the large disparity between BRT and heavy rail in terms of capital cost. For many years, heavy rail was the preferred transit improvement option in Bogotá, and between 1947 and 1997 there were a total of 10 attempts to implement heavy rail. The primary reason for the failure of each attempt was the high capital expenditures involved.

The heavy rail proposal would have provided 18 miles of rail-line for a total cost of $3,041M, equating to a cost of $169M per mile. In return, the heavy rail line would have carried an estimated 795,000 passengers per day, equating to 16 percent of the city’s total transit trips. In comparison, TransMilenio Phase I provided more transitway (25.6 miles versus 18.0 miles) and similar ridership levels, for a total capital cost of $340M, almost one tenth of the cost of the heavy rail option. While Phase II was approximately double the cost of Phase I (primarily due to increased investment in public space and other transportation infrastructure), it was still only around one seventh of the cost per mile of the heavy rail option.

The total capital cost of the full TransMilenio Masterplan (featuring 241 miles of exclusive busway) is estimated at $2,300M (USD) not including vehicle and fare collection costs (Hidalgo, 2002ii), and approximately $3,320M (USD) including vehicle and fare collection costs (Hidalgo, 2005). Comparing this figure to the capital cost of the 1997 heavy rail proposal ($3,041M), it can be concluded that TransMilenio offers Bogotá a city-wide rapid transit solution for similar capital expenditure as one rail corridor.

An additional analysis was conducted comparing the capital cost of the TransMilenio with different rail-based projects in the U.S. Some theoretical adjustments were made to account for the various contextual differences between the U.S and Colombia. The analysis showed that rapid transit project costs per mile are highly context specific and likely to be dependent on the unique characteristics of each transit corridor. It was found that TransMilenio capital costs per mile were similar to those associated with LRT systems in the U.S. However, considering only capital cost per mile does not capture the effectiveness of the system in carrying passengers. Using average weekday ridership per mile as a measure of system performance, it was found that TransMilenio Phases I and II outperform the U.S heavy rail systems by at least 3 times, U.S LRT by at least 12 times, and U.S BRT by at least 4 times. This result, however, is moderated by the fact that a transit trip in Bogotá is not directly comparable to a transit trip in the U.S because of significant differences in the transit mode share, costs, levels and expectations of service, ride quality, and comfort, among other factors. In essence, one transit trip in the U.S. is equivalent to many trips in Bogotá because transit does not have as many competitive advantages in terms of cost, utility, convenience, etc. Unfortunately, the demand function is not understood well enough to make such adjustments, but it can be said that the capital cost effectiveness of TransMilenio is likely to be superior to most transit investments of any mode in the U.S.

Samuel (2002) posits that the cost of bus systems should compare favorably to rail for the following reasons:

- The right-of-way or guideway requirements are much less expensive
- Buses are much less expensive than custom-designed rail cars
- Buses are more adaptable to changes in city traffic and demographic patterns, and are more able to provide "door-to-door" service

In sum, the volume of passengers in Bogotá and productivity of the vehicles, facilities, and staff is such that it makes the cost effectiveness of a TransMilenio-style system appear to be much greater than those experienced by most transit systems in the U.S. More research is required to better understand the applicability and isolate these differences.

BRT as the Centerpiece of an Urban Renewal Strategy

In 1998, Bogotá Mayor Enrique Peñalosa launched a long-term mobility strategy based on a package of measures to restrict private car use and stimulate urban renewal through public space improvements. TransMilenio became the centerpiece of this urban renewal/mobility program, facilitating the re-development of public space around the stations (including the provision of major terminal buildings), in addition to the provision of sidewalks/pedestrian avenues, pedestrian crossings and bicycle lanes. The success of this strategy demonstrates several important points:

- BRT systems can be used as the centerpiece for public sector led urban renewal programs.

- BRT projects would benefit from being implemented as part of wider package of measures that support sustainable transportation. Providing high quality access and facilities for non-motorized modes takes into account the complete transit user trip. Furthermore, experience in Bogotá shows that implementing concurrent restrictions on private automobile use enhances the likelihood of mode-shift to transit.

- BRT systems are capable of generating civic pride and making a positive impact on the social capital of a city. TransMilenio is widely recognized by its population as one the major icons of the city.

- BRT systems can be used to achieve social inclusion objectives. TransMilenio has raised the level of access between the city's centrally-located employment centers and the deprived, peripheral areas of Bogotá.

Private Sector Involvement - The TransMilenio Business Model

One of the greatest achievements of the TransMilenio system was the successful implementation of a concession contract-based system for regulating service operations. Providing operators with exclusive rights to specific service routes and paying them on a "per-kilometer" basis as opposed to a "per-passenger" basis facilitated healthy competition "for the market" as opposed to the unhealthy competition "in the market" that characterized the previous "traditional" system. This has undoubtedly enhanced operating efficiency, while reducing the fiscal risk imposed on Bogotá's city government.

If it is argued that the U.S transit industry efficiency suffers from a lack of private sector competition, the lesson to be learned is that too much competition and too little competition are both detrimental to operating efficiency, and that some form of regulated competition offers the greatest potential for efficient service provision. This suggests that more competitive private sector involvement in service operation may be beneficial to the U.S transit industry. Experience from Bogotá suggests that concession contracts can be effectively employed to achieve this, offering the potential for private companies to make a profit, while still reducing the subsidy required from the public sector (due to the efficiency gains afforded by competitive private sector involvement).

While relatively rare, such arrangements do exist in the United States. Foothill Transit in Los Angeles is a private company providing transit service in east Los Angeles under a concession contract arrangement with Los Angeles County Metropolitan Transportation Authority. Barriers to more widespread use of this approach in the U.S include the problem of low farebox recovery and cross-subsidy, the difficulty in providing socially desirable transit services in a non-self-sustaining economic context, and opposition from transit industry employee unions.

Politics

Historically, most Colombian presidents and Bogotá mayors, including Sr. Peñalosa, were pro-metro. Hidalgo (2006) cites a number of reasons for political support of heavy rail transit proposals. Table 4.2 lists these reasons and, in each case, comments on their applicability in the context of the U.S transit industry:

TABLE EX.1 – Reasons for Political Support of Rail Transit

*Hidalgo 2006**	Comments on Applicability to U.S
Rail capital costs are usually funded with federal assistance. Municipalities may prefer metros to ***maximize disbursements to the local economy****.*	Yes, there is a perception that (dollar for dollar) rail maximizes benefits to the local economy.
BRT may require ***reorganization of existing bus routes and operations****. This is politically difficult, and unpopular among local administrators. Most metros are implemented without any, or minimum, nuisance to existing private operators.*	Reorganization of existing routes is not as significant an issue in U.S because transit tends to be publicly operated and managed.
Metros are viewed as ***more modern*** *than buses.*	Yes, the stigma associated with buses is perhaps even more significant in the U.S.
The rail industry actively ***promotes*** *the implementation of Metros.*	Yes, the BRT industry in the U.S is in a relatively nascent state.
BRT is not yet ***understood*** *by decision-makers.*	Yes, but this may change as programs and institutions continue to promote BRT and other bus solutions.
Decision-makers typically do not use transit, but may find a Metro in a developed-world city ***comfortable, reliable and quiet****.*	Yes, local decision-makers of cities without rail transit may view metros as a way to make their cities "world class".

*Paraphrased from Hidalgo, D. (2006). *Comparing Transit Alternatives After Recent Developments in Latin America*. Presented at TRB 2006.

In summary, bus-based rapid transit projects in the U.S do not currently capture popular imagination to the same degree as rail-based projects and are not assumed to be capable of generating or directing urban growth. To a large degree, it appears that many people, and their political representatives, are not even aware that BRT alternatives exist – while many Americans have experienced extensive metro networks in World Cities like New York, London, and Paris, relatively few by comparison have visited Curitiba or Bogotá. While this problem may be beginning to be addressed by the emergence of high-profile BRT projects in U.S cities such as Boston, Los Angeles, and Las Vegas, it is likely that lack of political awareness will continue to be a barrier to the more widespread implementation of BRT systems. Other political issues raised by TransMilenio's implementation in Bogotá include:

– Decision-makers need to be encouraged to make public transit planning decisions based on an objective comparison of different modal alternatives.

– It is important to identify a high-profile political figurehead to champion BRT projects. Such figures need to have the political power, courage, and commitment displayed by Mayor Peñalosa to carry BRT projects through to successful implementation.

– While rail-based projects tend to require support over several consecutive administrations, BRT offers a major political advantage in its potential for implementation within one term of office.

– The support of national government is crucial to successful BRT implementation. The success of the TransMilenio system has resulted in a paradigm shift in the national government's attitude towards BRT, and the government is now backing the implementation of similar BRT systems across Colombia.

Characteristics of the BRT Service and Supporting Infrastructure

Experience in Bogotá suggests that successful BRT systems require a long-term commitment to high-quality supporting infrastructure and vehicles. Exclusive runningways, with at least one dedicated lane in each direction and passing lanes at stations, are desirable for the following reasons:

– Allows BRT systems to carry the large passenger volumes normally associated with rail-based transit.

– Guarantees that service conditions are maintained over time as traffic volumes on surrounding general purpose lanes reach capacity.

– Allows local and express trunk services to operate efficiently on the same facility. (Hidalgo and Hermann, 2004).

– Allows a competitive advantage for BRT over the automobile, in terms of travel time, in congested urban areas. This is particularly important in the U.S where BRT must be able to compete for "choice" riders.

TransMilenio also illustrates the importance of providing supporting infrastructure that is consistent to that provided for rail-based transit, such as permanent station facilities that feature off-board fare payment, level boarding, and quality pedestrian and bicycle access.

Replicating the Bogotá Model

TransMilenio provides insight into what BRT systems are capable of achieving in terms of passenger capacity, capital cost effectiveness, and urban renewal. While TransMilenio provides irrefutable evidence of what BRT can do, there is still the issue of whether these achievements can be replicated in the urban environments of developed world countries such as the United States. It is appropriate then that the report should close with a discussion of the issues associated with replication of the "Bogotá Model". This is provided in Table EX.2 on the next page, based on a similar commentary by Hidalgo in relation to Bogotá Model replication developing world countries.

TABLE EX.2 - Replicating the Bogotá Model - Issues to Consider

Issues*	Comments on Applicability to U.S.
***Defining a vision of the transport system required for the city:** Many local administrators have no clear long-term vision for their cities, and therefore continue existing plans that favor individual mobility or large-scale urban rail projects. These type of projects have long maturation time that extends beyond a given election cycle. If plans are changed in the next election, definitive solutions are often postponed for decades.*	Yes, the political cycle in the US is typically 4-5 years, which is enough time to implement BRT but perhaps not rail.
***Getting resources for project preparation**: BRT projects are complex and require technical, financial, and legal studies to guarantee successful implementation. There is usually a lack of money set aside for such studies. Some local administrations receive international cooperation or multilateral lending, but only after many months of hard work.*	In many ways, this is less of a problem in the U.S cities which in the past have preferred more expensive rail solutions over bus. As we move into a more financially constrained environment for transit federal funding, there seems to be growing support for lower cost options.
***Completing technical studies**: project design itself is not difficult, since the main engineering concepts for bus priority and operations are well known. Nevertheless, large data collection and model calibration studies are needed for successful demand forecasting, which is then used to define the fleet size, required services, and potential system income. All of this takes time, since data, such as origin-destination matrices and transit networks, are seldom readily available.*	This should be less of a problem in the U.S since many cities are required to regularly update regional travel demand models.
***Getting local transit providers to participate in the process (or at least overcoming their opposition)**: in developing countries, individual vehicle owners usually provide public transportation services. These bus owners and operators—often affiliated with trade unions or cooperatives—make their profits by reducing or eliminating vehicle maintenance and forcing drivers to work long hours without benefits. They tend to instinctively oppose, through political influence and strikes, any effort to rationalize the public transport sector out of fear that efforts to improve service will harm them financially. Winning over the traditional transport sector is perhaps the biggest challenge to the successful implementation of BRT systems in developing cities.*	This is less of an issue in US since providers and/or managers tend to be public agencies.
***Making changes in law, regulations and institutional frameworks**: this may include the creation or modification of agencies that are responsible for system oversight, bidding and contracting. This requires political bargaining within the elected bodies (city council, state legislature or national congress).*	Yes, this would include: – creation or modification of agencies that are responsible for the systems' oversight, bidding and contracting in an efficient and transparent process – appropriate distribution of rights, responsibilities and risks
***Creating adequate incentives for a sound economic scheme that remains over time**: designing appropriate distribution of rights, responsibilities and risks is always difficult as long as there are conflicting interests between maximizing profits and providing quality service. Neglecting this important issue significantly reduces the chances of a successful BRT system.*	Yes, this is probably more difficult in the U.S without profit as a motivator. Appropriate use of concession contracts may be a way to achieve this in the U.S.
***Securing financial resources for infrastructure**: despite the relative low cost of BRT as compared with rail-based alternatives, developing cities tend not to have capital readily available. Many resort to new taxes (fuel, value capture), which need approval by elected bodies, and grants from the national government. Some also seek finance from multilateral lending institutions, which takes time. Government-to-government concessionary loans would help increase BRT projects, just as they helped propagate rail-based alternatives in the past.*	Funding programs such as FTA "Small Starts" are becoming more accessible to BRT projects.
***Bidding service operations and infrastructure**: Developing proposals and evaluating and awarding contracts in a transparent way is often difficult as long as public agencies are subject of pressures from interest groups.*	The current limited size of the outsourced operations market in the U.S. may not yet be able to support healthy competition.

Source: Hidalgo, D., & Hermann, G. (2004). The Bogotá Model for Sustainable Transportation; Inspiring Developing Cities Throughout the World.

1. INTRODUCTION

1.1 Background

Bogotá's TransMilenio is one of the world's premier BRT systems, now carrying over one million passengers per day. Its success has stimulated plans to expand TransMilenio to other parts of Bogotá, and to provide similar services in several other Colombian cities, including Cali, Medellín, Pereira, Bucaramanga, Barranquilla, and Cartegena.

On September 15, 2005, a workshop titled "The TransMilenio" - A Revolutionary Mass Transit System" took place at Florida Atlantic University in Fort Lauderdale, Florida. The workshop, facilitated by TransMilenio staff, was conducted to disseminate information on the TransMilenio system to transportation professionals and students in the U.S. Following the workshop, the presenters met with Federal Transit Administration (FTA) and Federal Highway Administration (FHWA) officials in Washington D.C. to discuss the development of future transportation related public and private partnerships with Colombia. The Colombian officials invited FTA to attend the upcoming "First International Mass Transport Conference, Bogotá, Colombia", scheduled for November 8 and 9, 2005, to learn more about the TransMilenio system, develop further the relationship with TransMilenio, and initiate discussion with officials from the other Colombian cities considering BRT.

FTA assembled a delegation of BRT professionals from the U.S, led by the National Bus Rapid Transit Institute (NBRTI) at the University of South Florida, Center for Urban Transportation Research, to attend the conference and meet with leaders of the TransMilenio and transit officials from other Colombian cities. The delegation consisted of Alasdair Cain, NBRTI; Pilar Rodríguez, TranSystems; Michael Baltes, Mitretek Systems (now with FTA); and Georges Darido, Booz-Allen Hamilton (now with NBRTI).

1.2 Report Objectives

The objectives of this report are as follows:

- Summarize the planning, implementation and impacts of the TransMilenio system.
- Summarize the plans for future TransMilenio expansion, and the proposals for similar BRT systems in other Colombian cities .
- Assess future commercial potential for U.S transit industry participation in Colombia's BRT system expansion, and highlight other opportunities for relationship building.
- Assess the applicability of the TransMilenio system to the transit industry in the U.S, and document any applicable lessons learned.

1.3 Trip Activities

The U.S delegation visited Bogotá from November 6-10, 2005. Activities included a tour of the TransMilenio system, attendance at the First International Mass Transport Conference and meeting with Colombian transportation officials. Formal meetings were conducted with the following individuals during breaks in the conference schedule (see Appendix II for summarized minutes of these meetings):

- Juan Ricardo Noero Arango, Vice Minister to the Colombian Ministry of Transport, and his colleague, Andres Francisco Baquero Ruiz (Brian Winans of the U.S. Embassy was also in attendance).
- Astrid Martínez, General Manager of TransMilenio
- Raul Roa, TransMilenio Operations Manager
- Monica Vanegas, Pereira Megabus General Manager

Informal meetings were conducted with the following individuals:

- Angelica Castro Ortiz, Deputy Manager of TransMilenio
- Dario Hidalgo, Associate Director, Booz Allen Hamilton
- Garrone Reck, Technical Director, Logitrans
- Arturo Ardila-Gomez, Assistant Professor, Universidad de los Andes

Georges Darido and Alasdair Cain of the NBRTI gave a presentation titled “The Approach of the United States to BRT and Transit Infrastructure”, at the conference. The presentation stimulated questions from members of the audience and requests for further information. A more detailed description of the trip activities can be found in Appendix I.

2. BOGOTÁ AND THE TRANSMILENIO SYSTEM

2.1 Characteristics of Bogotá

Bogotá is the capital city of Colombia, located 8,500 feet above sea level on the highest plateau in the Colombian Andes. It covers an area of 669 square miles and has a very high population density of 9,629 persons per square mile[2]. Most of the urban area is flat, with some development in hilly areas in the southern and eastern parts of the city.

Bogotá has a population of around eight million people, with an average household size of 4.7. Average household income is much lower than in developed world cities. Table 2.1 shows that 44 percent of city households have an average income of US$5.9 per day or less, and 43 percent have an income of US$11.4 per day.

TABLE 2.1 – Average Household Income

Stratum (Av. Income)	% of Population
1 (US$4.2/day)	7%
2 (US$5.9/day)	37%
3 (US$11.4/day)	43%
4 (US$24.1/day)	7%
5 (US$39.2/day)	3%
6 (US$62.3/day)	2%

Source: Hidalgo & Yepes, 2005

Figure 2.2 shows how the different income strata are dispersed geographically. The poorest areas are located around the city periphery, while higher income areas are more centrally located. Most of the city's employment is in the Central Business District (CBD) and the industrial corridor extending west from the CBD. Eighty percent of the population does not have access to a car. Public transit and walking are the main two travel modes, as shown in Figure 2.1 below.

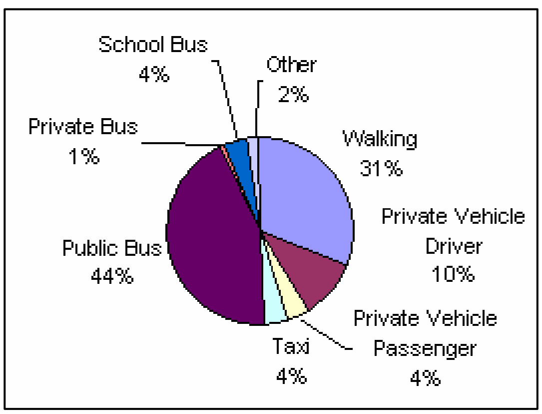

FIGURE 2.1 – Mode Share in Bogotá in 1995
Source: JICA, 1997

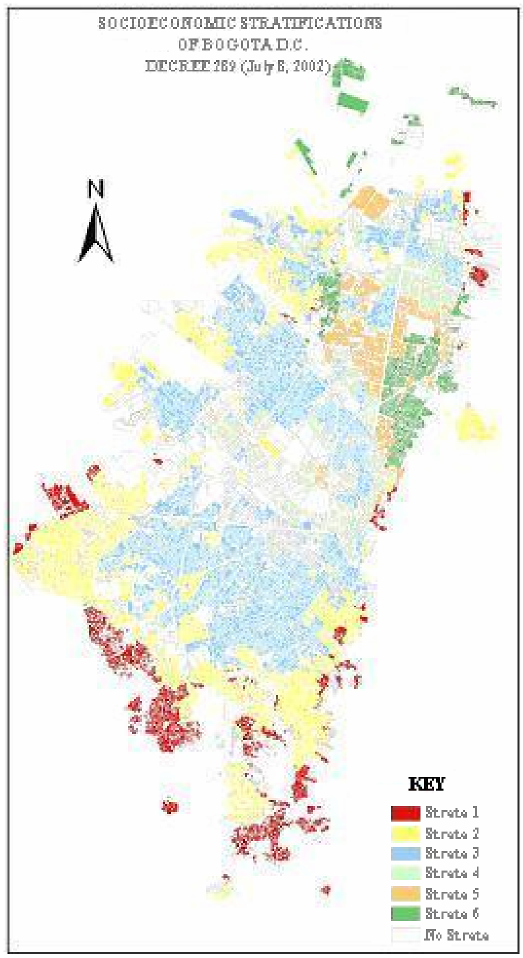

FIGURE 2.2 – Geographic Location of Bogotá's Different Income Groups
Source: Hidalgo & Yepes, 2005

[2] The urbanized area with the highest population density in the U.S. is Los Angeles, with a density of 7,068 persons per square mile. The average urbanized area population density in the U.S. is 2,169. (Census 2000).

2.2 Bogotá's Traditional Public Transportation System

Public transportation in Bogotá has historically been provided by large numbers of independent bus operators. Figure 2.3 illustrates the organizational model for this arrangement, commonly referred to as the "traditional system."

There are around 21,000 registered urban public transit vehicles and around 9,000 illegal vehicles. Urban routes are provided by 64 different private entities. Under the traditional system, these private entities make money by leasing routes to bus owners. The bus owners, and the drivers that work for them, derive their income directly from passenger fares. Routes are assigned via a subjective permitting system. Insufficient resources within the Secretariat of Traffic and Transport (STT) mean that permit regulations are not adequately enforced (Hidalgo, 2002i).

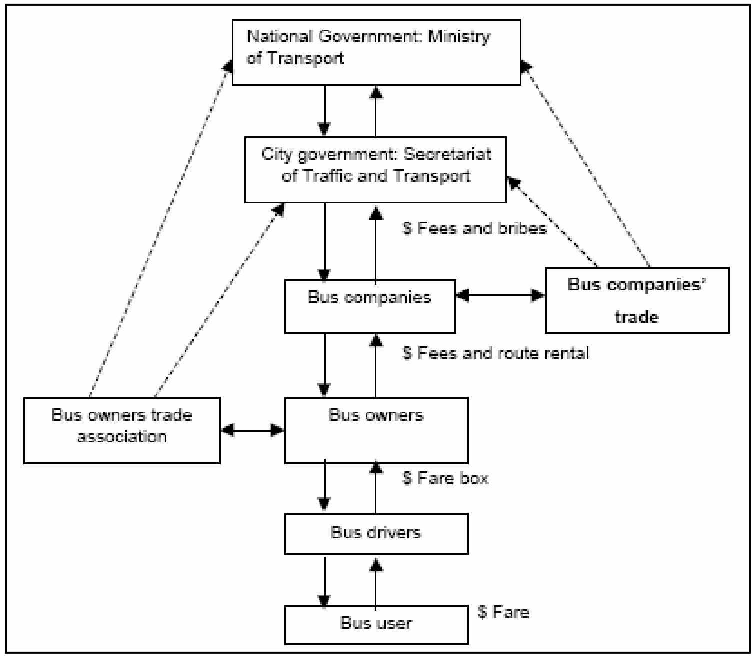

FIGURE 2.3 – Organizational Structure of Traditional Public Transit System. Source: Ardila-Gomez, 2004

Positive aspects of the traditional system are extensive route coverage and frequent service, particularly in the arterial streets in and around the CBD. Passenger volumes can be as high as 25,000 passengers per direction per hour. However, poor regulation has resulted in extremely high levels of competition for passengers, known locally as the "Penny War," resulting in low service quality, long travel times, high pollution levels, and high accident rates. Overall, the traditional system is very inefficient, with bus occupancy between 60 percent and 75 percent in peak periods, and 25 percent and 40 percent in off-peak periods. Traditional system productivity is also very low, with an average of only 2.4 passengers per kilometer (SDG, 2000).

FIGURE 2.4 – Typical Bogotá Streetscape Before TransMilenio

2.3 Mayor Peñalosa's Plan for Bogotá

For many years, the suggested solution to Bogotá's inefficient public transportation was to build a heavy rail metro system. There were a total of 10 attempts to implement heavy rail in Bogotá between 1947 and 1997 (Lleras, 2003). These attempts were continually thwarted by the high capital expenditures involved and opposition from the operators of the traditional public transportation system.

When Enrique Peñalosa was elected Mayor of Bogotá in 1997, he proposed an integrated transit system that featured both heavy rail (referred to as a Metro) and a network of busways. However, over time, it became clear that the national government did not have the necessary funds to build the metro, and the metro proposal was indefinitely postponed[3]. The administration decided to proceed with a busway-based approach, modeled on the busway networks already operational in Sao Paolo and Curitiba[4]. Mayor Peñalosa knew that even a completed metro could not offer the service coverage of a comprehensive network of buses. It was estimated that the completed metro would provide for around eight percent of the city's public transportation demand, and buses would continue to be the main mode of transportation in the city (Ardila-Gomez, 2004). He envisioned the new bus system as being the centerpiece of an overarching mobility strategy that would encourage non-motorized travel, discourage private vehicle use, and facilitate urban renewal through the redevelopment of the city's public space. Peñalosa also knew that addressing the institutional problems that had led to the Penny War was at least as important as any physical improvements associated with the new system (Ardila-Gomez, 2004).

On the physical side, Mayor Peñalosa wanted to build a larger version of Curitiba's system. Curitiba's highest demand is approximately 11,000 pphpd (Levinson et al., 2002) while TransMilenio would be designed to carry up to 45,000 pphpd. Mayor Peñalosa envisioned high-capacity buses, articulated or bi-articulated, not used until then in Bogotá. The buses would run on exclusive runningways, and passengers would pay upon entering the station (Ardila-Gomez, 2004). Traditional buses would be banned from the busway corridors. The transport plan would also provide an extensive network of sidewalks and bikeways, public space improvements, and various disincentives to car usage. These included higher fuel taxes, on-street parking restrictions, and a car use restriction known as "pico y placa" ("peak and plate") which prohibited 40 percent of the city's private vehicles from use during peak demand periods according to the last number plate digit.

On the institutional side, Mayor Peñalosa envisioned a new public sector agency that would plan the system and supervise daily service (see Figure 2.5). This agency would supervise private contractors responsible for ticketing and operations through the use of concession contracts. Contractors would be paid per service kilometer logged, not per passenger, eliminating the stimulus for the Penny War. Operators would be selected through a formal tendering process that evaluated experience, financial capabilities, and price offer.

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[3] The Rail System (First Metro Line) is still part of the Long Term City Plan (Plan de Ordenamiento Territorial). It does not have any implementation schedule or budget commitments, but the plan is that the high demand busways will be replaced by heavy rail when demand reaches system capacity (estimated at 45,000 pphpd). There is currently plenty of excess capacity in the TransMilenio system, and it is thought that the switch to Heavy Rail will not occur for several decades.

[4] Appendix III provides a summary of the planning process that lead to the decision to proceed with busways.

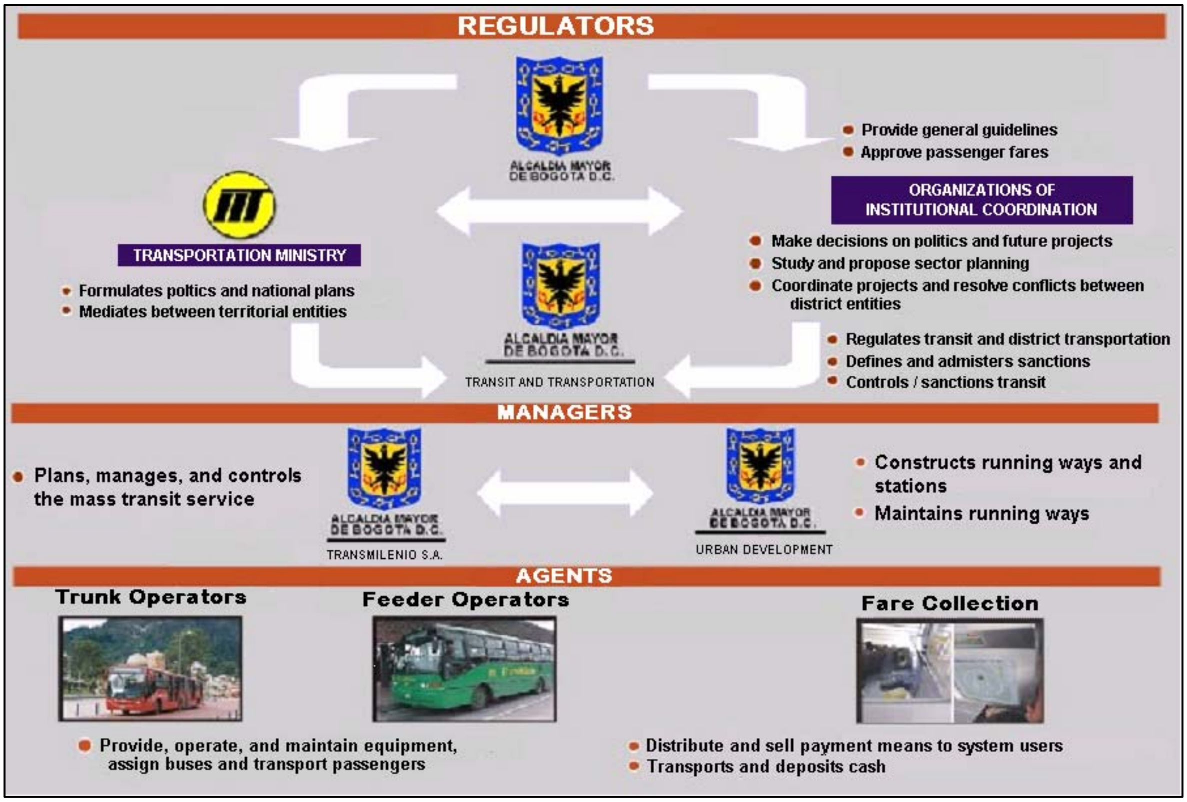


FIGURE 2.5 – TransMilenio's Organizational Structure
Source: TransMilenio S.A.

2.4 The TransMilenio – Phases I and II

2.4.1 Overview

The new transit authority, "TransMilenio S.A.," was established in October 1999 and given the responsibility of planning and managing the construction of the TransMilenio project and overseeing its operation. The project was planned, designed and constructed by both local and international companies. Initial planning studies identified six busway corridors for construction. Mayor Peñalosa wanted to construct all six busways within his three-year term of office. However, having been persuaded by his planning team that this would not be feasible, he agreed to focus on the construction of the first three trunk corridor busways on Caracas Avenue, Autopista Norte and Calle 80. Construction of the remaining three busways (on the Suba, NQS, and Americas corridors) would be left to the next mayoral administration. These two sets of three busways became Phases I and II of the TransMilenio system. The location of the Phase I and II busways are shown in Figure 2.6.

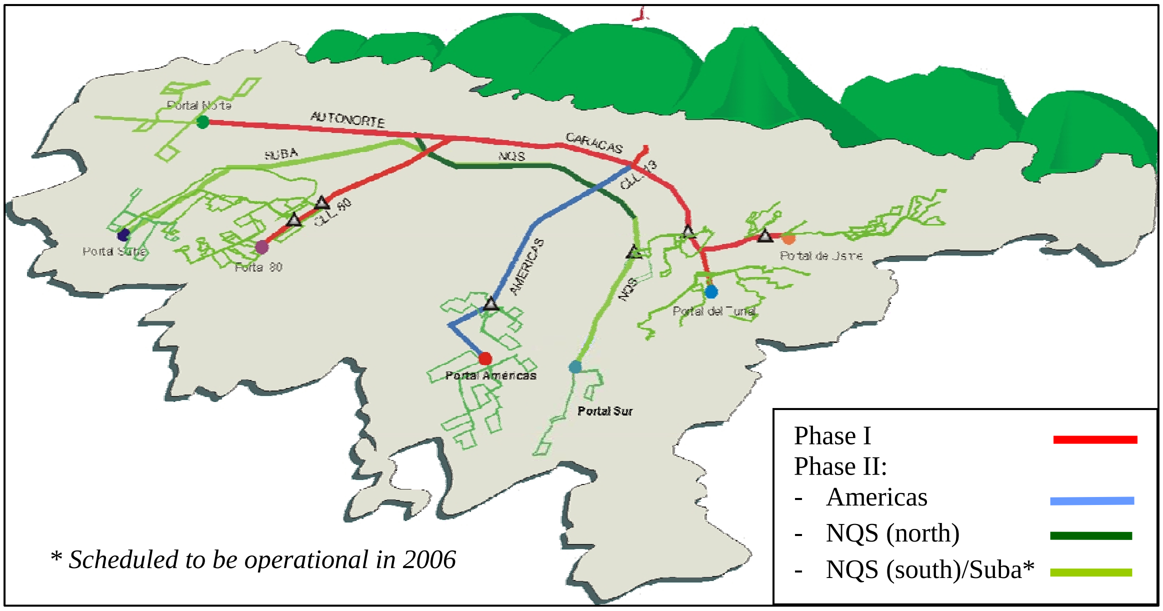


FIGURE 2.6 – Phases I and II of the TransMilenio System
Source: TransMilenio S.A.

Figure 2.6 shows the location of the completed Phase I trunk corridors along Autonorte and Calle 80, both connecting into the main Caracas Avenue corridor. The first section of Phase I opened in December 2000, less than three years after the system was conceived, and 12 days before the end of Mayor Peñalosa's term of office. Customers were initially allowed to ride the service for free; revenue service began in January 2001. The remaining sections were constructed in 2001 and 2002, and the full 41 km (25.6 miles) were operational by early 2002.

The Phase II Americas corridor was partially opened in 2003, but was not fully completed until November 2004. The northern section of the NQS corridor (shown in dark green in Figure 2.6) opened in June 2005, while the southwestern section (light green in Figure 2.6) is scheduled to open for revenue service in 2006. The Suba corridor (light green in Figure 2.6) is also currently under construction and is also scheduled to be operational in 2006. When fully operational, Phase II will provide an additional 41 km (25.6 miles) of trunk corridor, bringing the system total to 82 route km (51.2 miles). The figure also shows the location of the feeder routes that extend service coverage into the city's peripheral areas. Table 2.2 below provides additional information for each of the two phases.

TABLE 2.2 – Phase I and II Infrastructure and Costs

	Phase I	Phase II		
		Americas	NQS*	Suba*
Length (dedicated busway)	41 km (25.6 miles)	13 km (8.1 miles)	18 km (11.2 miles)	10 km (6.2 miles)
Busway lanes per direction	1 / 2	2	1	1
Feeder network coverage	7 zones (309 km / 192 miles)	7 zones (509 km / 316 miles)		
Terminal stations	4	1	1	1
Intermediate stations	4	1	1	0
Standard stations	53	16	21	13
Pedestrian overpasses	30	10	25	4
Buses	470 articulated (trunk) 235 conventional (feeder)	+335 articulated (trunk) +200 conventional (feeder)		
Expected date of commissioning	Different sections opened between 2000 and 2002	Opened 2003/2004	North: 2005 South: 2006	Expected 2006
Cost ($US)**	$240M	$117M	$286M	$142M
Funding sources	Local Fuel Surcharge (46%) Local General funds (28%) World Bank Loan (6%) National Government (20%)	Local Fuel Surcharge (34%) National Government (66%)		

* *Portions currently under construction. Expected to be fully operational in early 2006.*

** *Costs include all infrastructure. Costs do not include vehicle and fare collection costs (borne by private operators) or financing costs.*

Table 2.2 shows that the 41 km of dedicated busway constructed during Phase I are served by 470 articulated buses, supported by 235 feeder buses that provide 309 service km over seven feeder zones. The cost of the Phase I infrastructure was around $240M, financed through local fuel taxes (46%), national government grants (20%), a World Bank loan (6%) and other local funds (28%). Four different firms, formed by the traditional bus service operators, won the contracts to provide service on the trunk corridors. Cost per km for Phase I was $5.9M ($9.4M per mile).

Table 2.2 shows that Phase II will cost a total of $545M, resulting in a cost per km of $13.3M ($21.3M per mile). Reasons for the higher Phase II costs are discussed in Section 2.6.2. The table also shows that funding sources for Phase II are also significantly different from Phase I, with funding coming from the national government (66%) and the local fuel surcharge (34%).

2.4.2 Runningway

TransMilenio trunk services operate on exclusive, dedicated busways. There are essentially two types of segregated runningway, single carriageway and dual carriageway, both designed to high capacity transit vehicle specifications. The former usually has an additional passing lane provided at stations along the route. The current system consists of 33km (20.5 miles) of dual-carriageway and 32km (19.9 miles) of single carriageway, with 16km (9.9 miles) of additional single carriaway under construction on the NQS and Suba corridors. Examples of each are shown in Figure 2.7 below. Dual carriageways are typically 7 meters (23 feet) wide, while single carriageways are 3.5 meters (11.5 feet) wide with passing lanes provided at each station. Feeder buses run in regular mixed traffic lanes.

FIGURE 2.7 – Dual and Single Carriageways

Figure 2.8 illustrates a typical dual-carriageway cross-section, showing how provisions for pedestrians and bicyclists are considered in the corridor design.

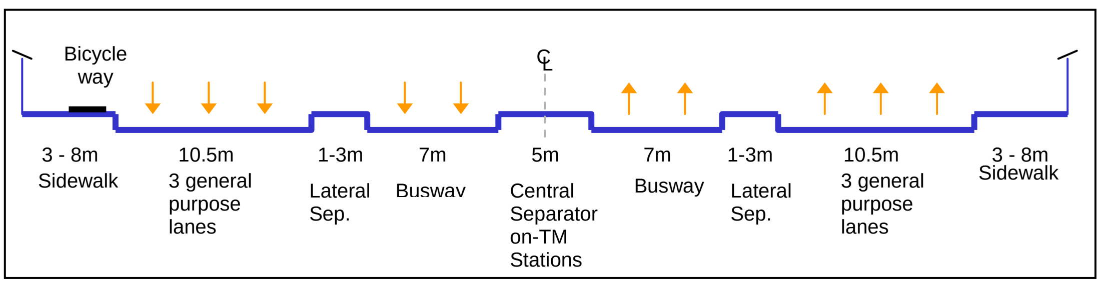


FIGURE 2.8 – TransMilenio Dual Carriageway Trunk Corridor Cross-Section
Source: TransMilenio S.A.

This type of section applies only where there is enough right of way. Avenida Caracas is more typical, with only two general purpose lanes, lateral separation provided by a 30 cm (one foot) wide barrier, and sidewalks of 3m (10 feet) or less.

2.4.3 Stations

The system contains four different station types. Portal stations are found at the end of each trunk corridor; these are the main stations for entering the trunk corridor and feeder routes. Intermediate stations are located along trunk corridors; their purpose is to allow passengers to quickly transfer between trunk routes and/or between trunk routes and feeder routes.

FIGURE 2.9 – Station Infrastructure

The third and fourth station types are very similar to one another and both are referred to as standard stations. Their main difference is in the layout of their platforms. The third type is the most common, providing access for passengers to travel from one platform to the other. The fourth station type has two totally separate platforms. One platform is for traveling in a specific direction, for example from north to south; and the second platform is for travel in the opposite direction. At these stations, it is not possible to cross from one platform to the other.

Stations along the trunk corridor are located approximately every 500 meters (1,640 feet) within the median. Pedestrian access is provided through overpasses, tunnels, or signalized intersections. Walkways, plazas, and sidewalks are also constructed to supply pedestrian and bicycle access. Stations have platforms at the same height as the floor of the buses (i.e. 90 cms / three feet) for easy boarding of all passengers including the disabled. Automatic doors in the stations are coordinated with the buses for safety and efficiency reasons. Single stations have one to five platforms and one or two access points. They are between 25 and 190 meters (82 and 623 feet) long, depending on the number of berths, and usually five meters (16 feet) wide.

During Phase I, 4 terminal stations, 4 intermediate stations and 53 standard stations were built. Phase II will add 3 terminal stations, 2 intermediate stations, and 50 standard stations.

2.4.4 Vehicles

Phase I utilizes 470 articulated buses and 235 feeder buses. Phase II, when fully operational, will use over 335 articulated buses and over 200 feeder buses. Articulated buses operate through the central trunk corridors and regular buses run through the feeder and local routes. The articulated buses are 19 meters long, with a capacity of up to 160 passengers (48 seated). They have high floors, automatic transmission, pneumatic suspension, and anti-lock brakes. Each bus has 4 large doors on the left side which are synchronized with the station doors, allowing an average dwell time of 25 seconds (Hidalgo, 2003). All buses also have a right side door with regular steps for access and egress in emergency situations or other times when the vehicle is not at platforms (i.e. garage). Feeder buses are assigned to routes in the outskirts of the urban area. Each feeder bus has a capacity of up to 80 passengers. All buses are equipped for people with physical needs, with specific seats reserved for the persons with disabilities, the elderly and pregnant women.

FIGURE 2.10 – TransMilenio's Trunk and Feeder Buses

All buses run on diesel in compliance with Euro II emission standards. However, fuel quality is poor, with sulphur content around 1,000 parts per million (ppm). Low-sulphur fuel is not available, and particulate matter emission is also a problem. These problems are exacerbated by heavy duty performance requirements, which demand that vehicles cover 350 km (217 miles) per day, fully loaded 75 percent of the time, at high altitude. A pilot program is currently underway to investigate the potential for bio-diesel or natural gas fuel options. Besides technology testing, another potential problem is the higher costs associated with switching to alternative fuels.

2.4.5 Fare Collection

TransMilenio uses pre-paid contact-less smartcard technology. Cards are charged at nearby ticket booths and automatically debited at the turnstiles. Cards can only be purchased inside the stations, which can cause queuing problems. Turnstiles are used to direct passenger flow and automatically charge the contact-less card. Fares are collected by a private concessionaire that deposits daily revenues in a trust fund, which is distributed weekly to system agents. The fare collection system includes producing and selling electronic cards, acquiring, installing, and maintaining equipment for access control, information validation, processing, and money handling.

FIGURE 2.11 – TransMilenio's Electronic Toll Collection System

At the end of Phase I, the system included 90 selling booths, 359 barriers, and 1,300,000 intelligent contact-less cards, producing revenue of about US$270,000 per day.

The full potential of the electronic fare system is currently underutilized. Multi-trip and time period discount options are not available, and the system has not been integrated with other services (parking, phone-cards, etc.).

2.4.6 Intelligent Transportation Systems

Operations are managed at a control center equipped with six workstations, each able to control 80 articulated buses. Phase II expansion requires an additional four work stations. The system permits voice and data transfer between all articulated buses and system supervisors. Each bus has a logic unit connected with a GPS unit, an odometer, and a door opening system. The logic unit reports the bus location every 6 seconds with 2 meter (6.6 feet) precision. Control center operators have a monitoring screen for each service in schematic display, and a digital map that shows the physical location of all buses in revenue service. Optimized timing of traffic signals at intersections along trunk corridors further reduces bus travel times.

During the first weeks of service, supervisors used radios to communicate with drivers and track schedule adherence. Continuous and complete operation of the control system was achieved by April 2001. The software verifies schedule compliance, giving the controllers the opportunity to make demand and supply adjustments in real time. This feature is not fully implemented, and there are problems in reporting passenger access in real time and dispatching additional buses when demand exceeds capacity. Advanced software supports control actions, including register, save, and report functions for all operational activities.

Most of these technological factors were implemented during Phase I. Phase II featured some improvement in the bus specifications. These included the placement of weight sensors in the bus suspension to prevent overload, electronic boards inside the buses for real-time service information, and an electronic taco-graph that records daily mileage for each bus. The feeder systems now feature electronic control as well.

2.4.7 Service and Operating Plans

Operating times vary by route and type of service. TransMilenio service plans are dynamic, with services liable to change over time to reflect changes in demand. The current plan (January 2006) is shown in Table 2.3.

TABLE 2.3 – TransMilenio Service Characteristics

	Weekdays (5:30a.m.-11:00a.m.)	Saturdays (5:30a.m.-11:00p.m.)	Sundays (6:00a.m.-10:00p.m.)
Local Services	5	5	5
Express Services	12 (7 all-day, 4 peak, 1 off-peak)	9 (all-day)	4 (all-day)
Super-Express Services	2 (1 all-day, 1 peak)		

Source: www.transmilenio.gov.co

Local services run all day at least from 5:30 a.m. to 11:00 p.m. Some services begin as early as 4:30 a.m. and end as late as 1:15 a.m. Express services stop at 40 to 60 percent of stations, while super-express services stop at less than 20 percent of stations. Both these types of "all day" service typically end at either 8:00 p.m. or 10:00 p.m. The combined effect of these different services is a two-minute headway during peak periods for each service line, and a maximum off-peak headway of 10 minutes, depending on demand levels. The combined headways of multiple service lines are as low as 13 seconds at busy stations along the trunk corridors.

2.5 System Performance

2.5.1 Travel Time

Severe congestion on Bogotá's major travel corridors, caused to a large extent by oversupply of individual bus operators, had limited average public transit travel speeds to 12kph (7.5mph) on Calle 80 and 18kph (11.2mph) on Caracas Avenue (Hidalgo, 2002ii). TransMilenio local services stop at all stations, resulting in an average speed of 21kph (13mph). Express services, which stop only at designated stations, have an average speed of 32kph (20mph) (Hidalgo, 2002ii). Overall, TransMilenio has increased average public transit travel speeds by approximately 15kph to 26.7kph (9.3mph to 16.6mph). This has resulted in an estimated system-wide travel time saving of 136,750 hours per day for TransMilenio Phase I, equating to a 32 percent reduction in average travel times for transit users (Yepes, 2003). To the individual transit user, this equates to a time saving of around 16 minutes per trip. Overall, it is estimated that TransMilenio has reduced average travel time in the city by 13 minutes per trip (Martínez, 2005). A further study, conducted by Yepes (2003), assessed the variation in travel time savings across different socio-economic strata. Results are provided in Figure 2.12.

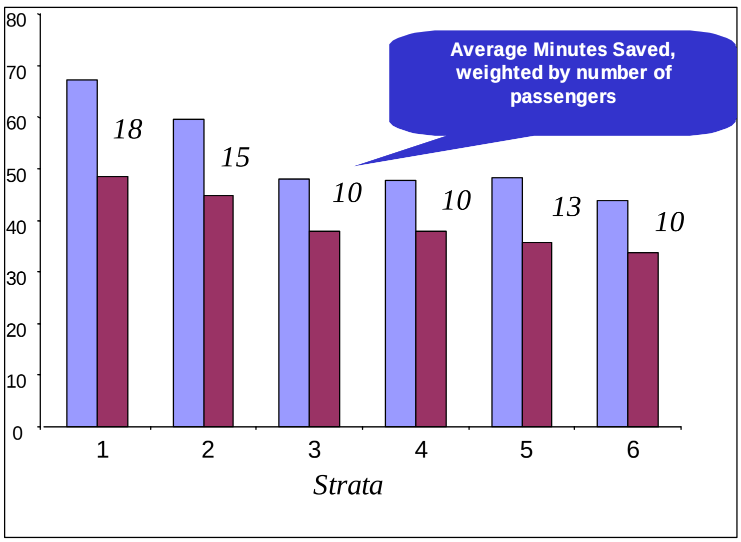


FIGURE 2.12 – Travel Time Before and After TransMilenio by Socio-Economic Stratum
Source: (Yepes, 2003)

The study found that travel time savings were greater for people in the lower income groups: 18 minutes for the lowest income stratum, compared to 10 minutes for the people in the highest income stratum. This is because the lowest income areas are congregated on the city periphery, typically enduring the longest distances to access the city's centrally located trip attractors. Travel time reductions were greatest for these longer trips. Travel time savings appear to be central to public acceptance of the service – 83 percent stated that time savings were the main reason for using TransMilenio, and 37 percent stated that they spend more time with their families as a result of the faster commute.

2.5.2 Identity and Image

The planning team understood the importance of branding the new system to establish a separate identity from the traditional bus system. The TransMilenio trademark (see Figure 2.13 below) was developed for this purpose and copyrighted.

FIGURE 2.13 – The TransMilenio Brand

Market exposure to the TransMilenio brand is primarily through vehicle branding- red articulated trunk buses and green feeder buses, all featuring the TransMilenio logo. A public education campaign was conducted in the lead up to system implementation to ensure that the public understood how to use the new system. Examples of the media used in this campaign are provided in Figure 2.14 below. The marketing campaign promoted the TransMilenio as the heart, lungs and nervous system of the city.

FIGURE 2.14 – Public Education Campaign Media

Public opinion surveys have found that the TransMilenio system has generally been very well received by Bogotá's population. Over 90 percent rated the system as good or very good during the first months of operation, declining to 76 percent more recently, as the public come to accept the system as a normal part of city life.

An independent survey by the local major newspaper (Bogotá, *Cómo Vamos*, 2005), showed that 56 percent of the respondents say that service is better than, 28 percent the same as and 15 percent worse than the previous system. The public generally perceive the system as faster and more convenient than other options. However, the public is critical of certain aspects of the service. Figure 2.15 shows the main concerns expressed by survey respondents between 2002 and 2005.

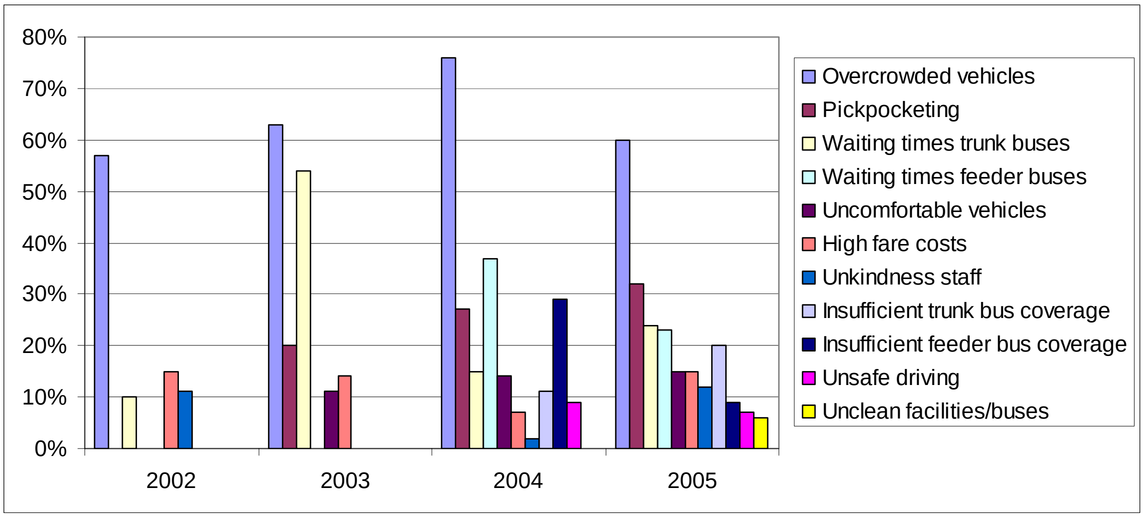


FIGURE 2.15 – User Complaints about the TransMilenio

Figure 2.15 shows that the primary complaint is vehicle overcrowding, which rose from 57 percent to 76 percent of survey respondents between 2002 and 2004, then decreased to 2002 levels in 2005. Other complaints include safety (pickpocketing is increasingly common), waiting times, and fare costs.

TRANSMILENIO S.A. has a service quality system (ISO 9000 certified), which is responsible for user surveys, performance measurements, and complaints. The system has allowed for service changes such as the elimination of exit fare validation, increase in feeder services, introduction of special express services, and improvement in passenger information (maps and variable message signs in stations and buses). In general, this institutional arrangement has proven to be capable of responding to new challenges as they arise.

2.5.3 Safety and Security

A study compared the number of accidents and robberies on the TransMilenio corridors before and after service implementation (1999 compared to 2001). Study results are summarized in Figure 2.16.

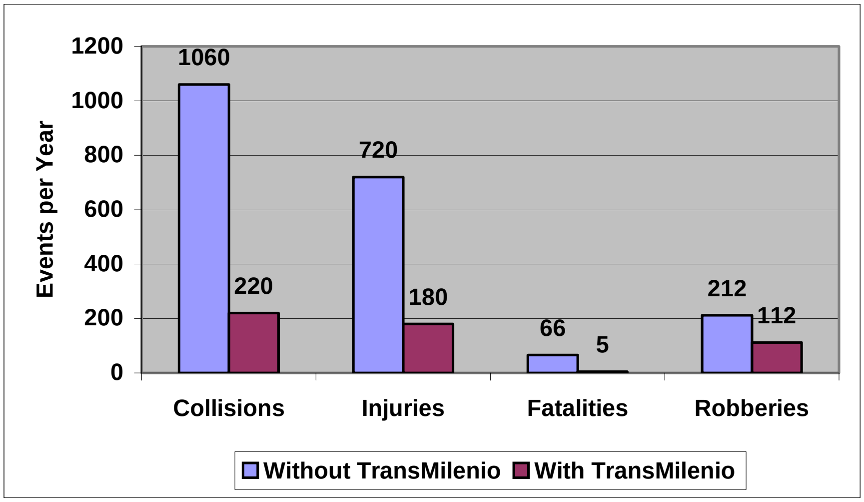


FIGURE 2.16 – Accidents and Robberies on TransMilenio Corridors Before (1999) and After (2001) TransMilenio Implementation

Source: STT and Metropolitan Police Department

The figure shows that the TransMilenio system has reduced the number of collisions on the service corridors from 1,060 to 220 (79% reduction), which has, in turn, dramatically reduced the number of injuries and fatalities. This relates to the restriction of trunk corridor busways to TransMilenio vehicles only, replacing the previously unregulated system, which featured aggressive and under-trained individual bus operators, and also to the provision of pedestrian overpasses that reduced the number of pedestrian-vehicle conflicts.

FIGURE 2.17 – Pedestrian Overpasses

Nearly half of the 62 stations are served by pedestrian overpasses (Cervero, 2005ii). In parts of the city where pedestrian overpasses are not feasible, signalized pedestrian crossings are provided. These are coordinated to minimize bus delays along the route.

TransMilenio implementation has also reduced the number of robberies on system corridors. This may relate to the significant police presence in and around TransMilenio stations. There is generally at least one state police guard at each station entrance, and four guards are normally assigned to each CBD station. Guards are also positioned on the pedestrian crossings. From 9:00 p.m. to 6:00 a.m., private security firms are employed to protect the TransMilenio stations from vandalism. TransMilenio is investigating the deployment of Closed Circuit Television (CCTV) to replace the guards.

FIGURE 2.18 – Police Presence at a TransMilenio Station

2.5.4 Capacity

Each articulated bus has a unit capacity of 160 passengers, transporting 1,596 passengers per day on average, five times more than the average for the traditional transit buses. Daily km per bus have been growing from 216 to 370 (134 to 230 daily miles per bus) as a result of the system expansion, extended hours of service, and a higher number of express services (Hidalgo, 2002ii).

Station capacity, enhanced by pre-board ticketing and multiple platforms, is estimated at 210 buses per hour per direction (Hidalgo, 2003). Combining express and local services on the dedicated busway provides a busway capacity of 280 buses per hour per direction (equating to a combined headway of 13 seconds at busy stations). These figures equate to a station capacity of 34,000 passengers per hour per direction (pphpd) and busway capacity of 45,000 pphpd. Overall system capacity tends to be constrained by the capacity of major stations at the system core. Theoretical system capacity is estimated at 48,000 to 60,000 pphpd, which could be achieved through optimized signal prioritization and grade separated intersections.

FIGURE 2.19– TransMilenio Bus Overcrowding During Rush Hour

Overcrowding can be a problem on peak period services running at or close to capacity (see Figure 2.19). In March 2004, passengers staged a protest to complain about these poor service conditions, which were exacerbated by a recent traffic accident and ongoing pavement repairs on all three busways (Ardila-Gomez, 2004). Preserving service quality at high passenger volumes is an ongoing challenge.

2.6 System Benefits

2.6.1 Ridership

Demand projections estimated TransMilenio Phase I ridership at 673,000 passengers per weekday (Ardila-Gomez, 2004). On the first day of operation (December 18, 2000), the system carried 19,000 people. Ridership steadily grew throughout 2001 and 2002, and by October 2002 the system was carrying around 770,000 passengers per day. In May 2003, weekday ridership on the Phase I system was estimated at 792,000. When the first part of the Phase II busway opened in late 2003, ridership rose to over 900,000 passengers per day. Ridership is currently 1,050,000 passengers per day (January 2006) and is expected to rise to 1.4 million passengers per day once Phase II is fully operational. Figure 2.20 tracks mode share from 1998 to 2005.

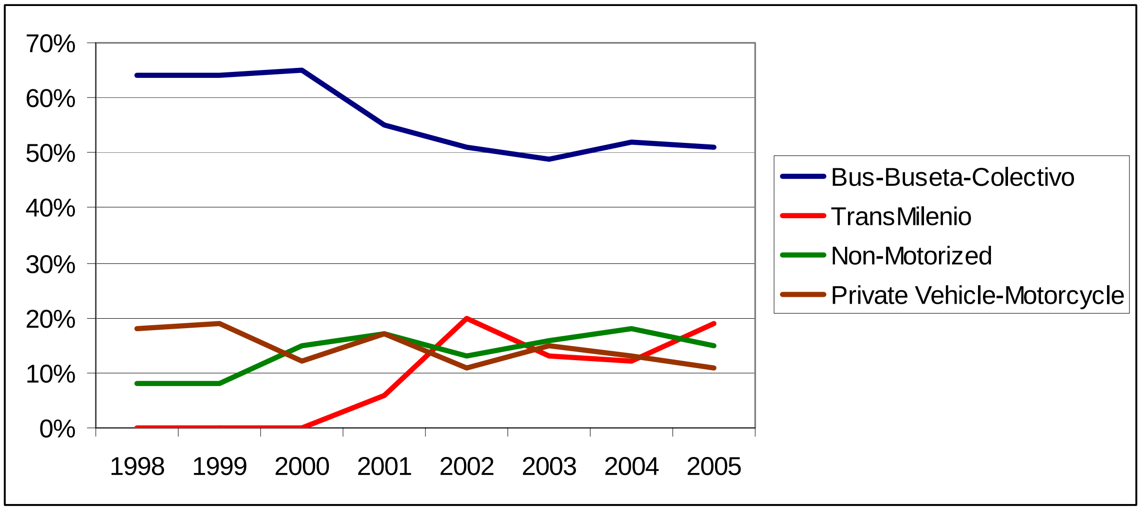


FIGURE 2.20 – Mode Split from 1998 to 2005 in Bogotá
Source: TransMilenio S.A

The figure shows that TransMilenio, along with other actions in the transport plan, has increased transit usage (the sum of "Bus-Buseta-Colectivo" and "TransMilenio") from 64 percent in 1999 to 70 percent in 2005. However, it should be noted that TransMilenio currently accounts for only around 27 percent of the city's total transit trips. The figure also shows that the proportion of non-motorized trips has increased from around 8 percent in 1999 to around 15 percent in 2005, while during the same period the proportion of vehicle trips has reduced from 18 percent to 11 percent. Overall, this suggests that TransMilenio implementation has induced some additional corridor ridership, and has succeeded to some degree in initiating a shift to non-motorized modes (*Bogotá Cómo Vamos*, www.eltiempo.gov.co).

Survey data also suggest that TransMilenio has induced some shift to public transit. Nine percent of surveyed riders stated that before TransMilenio they made the same trip by private car. However, this is also due to car use restrictions; 40 percent of cars are banned from using roads in the peak periods (7:00 to 9:00 a.m. and 5:00 to 7:00 p.m.) identified by the last number of the license plate (Hidalgo & Hermann, 2004). Another source reported that overcrowding and service interruptions caused by pavement failure problems has caused many middle-class "choice" riders to stop using TransMilenio (Cervero, 2005). Table 2.4 shows that people access TransMilenio by two main methods - either by connecting through other buses, or by walking directly to the TransMilenio stations.

TABLE 2.4 – Mode of Access to the TransMilenio System

Mode	Percent
Feeder System	26
Traditional Bus System	20
Regional Buses	5
Walking	47
Bicycle	2

Source: TransMilenio, S.A.

2.6.2 Capital Cost Effectiveness

Table 2.5 summarizes the capital costs and ridership associated with Phases I and II of the TransMilenio system.

TABLE 2.5 – Capital Costs of TransMilenio Phases I and II

	Phase I	Phase II		
		Americas	NQS*	Suba*
Length (dedicated busway)	41 km (25.6 miles)	13 km (8.1 miles)	18 km (11.2 miles)	10 km (6.2 miles)
Capital cost ($US)***	$240M	$117M	$286M	$142M
Cost ($US) per km / per mile	$5.9 M/km $9.4 M/mile	$9.0 M/km $14.4 M/mile	$15.9 M/km $25.5 M/mile	$14.2 M/km $22.9 M/mile
Passengers per day	792,000	186,000**	244,000**	234,000**
Passengers per day per capital cost ($M)	3,300	1,590	853	1,648

* *Corridors partially complete. Expected to be fully operational in early 2006.*
** *Projected ridership.*
*** *Costs include all infrastructure. Costs do not include vehicle or fare collection costs (borne by private operators) or financing costs.*

The table shows that Phase I constructed 41 km (25.6 miles) of dedicated busway for a total capital cost of $240M, equating to a cost per km of $5.9M ($9.4M per mile). This busway now carries close to 800,000 passengers per day, equating to 3,300 passengers per day per $1M spent. Conducting the same analysis on Phase II shows that costs per km range from $9.0M to $15.9M ($14.4M to $25.5M per mile), resulting in an overall Phase II average of $13.3M per km ($21.3 M per mile). Reasons for the significant difference between Phase I and Phase II costs are summarized in Table 2.6.

TABLE 2.6 – Comparing Infrastructure Characteristics of TransMilenio Phases I and II

	Phase I	Phase II
Design horizon	10 year	20 year
Type of contract	Design-build	Build-maintain
Form of payment	Unitary costs	Fixed total cost
Busway lanes per direction	1-2	1-2
General traffic lanes per direction	2-4	2-5
Pedestrian areas and bikeways	Not always included	Always included
Maintenance	Not included	5 year
Vehicle interchanges	3 (simple)	5 (complex)
Passenger interchanges	None	Two (using tunnels)
Pedestrian overpasses and public space	27	39
Land acquisition (number of properties)	300	1200

Source: TRANSMILENIO S.A., as presented in Hidalgo, 2004i.

Table 2.6 shows that the Phase II infrastructure is much more extensive, sometimes featuring an extra lane for cars, more complex intersections, more facilities for pedestrians and bicyclists, and requiring four times as much land acquisition as Phase I. Further analysis of Phase II costs show that only 37 percent of the costs are specifically for TransMilenio infrastructure (exclusive lanes, stations, terminals, pedestrian overpasses, and studies and designs). Of the remaining 63 percent, 40 percent is for general traffic lanes, non-grade intersections, sidewalks and utilities; 11 percent is for right of way acquisition; and 12 percent is for environmental and social mitigation, traffic management, detours, and maintenance. Thus, the TransMilenio portion of Phase II costs US$207M, equating to approximately $5M per km. The remaining $338M represents additional corridor and public space improvements. This also explains the lower capital cost effectiveness of Phase II, as presented in Table 2.5.

2.6.3 Operating Cost Efficiency

Current ridership (as measured in January 2006) is measured at 1,050,000 passengers per day, with up to 41,000 passengers per hour per direction on the busy sections. Daily revenue is estimated at US$572,727. Annual ridership was 315 million passengers in 2005, with total operating revenues of US$171,820,000. Of this, US$113.4M (66%) was paid to the trunk line operators, US$34.4M (20%) was paid to feeder bus operators, US$17.2M (10%) to fare collectors, and US$6.9M (4%) to TransMilenio, to cover system management and administration.

One of the major benefits of the TransMilenio Business Model is that operating costs, including vehicle costs, are covered by private sector contractors through concession contracts. The fare of approximately $0.40 allows the service to run without operational subsidies (Hidalgo, 2004ii). While commercial banks were reluctant to provide loans for TransMilenio Phase I, the unexpected profitability of Phase I has motivated the private sector to bid for the Phase II contracts.

The system's profitability can be explained by higher productivity levels. While buses on the traditional system carry less than 350 passengers per day, TransMilenio buses carry more than

1,600 passengers per day, equivalent to between 15,000 and 18,000 passengers per km, some of the highest figures in South America (Menckhoff, 2005). This high productivity is achieved through high bus frequency on dedicated busways unaffected by traffic congestion; efficient boarding/alighting due to well designed stations; vehicles with multiple doors and off-board fare payment; and the high capacity of the articulated buses (Menckhoff, 2005). Hidalgo states that two additional factors are also responsible for this high productivity: the ability for local and express services to share the same infrastructure and, centralized control, which reduces bunching and improves reliability (Hidalgo, 2005).

2.6.4 Transit-Supportive Land Development

A major objective of Mayor Peñalosa Mobility Strategy was to facilitate urban renewal and economic growth within the city. As a result, a significant amount of public space within the city was redeveloped, as summarized in Table 2.7 below.

TABLE 2.7 - Physical Advancement of the Mobility Strategy

Program	Units	1998	1999	2000
Bikeway construction	km	2.0	17.0	1.5
Public areas construction (walkways, green space, road dividers, sidewalks)	m^2	5,000	212,830	66,682
Public areas maintenance	km^2	2.8	29.0	4.3
Busway Construction	Lane-km	16.0	36.5	2.8
New roads and secondary network construction	Lane-km	56.1 3.1	76.7 30.1	5.1 2.5
Maintenance and rehabilitation	Lane-km	15.0	278.0	37.1

Source: IDU

The table shows that there was approximately 285,000 square meters (70 acres) of public area construction over a three-year period associated with TransMilenio Phase I. Much of the increased investment in Phase II is associated with further redevelopment of public space. This public sector directed urban redevelopment has already had a significant impact on the appearance of the city, as shown in Figure 2.21.

Although it is possibly too early to determine whether TransMilenio and the associated Mobility Strategy have impacted land use in and around service corridors, some research has been conducted using the Hedonic Pricing method. This method is typically used to assess the impact of environmental amenities (in this case, the improved public transportation system) on residential property values. In the first study, 490 housing lease values in the vicinity of the TransMilenio were assessed. The study found that every 100 meters (one block) from the corridor reduces the land rent value by \$0.8 to \$1.1, resulting in a price elasticity of -0.421 (Barrios, 2002). A second study found that every 100 meters (328 feet) from a TransMilenio station resulted in a 3.7 percent reduction in land rent value, and that there is a preference for commercial or institutional land use on the TransMilenio corridors (Targa, 2003).

However, this information cannot alone be used to infer that the TransMilenio has impacted land-use, but only that the corridors and station locations themselves are more desirable than the surrounding area. The second study addressed this issue by also considering the change in price, accounting for inflation, for 98 property zones within the city of Bogotá between 2001 and 2002. The study found that of the 28 zones that experienced a real increase in price, 15 were located within 1km (0.6 miles) of the TransMilenio trunk corridors (Targa, 2003). Their location is shown in Figure 2.22.

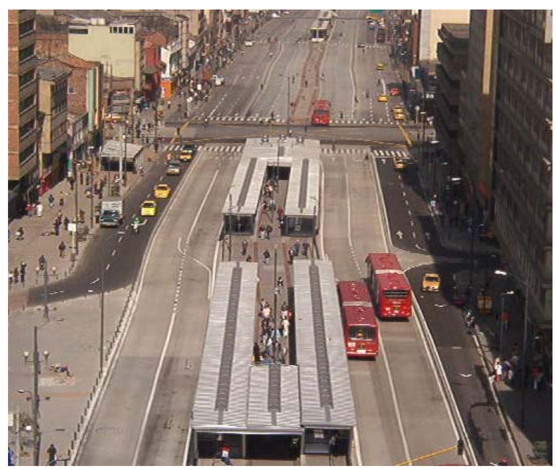
Before TransMilenio	**After TransMilenio**
	
	
	

FIGURE 2.21 – TransMilenio and Urban Renewal in Bogotá

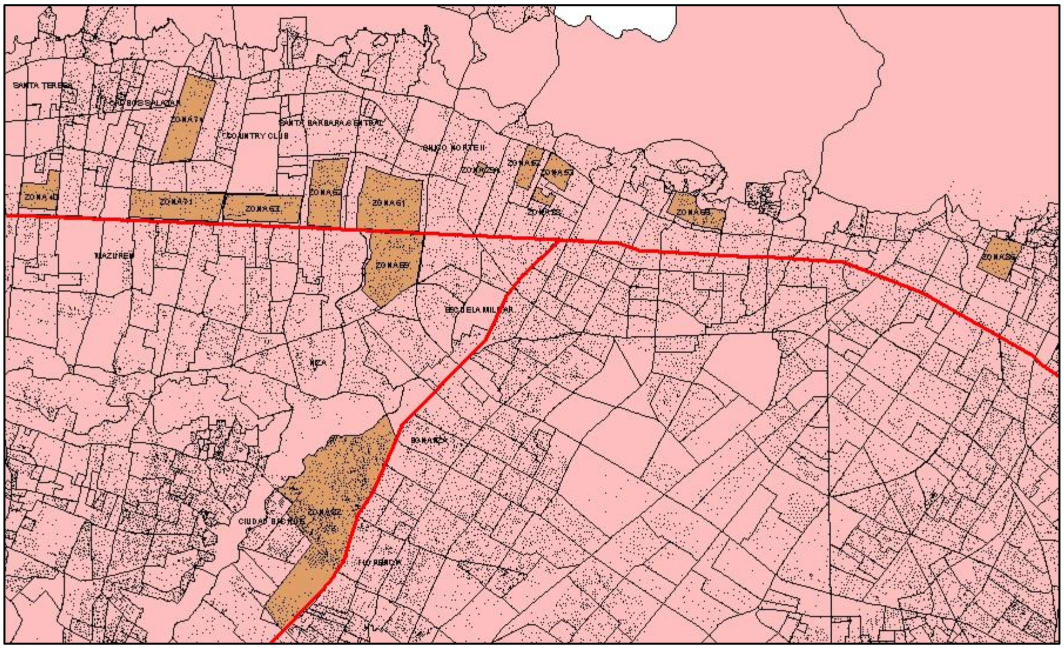


FIGURE 2.22 – Zones with Real Price Increase (2001 – 2002) within 1 km (0.6 miles) of TransMilenio Trunk Corridors

In summary, TransMilenio has shown that it is possible to base public sector directed urban renewal projects around BRT infrastructure. However, it remains to be seen whether this investment will stimulate private sector based changes in land-use.

2.6.5 Environmental Quality

Figure 2.23 below compares air quality measured in 2000 and 2001 at a monitoring station next to the main TransMilenio corridor on Caracas Avenue (on the left), and average air quality in Bogotá as a whole from 1998 to 2002.

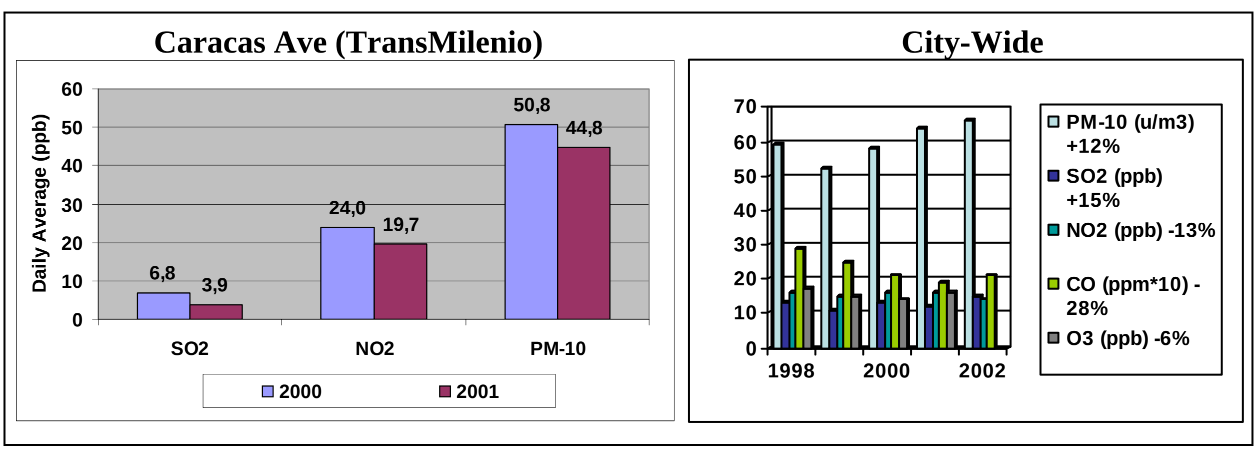


FIGURE 2.23 - Impact of TransMilenio on Air Quality – Locally and City-Wide

Source: DAMA, Air Quality Monitoring Sistema, Station MMA Carrera 13 con Calle 39

Figure 2.23 suggests that TransMilenio has had a positive impact on air quality in the Caracas Ave vicinity, with a 43 percent reduction in Sulphur Dioxide, an 18 percent reduction in nitrogen dioxide, and a 12 percent reduction in particulate matter. However, for the city as a whole, particulate matter has increased by 12 percent and sulphur dioxide has increased by 15 percent, while the other three pollutants have been reduced. Overall, this suggests that, while the TransMilenio may have had a localized positive impact on air pollution, it is not clear whether its impact has extended citywide.

2.7 Future Expansion of the TransMilenio System

2.7.1 The TransMilenio Masterplan

In 1998, when the TransMilenio project began, the city envisioned a 388 km (241 mile) busway network by the year 2016, which would cover 85 percent of the city's daily transit trip demands. This system would carry more than an estimated 5 million trips per day, covering all the major city roads (see Figure 2.24).

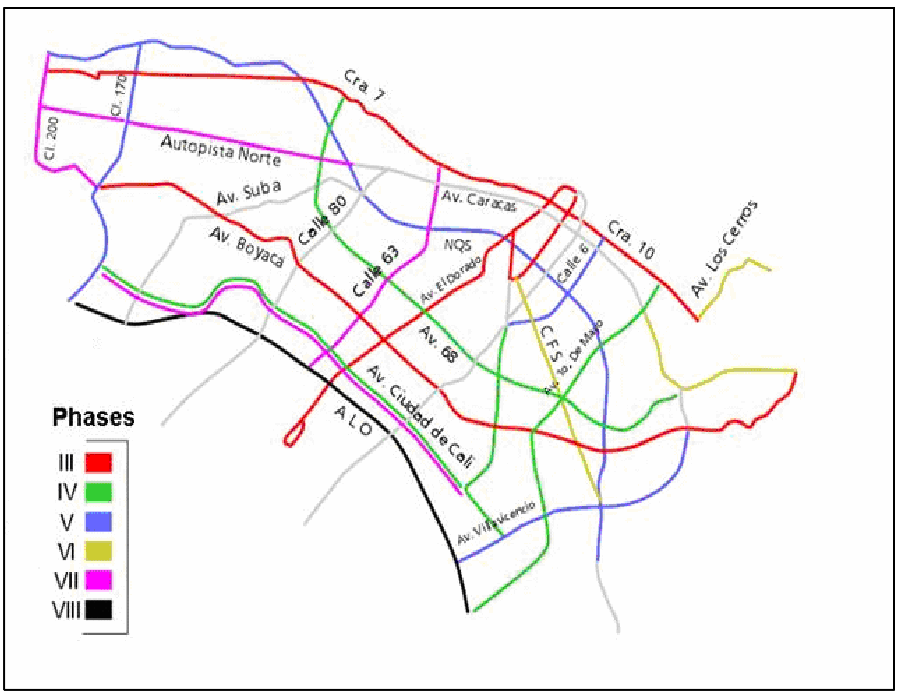


FIGURE 2.24 – The TransMilenio Masterplan

Currently, the extent of the plan itself has not been modified, but the optimistic original completion dates for each phase have been moved back. At this point, funding for the first stage of Phase III design has been secured and its implementation is underway. Phase III Stage 2 and the remaining phases will follow as funding becomes available. It is expected that by 2016 the original Masterplan will not be completely finished. Table 2.8 provides summary details of each Masterplan phase.

TABLE 2.8 – Characteristics of Planned Future TransMilenio Expansion

Phase	Trunk Corridor	Length (km)	Length (miles)
III	Stage 1 - Calle 26 / Av Eldorado	8.8	5.5
	Stage 1 - Carreras 10 y 7	12.2	7.6
	Stage 2 – Carrera 7 extension	6.6	4.1
	Stage 2 - Av Boyaca	19.5	12.1
	TOTAL	47.1	29.3
IV	Avenida 68	10.6	6.6
	Av. 1 de Mayo	12.3	7.6
	Av. Ciudad de Cali	16.8	10.4
	Calle 13	7.1	4.4
	TOTAL	46.8	29.1
V	NQS 2 (Cl.92 - Cl.170)	16.5	10.3
	Av V/cencio	10.3	6.4
	Calle 170	13.9	8.6
	Calle 6	4.9	3.0
	TOTAL	45.6	28.3
VI	CFS	12	7.5
	Av. de los Cerros	7.9	4.9
	Caracas 2	21	13.0
	TOTAL	40.9	25.4
VII	Calle 63	8.7	5.4
	Calle 200	6.8	4.2
	Av. Ciudad de Cali	14.1	8.8
	Autopista Norte 2	10	6.2
	TOTAL	39.6	24.6
VIII	ALO	48	29.8
	Remaining Connectors	38.3	23.8
	TOTAL	86.3	53.6

2.7.2 TransMilenio - Phase III

Despite the success of TransMilenio Phases I and II, the proposed Phase III expansion still faces the problems of limited resources to fund infrastructure development and opposition from current transport providers. However, local grants, national grants, and local funds have been allocated until the year 2016 to fund the first stage (i.e. Carreras 10 and 7 and Calle 26) of the Phase III expansion. This will involve the consolidation of some existing trunk corridors and the construction of 21km (13 miles) of dedicated busway. Additional daily passenger demand for the Phase III expansion is estimated at 290,000 passengers per day. This, combined with the estimated 1,400,000 passengers per day from Phase I and II, yields an estimated total ridership of 1,690,000 passengers per day once Phases I, II and III are complete.

TABLE 2.9 – Characteristics of Phase III – Stage 1 Corridors

Trunk Corridor	Individual Cost (US$M)	End of Construction	Begin Operating
Carrera 10ª	13.4	December 2007	December 2007
Calle 26 de Av. Ciudad de Cali a Cra. 3ª	13.4	December 2007	December 2007
Cra. 7ª hasta Calle 72	17	July 2008	August 2008

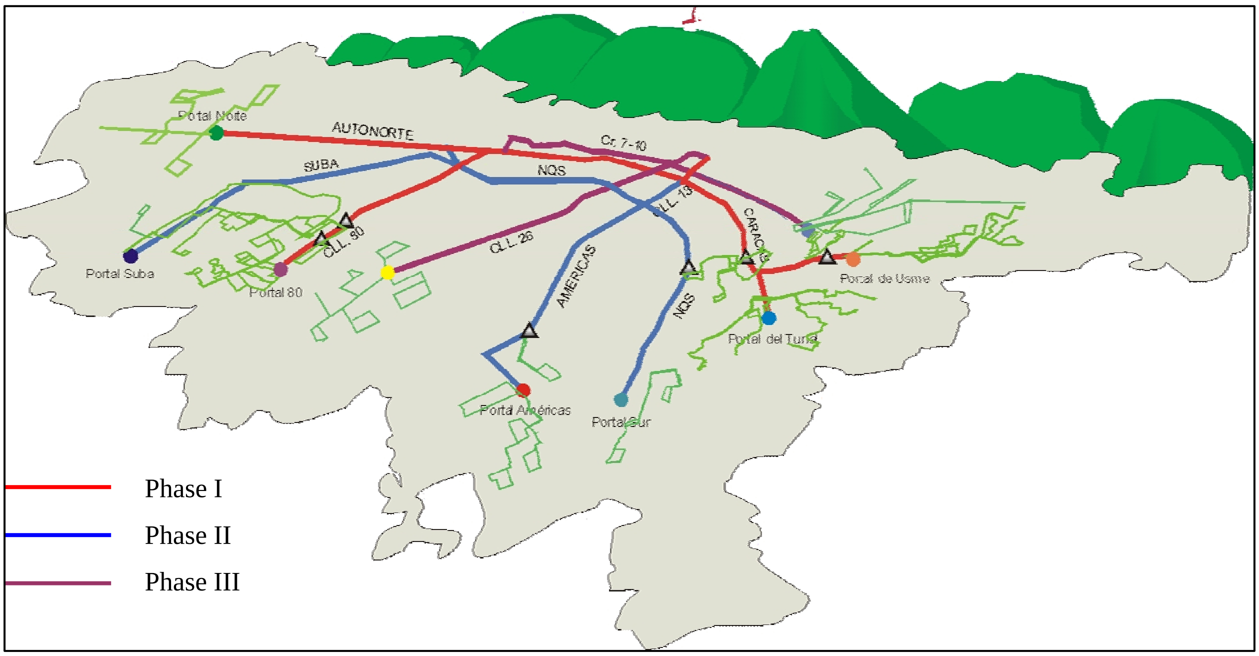


FIGURE 2.25 – Phase III Trunk Corridor Expansion and Feeder Areas
Source: TransMilenio S.A.

Currently, Carreras 10 and 7 (North to South) and Carrera 26-Av Eldorado (east to west) are under design as a part of Phase III, Stage 1. Carrera 7 features expensive and historical real estate that limits the space available for the proposed busway. One option is to use tunnels, but this may increase costs significantly. Developing a design that meets system requirements without dramatically increasing costs is a significant challenge. The designs should be completed by the end of 2006. Construction is scheduled for completion by 2008.

The second stage of Phase III, 19.5 busway km along Av Boyaca and the 6.6km extension of Carrera 7, does not have secure funding. Av Boyaca is an extensive north-south corridor which will go from Calle 170 (currently Portal del Norte) all the way to Portal Tunal through an already existing road. The road is wide enough to accommodate four lanes in each direction, two for buses and the other two for general traffic.

2.7.3 Soacha Extension

The Soacha extension is regarded as a separate project from TransMilenio, due to the fact that the corridor extends beyond the limits of the Capital District and requires several cross-jurisdictional agreements. The project has been approved by the National Government, the State Government of Cundinamarca (provincial government), and the Municipality of Soacha. Operation of the route will be managed by TransMilenio as an extension of the NQS corridor. It is likely that there will be a separate contract for the operations of the feeder area.

Soacha is a community with a very low average income that generates nearly 200,000 trips per day. Studies estimate that, once operational, 50 to 75 percent of this demand will be carried by the TransMilenio system. Its infrastructure is currently being designed. Development will most likely occur in parallel with Phase III (Stage 1) construction within Bogotá. It is planned for preparation during the next year, with construction in 2007-2008 and commissioning in 2008.

It was determined that the total cost will reach US$82.6M. The central government will contribute 70 percent (US$57.8M), and the local government will contribute the other 30 percent (US$24.8M). The length of the trunk corridors will be 5.9 km (3.7 miles). The system will cover 64 percent of the public transport trips from Soacha. Figure 2.26 shows the alignment and stations location of this Soacha extension.

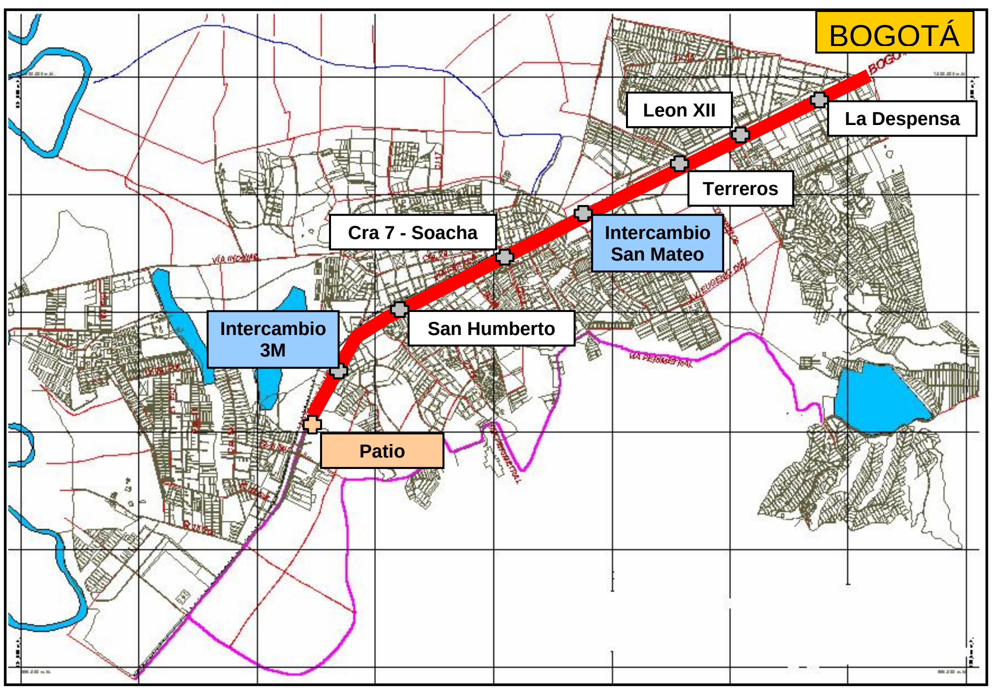


FIGURE 2.26 – Soacha Extension
Source: Colombian Ministry of Transport

The trunk corridor services will be operated by TransMilenio's Phase II operators. As for the construction work, the corridor was given to concession in 2004 with a specific set of works to be done. The concessionaire will undertake the construction project either as an extension of the existing contract or as a separate bid.

3. BUILDING RELATIONSHIPS

One of the primary objectives of the U.S delegation's trip to Bogotá was to continue to develop a relationship between the Colombian and U.S public transit industries. It is hoped that this relationship will be mutually beneficial for both countries, facilitating the two-way transfer of knowledge and experience, technical expertise, and commercial opportunities.

3.1 Business Opportunities

The main source of information on business opportunities in Colombia came from the meeting conducted with Juan Ricardo Noero Arango, Vice-Minster of Transport for the Colombian government, and his colleague Andres Baquero. The success of TransMilenio Phase I has prompted the Colombian government to commit to further significant investment in BRT infrastructure in several different cities across the country. The Vice-Minister discussed the various BRT initiatives currently under design and/or construction in Colombia. These are summarized in Table 3.1 (see Appendix IV for more detailed information on the BRT projects in each Colombian city.)

TABLE 3.1 – Current and Future Colombian BRT Initiatives

System Name and Location	Phase	Trunk Corridor Length (Km)	Estimated System Coverage (mode share)	Cost (2002 / 2003 USD)		Project Status		System Opening Date	Bid Details	
				Central Govt.	Local Govt.	Built (km)	Under Construction (km)		Works	Operation and Fare collection
TransMilenio (Bogotá)	Ph I	41	16%	$240M		41	-	2002	-	-
	Ph II	41	14%	$545M		23	19	2005/6	-	-
	Ph III (a)	21	?	$43.8M		In planning stages		2008	?	?
	Ph III (b)	26.1	?	?	?	Not funded		?	?	?
	Soacha*	5.9	64%	$57.8M	$24.8M	In planning stages		2008	?	?
MegaBus (Pereira)		16	46%	$56.8M	$29.2M	3.2	12.8	April 2006	Dec 05 – Mar 06: 2 interchange stations	?
Mio (Cali)	Ph I	25.6	?	$241M	$104M	6.1	12.9	2007	2006-2007: Transfer stations, trunk and feeder infrastructure	Dec 2005
	Ph II&III	23.4	90%	?	?	?	?	?	?	?
Transcaribe (Cartagena)		14.9	70%	$137.3M	$91.6M	-	1.3	2007	Mar – Jun 2007: Remaining trunk corridors and a transfer station	2006
TransMetro (Barranquilla)	Ph 1	13.2	28%	$124.7M	$68.5M	-	3.6	2007	Jan – Sept 2006: trunk corridors / transfer stations	2006
Metroplús (V.de Aburra, Medellín)	Ph 1	12.8	12%	$138.8M	$66.6M	-	1.1	2007	Nov 06 – Apr 07: 11.7km of trunk corridors and transfer stations	2006
MetroLinea (Bucaramanga)		8.6 excl. 36.2 shared	63%	$177.8M	$89.1M	-	-	2007	2006: trunk corridors and transfer stations	Dec 2005

* Included in this section due to geographical proximity to Bogotá. This corridor is not officially part of the TransMilenio system.

While TransMilenio Phases I and II, and Pereira's MegaBus infrastructure, are either already operational or under construction, a significant portion of the infrastructure in the other Colombian cities, and the extension of the TransMilenio to the suburb of Soacha, still remains to be constructed. A total of $1,408M has been earmarked in either central government or local government funds for this purpose. Contracts are available for both construction of infrastructure (Works) and for Operations and Fare Collection, although explicit contract values are not known. The bidding process has already begun, and will continue through 2007, so U.S industry would have to mobilize quickly in order to be considered in the bidding process.

The Vice-Minister commented that the major foreign input into the development of Colombia's transit infrastructure comes from Brazil, France, Germany, and Spain (Noero, 2005); U.S. companies have had comparatively little involvement (Booz Allen Hamilton and McKinsey have participated in a consultancy capacity). He invited U.S. companies to participate in the tendering process for Colombia's future BRT systems, which is based on the World Bank's open procurement procedures. He mentioned alternative fuels as an example of an area where he thought the U.S transit industry could participate – perhaps with U.S. alternative fuel transit vehicles being tested on Colombian BRT systems. He indicated that he would be happy to provide future assistance, volunteering himself or former Bogotá Mayor Peñalosa to visit Washington D.C to meet with representatives of the U.S transit industry (Noero, 2005).

There were two main reasons that U.S industry had not been more involved in Colombia's BRT provision (Hidalgo, 2005):

- Brazilian companies already have BRT expertise and products which have been employed extensively in Colombia to date.
- Colombia cannot afford U.S consultancy fees – Brazilian companies charge much more affordable rates and provide similar services

Hidalgo stated that there are potential BRT related business opportunities for U.S firms in Colombia and in other developing nations in the region (Ecuador, Peru, Panama, Dominican Republic, Nicaragua, Mexico, etc. all have BRT proposals): These business opportunities are mainly in the following areas (Hidalgo, 2005):

- Technology/ Intelligent Transportation Systems (ITS): This area offers the greatest potential for U.S transit industry involvement, capitalizing on U.S expertise in signal control, electronic fare collection, Traffic Signal Priority (TSP), passenger information systems (electronic displays, variable message signs), bus control systems (Automatic Vehicle Location [AVL], safety) and other ITS applications. Partnerships with local providers could bring business to U.S. firms.

- Alternative fuels: The Colombian government is interested in investigating options such as Compressed Natural Gas (CNG), due to the high price of diesel that is high in sulfur. Large gas reserves already exist in the region. U.S. companies such as Cummins and Westport already provide such engines, which are commonly installed in Brazilian buses and used throughout Latin-America TransMilenio is currently working on an agreement with the government's Ecopetrol for fuel, and a pilot program is currently underway.

- Construction technology: Early deterioration of pavements and station floors show the need for better design methods (impact dynamics of high volume bus movements on paving surfaces), materials (concrete and asphalt additives) and construction methods (reduced time, better quality).

- Consulting services: Participation of U.S consultants will be useful in technology definitions. Teaming with local and regional expertise (Colombia, Brazil, Chile) may bring business to U.S based firms.

3.2 Public Partnerships

TransMilenio is willing to share data and information with the FTA, but as a matter of policy requires a more formal agreement that establishes a reciprocal arrangement between the two organizations. Such an institutional agreement could simply facilitate the transfer of data or scanning tours or involve an exchange of personnel for a limited period of time. Such agreements have been made or are under consideration with the Colombia Engineers of Florida and ITDP (Martínez, 2005).

4. WHAT TRANSMILENIO DEMONSTRATES / U.S APPLICABILITY

Previous chapters aimed to provide a factual account of the TransMilenio system and its impacts. This section aims to highlight the different capabilities of BRT that are demonstrated by the TransMilenio system, and to discuss applicability to the U.S transit context.

4.1 Differences between Public Transit in Bogotá and in the United States

TransMilenio's applicability to the context of the U.S transit industry is a complex issue. Bogotá is a city in the developing world characterized by high density, CBD-focused urban form, low car ownership, and low income population (with the lower income groups residing in the city periphery), making it very different from a typical American city.

TransMilenio has a network master plan of around 400km (250 miles), of which approximately 100km (62 miles) will soon be completed. This network replaced dozens of "traditional" microbus routes and consists of numerous service routes on the same right-of-way (e.g., local, express, super-express, etc.). Banning traditional buses from the TransMilenio corridors guaranteed high levels of system demand. In fact, projections actually underestimated actual system demand. TransMilenio can therefore be seen as a comprehensive reorganization and enhancement of road-based public transportation services from a multi-point to a feeder-trunk system. This highly integrated approach is different from that of most U.S "New Start" projects, which plan a new transit service to try to create new, or reinforce weak, travel patterns because of the availability of right-of-way or stations but do not necessarily serve existing travel patterns.

The political contexts of the two countries are also very different. Like most cities in the developing world, Bogotá is located in a political environment characterized by a strong executive. A powerful executive figure, such as a president at the national level or a mayor at the local level, wields much more power and influence than their counterparts in typical developed world democracies, and plays a much more important role in policy initiation (Ardila-Gomez, 2004). This type of political system, also featuring fewer environmental controls and much less stringent bureaucratic review, also permits much faster policy implementation.

Although the public sector was largely responsible for TransMilenio's infrastructure costs (similar to the way in which the federal government contributes to the capital cost of transit projects in the U.S), farebox revenue from the TransMilenio system covers operating costs and actually generates profit (reportedly as high as 30 percent according to TransMilenio managers), allowing the Colombian government to turn system operation over to the private sector, using a tendering process to maximize operating efficiency. In the U.S, transit systems operate at a loss, imposing greater limitations on private sector involvement. Although there are examples of private sector involvement in transit service provision, in most cases the public sector continues to be fiscally responsible for the system, either through providing subsidies to the private companies who run the system or running the system directly.

The sheer size of Bogotá, with a population of around eight million, makes it comparable to only a small number of U.S cities[5]. In terms of size, the experience of smaller cities in Colombia, such as Pereira and Bucaramanga, may be more comparable to cities in the U.S. The experience in Medellín, where BRT will be integrated with the existing rail line, may also be comparable to cities in the U.S with rail lines that are considering extending their transit networks using BRT technology.

All these differences limit the extent to which Bogotá's experience of BRT can be applied in the U.S. Indeed, most of the interest in TransMilenio has come from other developing countries in East Asia and South America, where more similar economic, socio-political and urban form conditions exist. Some express the view that what happened in Bogotá cannot be replicated because it is the result of a unique set of circumstances related to the extraordinary administrations of Enrique Peñalosa and Antanas Mockus (Mayor of Bogotá before and after Peñalosa). There are even doubts about whether the trend toward sustainable transport in Bogotá can be maintained if the political agenda shifts towards other priorities (Hidalgo, 2004ii). However, as it stands, TransMilenio does provide evidence of a variety of different capabilities that have direct applicability to BRT initiatives in the United States. The following sections discuss these issues, commenting on the different lessons that can be learned.

4.2 Capacity

TransMilenio carries very high passenger volumes of up to 41,000 pphpd. This is made possible by a variety of system design features:

- high capacity articulated vehicles (160 passengers) with multiple doors
- high average bus occupancies (TransMilenio buses carry an average of 1,600 pax per day)
- exclusive runningways unaffected by traffic congestion, with double lanes allowing express buses to overtake local buses
- high capacity station design featuring level boarding and off-board fare payment
- centralized control of bus operations, which coordinate local and express services, reduce bunching and improve reliability
- high service frequency (two-to-three minute headways for each line during peak periods, resulting in a combined headway 13 seconds at busy stations)

The capacity of the current system configuration is estimated at 45,000 pphpd. Theoretical capacity is estimated at 48,000 to 60,000 pphpd, but would require signal priority measures and grade separation at major intersections.

[5] Such cities include New York / Newark (urbanized area population of 17.8 million) Los Angeles (11.8 million), Chicago (8.3 million), Philadelphia (5.1 million), and Miami (4.9 million). No other U.S urbanized area populations are significantly greater than 4 million (U.S. Census, 2000).

Applicability to the U.S

TransMilenio's high capacity is also the result of high in-vehicle passenger loading. While the TransMilenio system was designed to carry seven standing passengers per square meter (SDG, 2000), capacity calculations in the U.S assume much lower standing passenger loads. This explains why the assumed capacities of different transit modes in the U.S context (10,000 for bus-based transit, 26,000 for LRT and 50,000 for heavy rail) (TCRP, 2003) are lower than the theoretical capacities of the different transit modes: 15,000 pphpd for bus-based transit, 30,000 pphpd for LRT, and 72,000 for heavy rail (Vuchic, 1981).

The Transit Capacity and Quality of Service Manual (TCRP, 2003) considers passenger capacities based on the upper crowding limits that transit users in North America are willing to accept. The manual states that a 60ft articulated (high floor) bus has a capacity of 100 to 120 people, with 65 seated and 35 to 55 standing. If a passenger loading capacity of 100 people (48 seated, 52 standing) per articulated bus were applied to the bus frequencies observed in Bogotá, this would equate to a busway capacity of approximately 28,000 pphpd.

The BRT capacity figure of 28,000 pphpd is clearly much higher than the commonly assumed 10,000 pphpd. According to Samuel (2002), calculation of BRT system capacity in the U.S often is limited to only 10,000 to 12,000 pphpd because the headways used in this calculation are typically assumed to be 40 to 60 seconds (60 to 90 buses per hour). Vuchic (1992) states that this assumption is valid only for a situation where there are no special bus terminals and only limited passing capability at stops. If these infrastructure requirements are met, it is possible to run buses at six to eight second headways (450 to 600 buses per hour per lane). This equates to a seated capacity of 27,000 to 36,000 passengers per hour. TransMilenio demonstrates the validity of these calculations, with headways as low as 13 seconds. Rubin (1997) states that bus services can run safely with headways of only three seconds at 60mph. This equates to a theoretical capacity of 70,000 passengers per lane per hour. In contrast, heavy rail capacity analyses are often based on 1-minute headways, while the shortest observed headways in the U.S for this mode is the San Francisco BART, at 2 minutes and 40 seconds (Rubin, 1997). Samuel (2002) concludes by stating that the approximate tenfold headway advantage of buses over rail more than compensates for the additional capacity of a coupled rail vehicle over a single bus.

The assumption that BRT options have limited capacity compared to LRT is often used to justify their rejection early in the alternatives analysis process. TransMilenio demonstrates that BRT systems are capable of carrying the passenger volumes commonly associated with rail-based transit, even under U.S passenger loading standards. This demonstrates that BRT should not be ruled out of alternatives analyses in favor of LRT on the grounds of insufficient capacity.

4.3 Capital Cost Effectiveness

The history of transit planning in Bogotá provides a useful demonstration of the large disparity between BRT and heavy rail in terms of capital cost. For many years, heavy rail was the preferred transit improvement option in Bogotá, and between 1947 and 1997 there were a total of 10 attempts to implement various heavy rail options. The primary reason for the failure of each attempt was the high capital expenditures involved. Table 4.1 compares the cost of the heavy rail option that was being proposed at the same time as TransMilenio, with the costs of TransMilenio Phases I and II.

TABLE 4.1 – Capital Cost Comparison of the 1997 Heavy Rail Proposal with TransMilenio Phases I and II

	Heavy Rail (1997 Proposal)	TransMilenio Phase 1	TransMilenio Phase II
Capital Cost (Infrastructure)	$2,350M	$240M	$545M
Cost of Vehicles / fare collection	$691M	$100M	$80M
Total Capital Cost*	$3,041M	$340M	$625M
Length km / (miles)	29km (18.0 miles)	41km (25.6miles)	41km (25.6miles)
Cost per km / (Cost per mile)	$105M / ($169M)	$8.3M / ($13.3M)	$15.2M / ($24.4M)
Weekday Ridership	795,000**	792,000	664,000***
Coverage of City's Total Transit Trips	16 percent****	16 percent	14 percent

* The heavy rail costs are provided in 1997 prices while the TransMilenio costs are in 2003 prices. Accounting for inflation would slightly increase the cost the heavy rail option relative to the TransMilenio options.

** Estimated daily ridership without integration with TransMilenio system and "traditional" buses.

*** Expected daily ridership upon completion of Phase II in 2006.

**** As stated previously in this report, Ardila-Gomez (2004) stated that the metro proposal would account for only eight percent of the city's total transit trips. A later analysis by Hidalgo (1999) estimated metro proposal coverage at 26 percent (1,325,000 daily trips) if fully integrated with the new TransMilenio system, and 16 percent (795,000 daily trips) without integration. It is the view of the authors that the 16 percent figure is the most appropriate for comparison purposes.

The total capital cost of the heavy rail option included both infrastructure costs and the cost of vehicles and fare collection. Equivalent costs have therefore also been added to the TransMilenio figures, even though in reality these costs are assumed by the private operators. Table 4.1 shows that the heavy rail proposal would have provided 18 miles of rail-line for a total cost of $3,041M, equating to a cost of $169M per mile. In return, the heavy rail line would have carried an estimated 795,000 passengers per day, equating to 16 percent of the city's total transit trips. In comparison, TransMilenio Phase I provided more transitway (25.6 miles versus 18.0 miles) and similar ridership levels, for a total capital cost of $340M, almost one tenth of the cost of the heavy rail option. While Phase II was approximately double the cost of Phase I, it was still only around one seventh of the cost per mile of the heavy rail option.

The total capital cost of the full TransMilenio Masterplan (featuring 241 miles of exclusive busway) is estimated at $2,300M, not including vehicle and fare collection costs (Hidalgo, 2002ii), and approximately $3,320M including vehicle and fare collection costs (Hidalgo, 2005). Comparing this figure to the capital cost of the 1997 heavy rail proposal ($3,041M), it can be concluded that TransMilenio offers Bogotá a city-wide rapid transit solution for similar capital expenditure as one rail corridor.

Applicability to the U.S.

Table 4.2 is a preliminary comparison of three recently implemented U.S. BRT systems (Boston, Las Vegas, and the Orange Line in Los Angeles), two U.S. light rail transit systems (Salt Lake and Minneapolis), two U.S. heavy rail systems (Los Angeles and Washington), and Phases I and II of the TransMilenio. A number of considerations and adjustments are required in order to better isolate the relevant differences and begin making a fair capital cost comparison between modes and locations. Total capital costs are reported in 2003 US$.

TABLE 4.2 – Comparison of Select U.S. System Parameters to TransMilenio

	Mode	Length (Miles)	Total Project Capital Cost US$M (2003 USD)	Capital Cost per Mile US$M/Mile (2003 USD)	Estimated Average Weekday Ridership	Average Weekday Passengers per Mile
Las Vegas MAX – Las Vegas Boulevard North	BRT (surface)	7.5	$20.30	$2.70	6,300	840
Boston SilverLine Phase 1 - Washington St	BRT (surface)	2.3	$27.30	$11.90	14,000	6,087
Los Angeles Orange Line	BRT (exclusive ROW)	14	$323.0	$23.07	18,000	1,286
Bogotá TransMilenio (Phase 1)	BRT (exclusive ROW)	25.6	$340.0*	$13.30	792,000	30,907
Bogotá TransMilenio (Phase 2)	BRT (exclusive ROW)	25.6	$625.0*	$24.80	664,000 (Projected)	25,912
Salt Lake North South Corridor	LRT (surface)	15	$397.30	$26.50	20,000	1,333
Minneapolis Hiawatha Corridor	LRT (surface, 1.5 mile tunnel)	11.6	$612.60	$52.80	25,000	2,155
Los Angeles (LACMTA) Red Line	HRT (undergrou nd)	16.5	$5,557.30	$337.60	96,000	5,832
Washington (WMATA) Entire Metrorail System	HRT	112	$16,300.00 (Est.)	$145.50	956,000	8,536

* Total capital cost includes cost of vehicles and fare collection. In Bogotá, these costs are actually assumed by the private sector.

Normalizing the capital cost figures per mile reveals that the costs per mile of all three modes are highly variable. The Las Vegas Max project cost per mile was approximately one tenth of the LA Orange Line, the Salt Lake LRT cost per mile was approximately one half the cost of the Minneapolis LRT, and the cost per mile of the Washington metro was less than half that of the Red Line in LA. Indeed, the cost per mile of TransMilenio Phase II was almost double that of Phase I, even though these projects were in the same city. Overall, this suggests that rapid transit project costs are highly context specific, affected by the unique characteristics of each corridor. While remaining cognizant of this issue, the table does suggest that the upper bound of BRT costs per mile corresponds to the lower bound of LRT costs per mile, while HRT cost per mile is significantly higher than both the other two modes. More research is required to verify this hypothesis, with the best approach likely to involve comparing modal alternative costs on the same corridor, thus removing the issue of context.

When comparing the cost of the TransMilenio with that of rapid transit systems in the U.S, the significant differences in labor rates and material prices between the countries should be noted. For example, labor rates in Colombia are about one-quarter and material prices about one-half of those in the U.S. Consequently, $1 of capital cost in the U.S. may be equivalent to less than $0.50 in Colombia. Making this theoretical adjustment to the TransMilenio capital costs per mile results in similar figures to the LRT systems.

Nonetheless, the capital cost per mile measure alone does not capture the effectiveness of the system in carrying passengers. The average weekday ridership for all of the systems can be normalized per mile to yield a measure of system performance. TransMilenio Phases I and II outperform the heavy rail systems in this measure by at least 3 times, LRT by at least 12 times, and BRT by at least 4 times. This result, however, is moderated by the fact that a transit trip in Bogotá is not directly comparable to a transit trip in the U.S because of significant differences in the transit mode share, costs, levels and expectations of service, ride quality, and comfort among other factors. In essence, one transit trip in the U.S is equivalent to many trips in Bogotá because transit does not have as many competitive advantages in terms of cost, utility, convenience, etc. Unfortunately, the demand function is not understood well enough to make such adjustments but it can be said that the capital cost effectiveness of TransMilenio is likely to be superior to most transit investments of any mode in the U.S. Samuel (2002) posits that the cost of bus systems should compare favorably to rail for the following reasons:

- The right-of-way or guideway requirements are much less expensive.
- Buses are much less expensive than custom-designed rail cars.
- Buses are more adaptable to changes in city traffic and demographic patterns and are more able to provide “door-to-door” service.

It is important to note that a complete cost comparison of alternative rapid transit modes must consider both capital costs and the cost of operating the system over the life of the project. This is important because BRT is often criticized for having higher operating costs than rail-based options, primarily due to higher labor costs. Hidalgo (2006) compared the lifecycle costs associated with different rapid transit modes over a hypothetical 20 year lifecycle. The study found that even though BRT operating costs were higher than both LRT and HRT, this was more than offset by much lower infrastructure and vehicle costs.

In sum, the volume of passengers in Bogotá and productivity of the vehicles, facilities, and staff is such that it makes the cost effectiveness of a TransMilenio-style system appear to be much greater than those experienced by most transit systems in the U.S. More research is required to better understand the applicability and isolate these differences.

4.4 BRT and Urban Renewal

In 1998, Mayor Peñalosa launched a long-term mobility strategy based on a package of measures to restrict private car use and stimulate urban renewal through public space improvements. The package of measures included improvement to non-motorized transportation, improvements to public transit, and automobile restrictions. TransMilenio became the centerpiece of this urban renewal/mobility program, facilitating the re-development of public space around the stations (including the provision of major terminal buildings), in addition to the provision of sidewalks/pedestrian avenues, pedestrian crossings, and bicycle lanes.

This achievement demonstrates that public-sector-led urban renewal programs can be built around BRT systems (as had been shown previously in Curitiba). This is important to note because bus-based transit is often regarded as not suitable for this task[6]. More costly rail-based options are often selected in alternatives analysis under the assumption that economic development in the vicinity of the rail-line will compensate for the large initial capital investment. Although there is some evidence that TransMilenio has had an impact on private sector land-use along its trunk corridors, it is too early to make any definitive conclusions on this issue.

Second, the Bogotá Model shows that BRT transit projects would benefit from being implemented as part of wider package of supporting mobility measures. Providing high quality access and facilities for non-motorized modes takes into account the complete transit user trip. Experience in Bogotá also shows that implementing restrictions on private automobile use enhances the likelihood of mode-shift to transit.

Third, the civic pride shown by the people of Bogotá towards TransMilenio and the associated public space improvements also shows that BRT systems are capable of making a noticeable positive impact on the social capital of a city. TransMilenio is widely recognized by its population as one the major icons of the city. A similar community response was also observed in Curitiba.

Finally, TransMilenio and the associated non-motorized transportation improvements have proven to be successful in reducing social exclusion by raising the level of access between the city's centrally located employment centers and its deprived, peripheral areas (Hidalgo & Yepes, 2005). This issue may become increasingly important due to the World Bank's recent decision that new transit proposals must meet a "poverty alleviation" litmus test to qualify for World Bank funding. This stipulation has resulted from criticism of costly World-Bank-funded metro projects in developing countries that have predominantly benefited higher income groups (Cervero, 2005ii).

[6] When the Caracas Avenue Busway was implemented in the late 1980s and early 1990s, it was built without the accompanying public space investments made in TransMilenio. Subsequently, it was not considered as successful as TransMilenio in terms of urban renewal and some property values along the corridor actually decreased following its implementation.

4.5 The TransMilenio Business Model

One of TransMilenio's greatest achievements was the successful implementation of a contract-based system for regulating service operations. Changing the way in which operators were paid from a "per-passenger" basis to a "per-kilometer" basis eliminated the "Penny-War" problem. Implementation of a formal bidding process for exclusive rights to operate specific service routes facilitated healthy competition "for the market" as opposed to unhealthy competition "in the market." This has undoubtedly enhanced operating efficiency, while reducing the fiscal risk imposed on Bogotá's city government.

Applicability to the U.S.

In considering the extent to which this approach can be applied to the U.S public transit industry, it must be noted that the TransMilenio system operates at a profit, while U.S transit systems operate at a loss. This makes it much more difficult to involve the private sector. Thus, operation of U.S transit systems tend to remain the responsibility of the public sector, with local transit agencies typically having a monopoly on service provision, reducing the incentive to maximize operating efficiency. This is, in a sense, the exact opposite of the situation in Bogotá, where service efficiency suffered from too much unregulated competition.

Clearly, the lesson to be learned is that too much competition and too little competition both are detrimental to operating efficiency, and that some form of regulated competition offers the greatest potential for efficient service provision. This suggests that more private sector involvement in service operation may be beneficial to the U.S transit industry. Experience from Bogotá suggests that concession contracts provide a way of achieving this, offering the potential for private companies to make a profit, while still reducing the subsidy required from the public sector (due to the efficiency gains afforded by competitive private sector involvement).

London Transport in the United Kingdom uses such an approach for its bus operations. In London, the government defines the bus routes, service characteristics, and fare levels, and then invites private contractors to submit bids that state the fixed annual subsidy that they would require to provide service. The winning bidder makes a profit by keeping costs below the fixed price paid by the government (Savas & McMahon, 2002).

Such arrangements also exist in the United States. For example, Foothill Transit in Los Angeles is a private company providing transit service in east Los Angeles under a concession contract arrangement with Los Angeles County Metropolitan Transportation Authority. Barriers to more widespread use of this approach in the U.S include the problem of low farebox recovery and cross-subsidy, the difficulty in providing socially desirable transit services in a non-self-sustaining economic context, and opposition from transit industry employee unions.

4.6 Politics

Appendix III presents a summarized version of the long process that led to the adoption of the TransMilenio as the core of Bogotá's public transit system. As always, politics played a central role in shaping transportation policy in Bogotá. Mayor Peñalosa's egalitarian political philosophy produced a raft of polices that prioritized quality of life distribution over income distribution. To him, "equality of life" was synonymous with "a living environment as free of motor vehicles as possible." Thus, his mobility strategy gave investment priority to pedestrians, followed by bicycle facilities, then public transit, and lastly cars (i.e., investment prioritization in inverse proportion to travel speed) (Cervero, 2005ii). Such a political philosophy would be viewed as radical in the United States.

In both the developing and the developed world, politicians running for election often make major transportation projects a central part of their election manifesto. Such projects are designed to capture the imagination of the voting population. It is not surprising then that the views of the incumbent President of Colombia, and incumbent Mayor of Bogotá, tended to dictate public transit policy in the city. Most of the Colombian presidents and Bogotá mayors, including Mayor Peñalosa, were pro-metro. Hidalgo (2006) cites a number of reasons for political support of heavy rail transit proposals. Table 4.2 provides these reasons, and in each case comments on their applicability in the context of the U.S transit industry.

TABLE 4.2 – Reasons for Political Support of Rail Transit

*Hidalgo 2006**	Comments on Applicability to U.S
*Rail capital costs are usually funded with federal assistance. Municipalities may prefer metros to **maximize disbursements to the local economy**.*	Yes, there is a perception that (dollar for dollar) rail maximizes benefits to the local economy.
*BRT may require **reorganization of existing bus routes and operations**. This is politically difficult, and unpopular among local administrators. Most metros are implemented without any, or minimum, nuisance to existing private operators.*	Reorganization of existing routes is not as significant an issue in U.S because transit tends to be publicly operated and managed.
*Metros are viewed as **more modern** than buses.*	Yes, the stigma associated with buses is perhaps even more significant in the U.S.
*The rail industry actively **promotes** the implementation of Metros.*	Yes, the BRT industry in the U.S is in a relatively nascent state.
*BRT is not yet **understood** by decision-makers.*	Yes, but this may change as programs and institutions continue to promote BRT and other bus solutions.
*Decision-makers typically do not use transit, but may find a Metro in a developed-world city **comfortable, reliable and quiet**.*	Yes, local decision-makers of cities without rail transit may view metros as a way to make their cities "world class".

* Paraphrased from Hidalgo, D. (2006). *Comparing Transit Alternatives After Recent Developments in Latin America*. For presentation at the Transportation Research Board's 2006 Annual Meeting.

In summary, bus-based rapid transit projects in the U.S do not currently capture popular imagination to the same degree as rail-based projects and are not assumed to be capable of generating or directing urban growth. To a large degree, it appears that many people, and their political representatives, are not even aware that BRT alternatives exist – while many Americans have experienced extensive metro networks in world cities like New York, London, and Paris, relatively few by comparison have been to Curitiba or Bogotá. While this problem may be beginning to be addressed by the emergence of high-profile BRT projects in U.S cities such as Boston, Los Angeles, and Las Vegas, it is likely that lack of political awareness will continue to be a barrier to the future implementation of other BRT systems.

The crucial difference between Mayors Peñalosa and Antanas Mockus, compared to other Bogotá mayors, is that they both demanded an objective comparison of BRT versus heavy rail. The major lesson from Bogotá appears to be that decision-makers need to be encouraged to make public transit planning decisions based on an objective comparison of the different modal alternatives. Despite the fact that politicians in the U.S may wield less executive power, the importance of having a high-profile political figure to champion a local BRT project cannot be underestimated. Such figures need to have the political power, courage, and commitment displayed by Mayor Peñalosa to carry their BRT project through to successful implementation.

A major political advantage associated with BRT is that it has much greater potential for implementation within one term of office, while heavy rail projects tend to take much longer. This allows newly-elected officials to achieve a stated policy objective during their first term, thus increasing the chance of reelection (assuming the project is regarded as a success). Although the planning and construction period required for BRT is likely to be longer in the U.S, political terms of office are also longer, typically four to five years. Such term lengths, while still not long enough to bring heavy rail proposals to implementation, provide enough time for the voting public to experience the benefits of a new BRT system.

Finally, it is important to acknowledge the importance of national government support (both financial and political) to BRT project implementation. For many years, the pro-metro Colombian national government put pressure on each Bogotá mayor to make provisions for a metro line. The success of the TransMilenio system has resulted in a paradigm shift in the national government's attitude towards BRT, and it is now backing the implementation of similar BRT systems across Colombia, providing funding to allow planning and construction to commence.

4.7 BRT Infrastructure Characteristics

TransMilenio's high passenger volumes are made possible by its significant investment in high capacity runningway and station infrastructure. Off-board payment and level boarding allow dwell times to be minimized, while dedicated runningways ensure high travel speeds and service reliability. This is particularly important in growing urban areas, where conditions on surrounding roadways invariably deteriorate over time as traffic levels increase. This experience suggests that successful BRT systems require a long-term commitment to high quality supporting infrastructure. Hidalgo and Herman (2004) state that one of the major challenges is convincing politicians that, for BRT to function well, buses must be given at least one dedicated lane in each direction. This is the only way in which large passenger volumes can be efficiently managed while retaining a high level of service.

In the U.S, where much higher levels of auto availability exist, "choice" riders will be attracted to BRT only if they are able to maintain some form of competitive advantage over the auto, ideally in terms of both travel time and travel cost. Exclusive runningways such as those provided in Bogotá are the most effective way to guarantee a travel time advantage in congested corridors, but other lower cost options such as Traffic Signal Priority (TSP) also exist.

It is also important that the supporting infrastructure is consistent to what would be provided for an LRT or heavy rail project. This means permanent station facilities, not just bus stops. In Bogotá, each stop features attractive permanent station structures, providing shelter from the elements, while the main line stations (portals) and transfer terminals are very similar to those commonly associated with heavy rail systems. Many stops also feature extensive overhead pedestrian walkway infrastructure. All this gives the TransMilenio system a real sense of permanence within the city. This is important because BRT is often criticized for not achieving the sense of permanence associated with rail-based projects, which generates concern among planners and private developers that such systems could easily be removed if the political climate changes.

The Bogotá example also shows that the system can be planned and executed in phases, as and when funding becomes available, providing greater long-term flexibility. Furthermore, BRT network construction can focus first on the sections that yield the greatest benefits, while rail-based networks are constrained to beginning construction in the center and then building outwards in contiguous sections, whether or not these sections are needed. This phased implementation capability applies to both service level (frequency and service span) as well as service infrastructure (TSP can be provided before exclusive ROW is achieved, a simple bus lane can be a short-term precursor to fully dedicated runningway, etc.). BRT projects can also be implemented independently, providing more flexibility for targeting political or economic "windows of opportunity," or to allow for changes in institutional service responsibilities. The latter allows greater flexibility in terms of regulating/procuring the design, construction, operation, and maintenance of BRT systems.

4.8 Replicating the Bogotá Model

TransMilenio provides insight into what BRT systems are capable of in terms of passenger capacity, capital cost effectiveness, and urban renewal. While TransMilenio provides irrefutable evidence of what BRT can do, there is still the issue of whether these achievements can be replicated in the urban environments of developed world countries such as the United States. It is appropriate then that the report should close with a discussion of the issues associated with replication of the "Bogotá Model". This is provided in Table 4.3 on the next page, based on a similar commentary by Hidalgo in relation to Bogotá Model replication developing world countries.

TABLE 4.3 – Replicating the Bogotá Model - Issues to Consider

Issues*	Comments on Applicability to U.S.
Defining a vision of the transport system required for the city: *Many local administrators have no clear long-term vision for their cities, and therefore continue existing plans that favor individual mobility or large-scale urban rail projects. These type of projects have long maturation time that extends beyond a given election cycle. If plans are changed in the next election, definitive solutions are often postponed for decades.*	Yes, the political cycle in the US is typically 4-5 years, which is enough time to implement BRT but perhaps not rail.
Getting resources for project preparation*: BRT projects are complex and require technical, financial, and legal studies to guarantee successful implementation. There is usually a lack of money set aside for such studies. Some local administrations receive international cooperation or multilateral lending, but only after many months of hard work.*	In many ways, this is less of a problem in the U.S cities which in the past have preferred more expensive rail solutions over bus. As we move into a more financially constrained environment for transit federal funding, there seems to be growing support for lower cost options.
Completing technical studies*: project design itself is not difficult, since the main engineering concepts for bus priority and operations are well known. Nevertheless, large data collection and model calibration studies are needed for successful demand forecasting, which is then used to define the fleet size, required services, and potential system income. All of this takes time, since data, such as origin-destination matrices and transit networks, are seldom readily available.*	This should be less of a problem in the U.S since many cities are required to regularly update regional travel demand models.
Getting local transit providers to participate in the process (or at least overcoming their opposition)*: in developing countries, individual vehicle owners usually provide public transportation services. These bus owners and operators—often affiliated with trade unions or cooperatives—make their profits by reducing or eliminating vehicle maintenance and forcing drivers to work long hours without benefits. They tend to instinctively oppose, through political influence and strikes, any effort to rationalize the public transport sector out of fear that efforts to improve service will harm them financially. Winning over the traditional transport sector is perhaps the biggest challenge to the successful implementation of BRT systems in developing cities.*	This is less of an issue in US since providers and/or managers tend to be public agencies.
Making changes in law, regulations and institutional frameworks*: this may include the creation or modification of agencies that are responsible for system oversight, bidding and contracting. This requires political bargaining within the elected bodies (city council, state legislature or national congress).*	Yes, this would include: – creation or modification of agencies that are responsible for the systems' oversight, bidding and contracting in an efficient and transparent process – appropriate distribution of rights, responsibilities and risks
Creating adequate incentives for a sound economic scheme that remains over time*: designing appropriate distribution of rights, responsibilities and risks is always difficult as long as there are conflicting interests between maximizing profits and providing quality service. Neglecting this important issue significantly reduces the chances of a successful BRT system.*	Yes, this is probably more difficult in the U.S without profit as a motivator. Appropriate use of concession contracts may be a way to achieve this in the U.S.
Securing financial resources for infrastructure*: despite the relative low cost of BRT as compared with rail-based alternatives, developing cities tend not to have capital readily available. Many resort to new taxes (fuel, value capture), which need approval by elected bodies, and grants from the national government. Some also seek finance from multilateral lending institutions, which takes time. Government-to-government concessionary loans would help increase BRT projects, just as they helped propagate rail-based alternatives in the past.*	Funding programs such as FTA "Small Starts" are becoming more accessible to BRT projects.
Bidding service operations and infrastructure*: Developing proposals and evaluating and awarding contracts in a transparent way is often difficult as long as public agencies are subject of pressures from interest groups.*	The current limited size of the outsourced operations market in the U.S. may not yet be able to support healthy competition.

* Source: Hidalgo, D., & Hermann, G. (2004). *The Bogotá Model for Sustainable Transportation; Inspiring Developing Cities Throughout the World.*

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APPENDIX I – SUMMARY OF TRIP ACTIVITIES

I.1 The Conference

The four-member U.S delegation attended the Conference on November 8 and 9, 2005. Conference sessions that were particularly applicable to the team's trip objectives included:

- A presentation by Vice-Minister Juan Ricardo Noero Arango of the Ministry of Transport, which provided an excellent overview of the Colombian government's position on BRT, and summarized project status in each of the Colombian cities currently implementing BRT systems

- A presentation from Astrid Martínez, General Manager of TransMilenio, which provided details of the development of TransMilenio to date, and plans for future expansion

Georges Darido and Alasdair Cain of the NBRTI gave a presentation titled "The Approach of the United States to BRT and Transit Infrastructure", at the conference. The presentation stimulated questions from members of the audience and requests for further information.

I.2 System Tours

The team was invited to join a formal tour of the TransMilenio system with a Japanese delegation on the morning of November 7. The tour began at the main control center, led by the control center supervisor. TransMilenio staff explained how individual buses are monitored as they travel along their routes to ensure equal vehicle spacing. Staff also explained the use of the real-time CCTV camera station monitoring system. The tour participants then boarded a green "feeder bus," and were taken along a major highway to view an underground vehicle staging facility. The tour then proceeded to the Ricaurte station, a TransMilenio Transfer Station, where the tour transferred to a red articulated trunk route bus. The bus traveled along the NQS and Las Americas trunk corridors in the dedicated runningway to the Portal de las Americas Terminal at the end of the route, then on to a vehicle depot, where tour participants participated in a Q&A session with Alberto Duarte, the manager of the facility, and viewed bus cleaning operations.

Following the formal tour, the team was driven around the rest of the trunk route system in a private car, ending in the downtown area of the city. A walking tour of public space development in and around a downtown TransMilenio station was then conducted. Police at the station would not permit photography.

The team was able to obtain permission from TransMilenio to view and photograph operations at the Calle 76 Station on the Caracas corridor, one of the busiest stations in the system, during Wednesday morning peak conditions. This visit provided an excellent opportunity for the team to observe and gather footage of system operations during a period of peak demand.

I.3 Personal Meetings

Formal meetings were conducted with the following individuals:

- Vice-Minister Noero of the Colombian Ministry of Transport and his colleague Andres Baquero (Brian Winans from the U.S. Embassy also attended this meeting).
- Astrid Martínez, General Manager of TransMilenio
- Raul Roa, TransMilenio Operations Manager
- Monica Vanegas, Pereira Megabus General Manager

Summaries of these meetings are provided in Appendix II.

Informal meetings were conducted with the following individuals.

- Angelica Castro Ortiz, Deputy Manager of TransMilenio
- Dario Hidalgo, Associate Director, Booz Allen Hamilton
- Garrone Reck, Technical Director, Logitrans
- Arturo Ardila-Gomez, Assistant Professor, Universidad de los Andes

APPENDIX II – MEETING MINUTES

II.1 Summary of Meeting with Vice Minister Noero and Andres Baquero

The Vice-Minister commented that the major foreign input into the development of Colombia's transit infrastructure comes from Brazil, France, Germany, and Spain (Noero, 2005), while American companies have had comparatively little involvement (Booz Allen Hamilton and McKinsey have had some involvement in a consultancy capacity). He invited American companies to participate in the tendering process for Colombia's future BRT systems, which will follow the World Bank's open procurement procedures. He mentioned alternative fuels as an example of one area where he thought the U.S transit industry could participate – perhaps with American alternative fuel vehicles being tested on Colombian systems. He indicated that he would be happy to provide future assistance, volunteering himself or former Bogotá Mayor Peñalosa to visit Washington D.C to meet with representatives of the U.S transit industry.

II.2 Summary of Meetings with Senior TransMilenio Staff

This section summarizes the meetings with Astrid Martínez, Raul Roa, Angelica Castro of TransMilenio. Technical/institutional issues currently under consideration by TransMilenio:

Vehicles for Phase III:

- Considering diesel or natural gas buses
- Low sulfur diesel currently not available
- Working on agreement with the government's Ecopetrol for fuel
- Pilot program under evaluation

Financial resources/constraints for further expansion of the system:

- Private financing – profit of existing Phase I operators is as high as 33%
- Transit oriented development and "valorization" (increased property values)
- Impact fees ("plus valia")
- Marketing and merchandising
- Cross-subsidizing socially-desirable routes
- Two ways to make TransMilenio more accessible to the poor: 1) improve services to the periphery, 2) reduce the fare (currently around U.S$0.40, relatively expensive in Bogotá)

Public Partnerships

- Future legal framework may be to unite Secretary and TransMilenio
- TransMilenio (TM) is willing to share data and information with the FTA, but as a matter of policy requires a more formal agreement that establishes a reciprocal arrangement between the two organizations. Such an institutional agreement could simply facilitate the transfer of data, or involve an exchange of personnel for a limited period of time. Such agreements have been made or are under consideration with the Colombia Engineers of Florida and ITDP (Institute for Transportation and Development Policy).
- The FTA scanning tour could be arranged through such an agreement.

Capacity and Throughput

- Station at Calle 76 carries 42,000 pax/hour/direction in the peak
- TransMilenio believes this to be 48,000 to 60,000 theoretical
- Constraint to capacity tends to be the stations in the core
- For Super Express Service, capacity constraint is signalization at intersections
- Considering traffic signal priority and/or intersection over/underpasses

Real-Time Information and Operations

- Fare collection system data used for service planning and operations, however, there are problems trying to reconcile passengers carried with turnstile counts
- Station cameras also used for operational interventions
- Real-time passenger information signs are available in some stations
- Not all feeder buses have AVL and there is a problem with bus bunching

Passenger Experience

- TM is performing an analysis that decomposes travel, wait, and dwell times by service
- There is no published schedule since the service is so frequent
- In general, the travel time savings in Bogotá as a result of TM is 13 minutes
- For TM passengers, the travel time savings is 16 minutes compared with previous conditions
- There are monthly surveys with demographic and economic information used to distribute bonus funds every 6 months

Climate Change Initiatives

- Bogotá is preparing a Clean Development Mechanism (CDM) application by collecting data on TM
- Before data on land uses exist

Security

- 4 guards (state police) per station in the CBD
- From 9PM to 6AM, there is private security
- Trying to replace guards with more cameras

TM Service Span

- Service opens around 4:30-5AM
- Service closes around 12:50-1:15AM depending on the line and service

II.3 Summary of Meeting with Monica Vanegas, Megabus General Manager (Pereira)

Major differences between TM and Megabus:

- In Pereira, there are 3 municipalities and 1 metropolitan authority
- Smaller region, 700,000 inhabitants with 80% transit mode share
- 1,100 old buses/microbuses being replaced/scrapped
- Still a trunk-feeder system with a 16.6 km trunk (phase 1)

Project History

- Pre-Feasibility Study (1998) performed by Systra and Brazilian consultancies
- 10-year Master Plan's objective is to provide 50% coverage of the region (within 500 meters of a station/stop) with Phase 1
- Design (2000) performed by Logitrans (Brazilian consultancy from Curitiba)
    - Two intermodal stations—one elevated and one underground
    - Bus lane each way
    - 3 minute peak headway
- Construction started in 2003

Other Lessons Learned from TM:

- Separately procured feeder system creates a second class system
    - Pereira is issuing one procurement with concessions in 2 areas (trunk line operations and smaller operators)
    - The idea is for local operators/bidders to build partnerships with larger, out-of-town operators (e.g. Bogotá) but maintain a majority of the ownership local
- Integration of Fare Collection/Control Center/Technological components
    - One 12-year concession that integrates all components instead of separate concession in Bogotá which she believes created some problems
    - Required fare distribution network of 60 external points of sale (including pharmacies and other 24 hour businesses)
    - Negative balance allowed on fare cards owned by the passenger
    - 4 consortiums in the running: Siemens, Angelcom (Bogotá's fare concessionaire), Systra/RATP/Medellín, and a Brazilian consortium
    - Competition on the basis of lowest price per paid passenger
    - Scheduled to be let in April 2006
- Buses
    - Volvo and Mercedes to import buses
    - 51 articulated, 53 feeder
    - Only feeder buses that are 2001 or newer will be allowed to operate
    - Older microbuses will be scrapped for newer feeders on a 1 to 1 ratio
    - 8 microbuses will be scrapped for every 1 articulated trunkline bus
    - 10% of old fleet already scrapped
- Performance measures for operators
    - Award based on lowest price fare offered for the service, which is bound by a range defined by the authority

- Fare to include the cost of the trunkline depots and a % for maintenance of the roadways
- Training for drivers

Public Partnerships/Institutional Arrangements

- Pereira would be happy to host a visit by the FTA scanning tour in 2006
- There is now an opportunity to collect “before” data in the first half of 2006

APPENDIX III – A SHORT HISTORY OF TRANSIT PLANNING IN BOGOTÁ[7]

It is important to understand the process by which Colombia decided to select exclusive busways as the preferred transit improvement option for Bogotá, and subsequently for many other cities across the country. Bogotá's traditional transit system consisted of a multitude of independent bus operators competing for customers in the so-called "penny war." The result of this was inefficient service provision, high levels of traffic congestion, and the associated negative economic and environmental impacts that traffic congestion brings.

For many years, the suggested solution to this inefficient system was a heavy rail (metro) system. There were a total of 10 attempts to implement a heavy rail solution in Bogotá between 1947 and 1997 (Lleras, 2003). Over these years, Bogotá became the battleground between two opposing transit planning philosophies. First, the school that believed that a metro network ought to be the backbone of the transit system, complemented by bus-based services. Second, the school that believed that exclusive busways and Bus Rapid Transit style services could provide a similar level of service without the need for heavy rail. Each school was composed of both politicians and planners/technical experts. This section focuses on the period between 1986 and 2001, discussing the factors that led to the ultimate selection of the BRT approach (Ardila-Gomez, 2004). The major milestones over this period are summarized in Table III.1 below.

Table III.1- Adoption and Rejection on Various Public Transit Initiatives in Bogotá

Year (Approx.)	Project/Policy	Adopted - Yes or No
1986-92	Metro line 1	No
1988-90	Caracas Av Busway, Phase I	Yes
1990-93	Caracas Av. Busway, Phase II	Yes
1993-95	Metrobus BRT	No
1994-98	Transportation Master Plan	No
1994-2001	Metro line 1	No
1998-2001	TransMilenio - Phase 1, BRT	Yes
2001-03	Circuitos, Busway	No
2001-03	TransMilenio - Phase 2, BRT	Yes

Source: Ardila-Gomez, A. (2004). *Transit Planning in Curitiba and Bogotá. Roles in Interaction, Risk, and Change.* PhD Dissertation. Massachusetts Institute of Technology.

[7] The information provided in this section is a summary of Chapters 8, 9, 10, and 11 of the MIT doctoral dissertation of Arturo Ardila-Gomez (2004), titled "Transit Planning in Curitiba and Bogotá: Roles in Interaction, Risk, and Change."

The Colombian city of Medellín was going through an economic crisis in the early 1980's. Politicians there decided to build a metro system as a way of stimulating economic growth. This also appealed to officials and politicians in Medellín as it would mean that their city would be the first in Colombia to have a metro. Construction of the Medellín metro began in 1985.

With Medellín building an impressive new system, the traditional bus system employed in Bogotá seemed even more archaic. This prompted the President of Colombia, President Barco, to order his appointed Mayor of Bogotá, Julio Sanchez, to conduct a study on how to implement a metro system in Bogotá. The study proposed using existing inter-city rail corridors for the system. This minimized the capital cost of the project, as the land required for the proposal was already owned by the government, but meant that the system would not be capable of serving the major trip origins and destinations in the city.

In 1988, Andres Pastrana became the first elected mayor of Bogotá (previously, mayors had been directly appointed by the incumbent President of Colombia). Pastrana was persuaded by Jorge Acevedo, the head of a local think-tank called the SER Research Institute, to consider a bus-based alternative, following the success of similar projects in Brazilian cities such as Sao Paolo. A study by Acevedo concluded that a busway could be built along Caracas Avenue, the city's main north-south corridor. He also highlighted the fact that the busway could be built within a two-year mayoral term. At the same time, the Medellín metro project was running into financial difficulties, and Pastrana became increasingly skeptical about the merits of building an expensive metro system in Bogotá that would only be able to serve a maximum of eight percent of public transit demand. Pastrana agreed to proceed with the busway project, while delaying making a decision on the metro. The Caracas Avenue Busway, known locally as Troncal, opened in 1990, extending 8 km northwards from the central business district.

Although the new mayor, Juan Martin Caicedo, briefly revived the metro idea in 1990, four commissioned reports recommended against it, citing vague technical specifications, overestimated service demand and underestimated costs. The national government subsequently decided not to pursue the metro proposal. The second phase of the Caracas Avenue busway was added in 1992, extending an additional 8 km northwards into Bogotá's middleclass suburbs. The Caracas Avenue Busway is now recognized as an important precursor to the TransMilenio, proving that an exclusive busway was capable of handling the high levels of demand normally associated with heavy rail. However, service operations still followed the relatively unregulated traditional approach, resulting in the same low level of service associated with the "Penny Wars" in other corridors. The vehicles themselves were also the traditional type, built on truck chassis with high entry levels and high pollution levels.

In 1992, a new mayor, Jaime Castro, entered office. Proponents of both the busway and metro options lobbied the new mayor, including several large international firms promoting the heavy rail option. Castro's response was to establish a bidding process that would specify certain criteria for the city's new transit system, including the fact that the proposal had to be funded by the private sector through a concession scheme. The decision on which transit mode to use would be left to the individual contractors. Six proposals were considered; three contractors presented solutions using heavy rail only, two presented solutions based on busways only, while one contractor's bid featured the integration of both rail and busways. The evaluation of these bids was conducted in 1994 by British Halcrow-Fox and Associates. It was found that only the bid from the Metrobus company, which proposed 40 km of exclusive busway (12 new lines), was technically and financially feasible. Because the proposal was based on a concession contract, Metrobus wanted to ensure the financial success of the project, and demanded that all other bus companies were banned from providing service on the busway corridors. Pressure from the bus companies made it impossible for the city government to guarantee this. Metrobus also wanted to have exclusive control over the fare levels for their system, which again, the city government was not willing to do. As a result, Metrobus signed the concession contract to build and operate the busway network for 20 years, on the provision that if they could not secure financial backing, they could withdraw from the project without penalization. In the end, Metrobus was unable to secure the required funding, due to bank concerns about the relatively high fares being proposed, the inability of Metrobus to control the fare levels, competition from other operators on the corridor, and likely opposition to the project from these same competitors.

When Enrique Peñalosa became mayor in 1997, the city planners had settled on a Transportation Master Plan that proposed the construction of an integrated transportation system, featuring improvements to road infrastructure (including 400 km of new roads), parking schemes, a bicycle path network, a network of 15 busways, and one metro line. The plan also recommended a reorganization of the bus system into fewer routes following a trunk and feeder pattern. Including both bus and rail elements in the plan seemed to partially satisfy both transit schools of thought. However, how to fund the plan, with an estimated cost of $4.3 billion, still remained to be determined. Peñalosa quickly rejected the Transportation Master Plan, finding the plan to be lacking in detail and therefore difficult to implement. Peñalosa's own Development Plan was initially supportive of the metro concept, due to its potential for stimulating urban renewal and structuring the city's growth. However, he was only willing to proceed with it if the majority of funding (70%) came from national government, and it was supported by the construction of the busway network around it. An agreement with the national government was signed in 1998, with the national government agreeing to fund the 70 percent project costs ($2.72 billion) for the first stage of the metro line (30 km and 24 stations), which was to be managed through a concession contract with a private operator. The plans also included 29.1 km of busways to complement the metro.

In 1998, Andres Pastrana was elected President of Colombia. Despite his reticence towards the metro proposal while Mayor of Bogotá in the late 1980s, in his presidential campaign he pledged to support its implementation. However, by the late 1990s, Colombia and Bogotá were immersed in a deep recession, making it increasingly unlikely that the national government would be able to justify spending 49 percent of their total capital expenditure for the next several years on metro lines in Bogotá and Cali. At the same time, it was realized that it would be difficult to guarantee potential private investors the required rate of return on their investment of around 14 percent. Peñalosa began to realize that it may be more prudent to engineer the transfer of funding earmarked for metro to his now emerging TransMilenio project. While this was politically difficult to do, figures in national government began to question the rationale of funding a metro at $100M per km, in such adverse economic conditions, when a busway based system could be funded for only $5M per km. Under increasing pressure from Peñalosa, the national government finally agreed to transfer the metro funds to the TransMilenio project. The metro proposal was cancelled.

The Longer-Term Vision

The Rail System (First Metro Line) is still part of the Long Term City Plan (Plan de Ordenamiento Territorial). It does not have any implementation schedule or budget commitments, but the plan is that the high demand busways will be replaced by Heavy Rail when demand reaches system capacity (estimated at 45,000 pphpd). There is currently plenty of excess capacity in the TransMilenio system, and it is thought that the switch to heavy rail will not occur for several decades.

APPENDIX IV – COLOMBIA'S OTHER PLANNED BRT SYSTEMS[8]

IV.1 Overview

The National Development Plan Act of 2003 stated that "municipalities or metropolitan areas with populations of over 600,000 inhabitants would be eligible to receive funds from central government to take forward [Bus Rapid Transit] schemes." Many Colombian cities also suffer from over-saturation of individual bus operators, and this legislation resulted in several cities committing to busway based transit projects, based on the "Bogotá Model." Each city is at a different stage in the implementation process. The remainder of this section summarizes project status in each case.

IV.2 MetroCali – Cali

The City of Santiago de Cali began system planning in 1999. The system is based on TransMilenio's trunk/feeder system. Figure IV.1 below shows the location of the Phase I trunk routes in Cali.

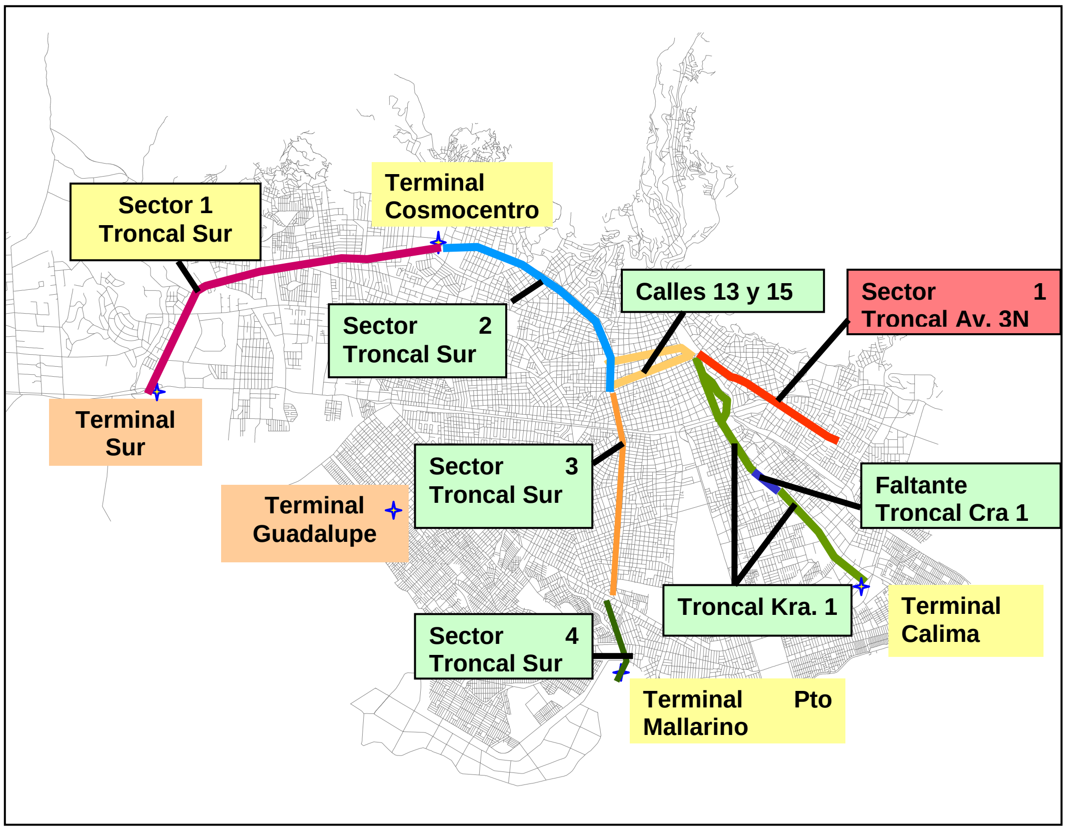

FIGURE IV.1 – Location of Phase I Trunk Routes in Cali
Source: Colombian Ministry of Transport

[8] The information used in this appendix comes primarily from the presentation made by Vice Minister Juan Ricardo Noero Arango at the First International Mass Transport Conference, Bogotá, November 2005. Readers should note that some of the information presented in this appendix differs from the information provided in Table 3.1, which comes from the dossier provided by the Ministry of Transport.

Trunk service will be provided by articulated buses operating in the median of the main city arterials, physically separated from the rest of the traffic. Some of the trunk corridors do not require the use of articulated buses and will not be physically separated from mixed traffic. However, the buses will still use center lanes with preferred access and have the capacity to carry around one hundred passengers each. To ensure fast and adequate service along the corridors 5 bridges will be altered, 5 bridges constructed, and 12 intersections improved. The feeder system will be operated on some routes by smaller buses that hold approximately 50 passengers, while the other routes will use traditional minibuses.

Terminals will be located along the trunk corridor intermediately and at the ends of the routes. They can be used as transfer stations among the feeder and trunk routes. Stations will be located in the center median every five hundred meters for boarding and unloading of passengers. The system plans to meet at least 72 percent of public transit demand and a spatial coverage of 97 percent of the city (within 500 meters of system). The project has been divided into three phases - Phase I consists of the construction of 25.6 km of dedicated busway. Project costs for this phase are estimated at $345M.

TABLE IV.1 – Phase I - Capital
Infrastructure Works and Bid Timing in Cali

Infrastructure Type	Title	Length	Bid	Work
Trunk Corridors	Sector 1 Troncal Sur	6.5 km	Dec/05	Mar/06 – Mar/07
	Sector 2 Troncal Sur	4.7 km	Dec/04	Jul/05 – Aug/06
	Sector 3 Troncal Sur	3.6 km	Dec/04	Jul/05 – Jul/06
	Sector 4 Troncal Sur	1.2 km	Jul/05	Dec/05 – Jan/07
	Calles 13 y 15	3.2 km	Jul/05	Dec/05 – Jul/06
	Sector 1 Troncal Av. 3N	2.8 km	Aug/06	Jan/07 – Feb/08
	Faltante Troncal Cra 1	0.6 km	Jul/05	Dec/05 – Aug/06
	Troncal Kra. 1	6.1 km	-	Aug/04 – Dec/05
Terminals	Terminal Sur	-		
	Terminal Guadalupe	-		
	Terminal Cosmocentro	-		
	Terminal Pto Mallarino	-		
	Terminal Calima	-		

Characteristics of the complete system are summarized in Table IV.2 below.

TABLE IV.2 – Characteristics of Trunk and Feeder System is Cali

Trunk Corridors:	Total Length:	49 km
	Stations:	77
	Pedestrian Overpasses:	31
	Intermediate Terminals:	4
	End terminals:	5
Feeder Systems:	Total Length:	194 km
	Covered Wait Areas:	655

IV.3 Metroplús – Valle de Aburra (Medellín)

Medellín is the only Colombian city with a heavy rail (i.e. metro) system. The bus rapid transit system will be integrated with the metro system. The Metroplús project covers four municipalities: central Medellín, Envigado, Itagüí (south), and Bello (north). The majority of the proposals and development has been made in the first two sections.

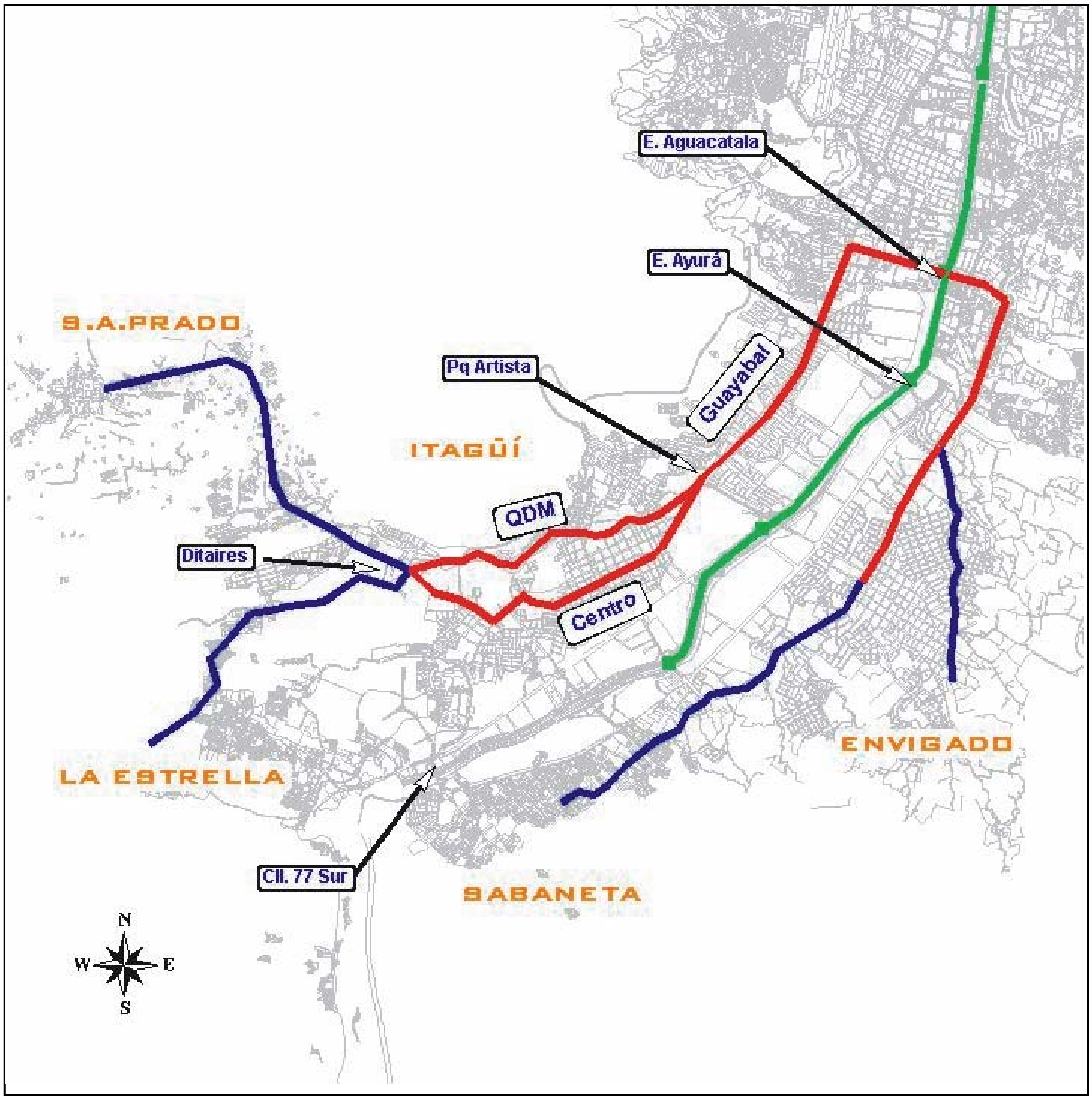

FIGURE IV.2 – Metropolitan Corridors Envigado - Itagüí
Source: Colombian Ministry of Transport

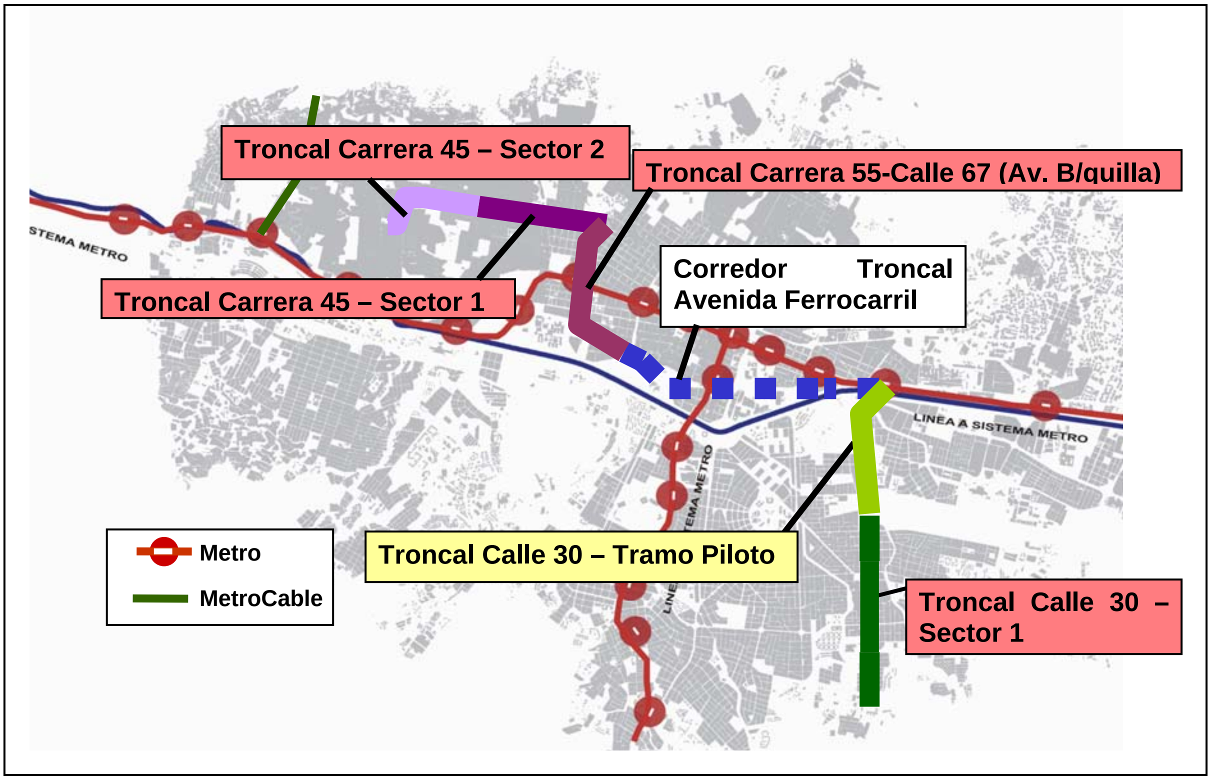

FIGURE IV.3 – BRT Network within Central Medellín
Source: Colombian Ministry of Transport

Within central Medellín, the trunk corridor will be 12.8 km long. The corridor will have center bus lanes, but will not use articulated buses. The buses are expected to be Euro III as one of the major components of this project is low emissions and a better living environment. They have left side doors, prepaid fare technology, and will hold up to 80 passengers. A total of 22 stations will be provided with an expected usage of 125,000 passengers per day. Project cost is estimated at $205.4M ($138.8M from central government and $66.6M from local government).

TABLE IV.3 - Capital Infrastructure Works and Bid Timing in Medellín

Location	Length	Bid	Work
Troncal Carrera 45 – Sector 1	1.7 Km	Nov/05	Feb/06 – Nov/06
Troncal Carrera 45 – Sector 2	1.7 Km	Feb/06	May/06 – Jan/07
Troncal Carrera 55 - Calle 67 (Av. B/quilla)	2.3 Km	Feb/06	May/06 – Jan/07
Design Corredor Troncal Avenida Ferrocarril	4.2 Km	-	Nov/05-Jan/06 (developed)
Works Av. Ferrocarril	-	Apr/06	Jul/06-Abr/07
Troncal Calle 30 – Tramo Piloto	1.48 Km	Awarded: Aug 22/05 Contractor: ESTYMA S.A.	Sep 12/05
Troncal Calle 30 – Sector 1	2.5 Km	Nov/05	Feb/06 – Nov/06

IV.4 Megabus – Pereira – Dosquebradas

In 2000, a mass transit project was launched in Pereira and the surrounding area of Dosquebradas as part of the plans for "Territorial Order". As a result Megabus was developed to serve these areas. These areas include Pereira, Dosquebradas, and La Virginia.

Megabus includes a trunk corridor route with end terminals. The trunk corridor will be serviced by articulated buses with heavy passenger capacity. Feeder routes will be located in the sectors outside of the end terminals and distribute among the surrounding areas. The feeder buses will have 40 to 80 passenger capacity and measure between 8 and 11 meters. Total trunk corridor length is 16 km; 12.8 km have already been built, and 3.2 km are under construction. Total cost is $86M ($56M from central government and $29M from local government).

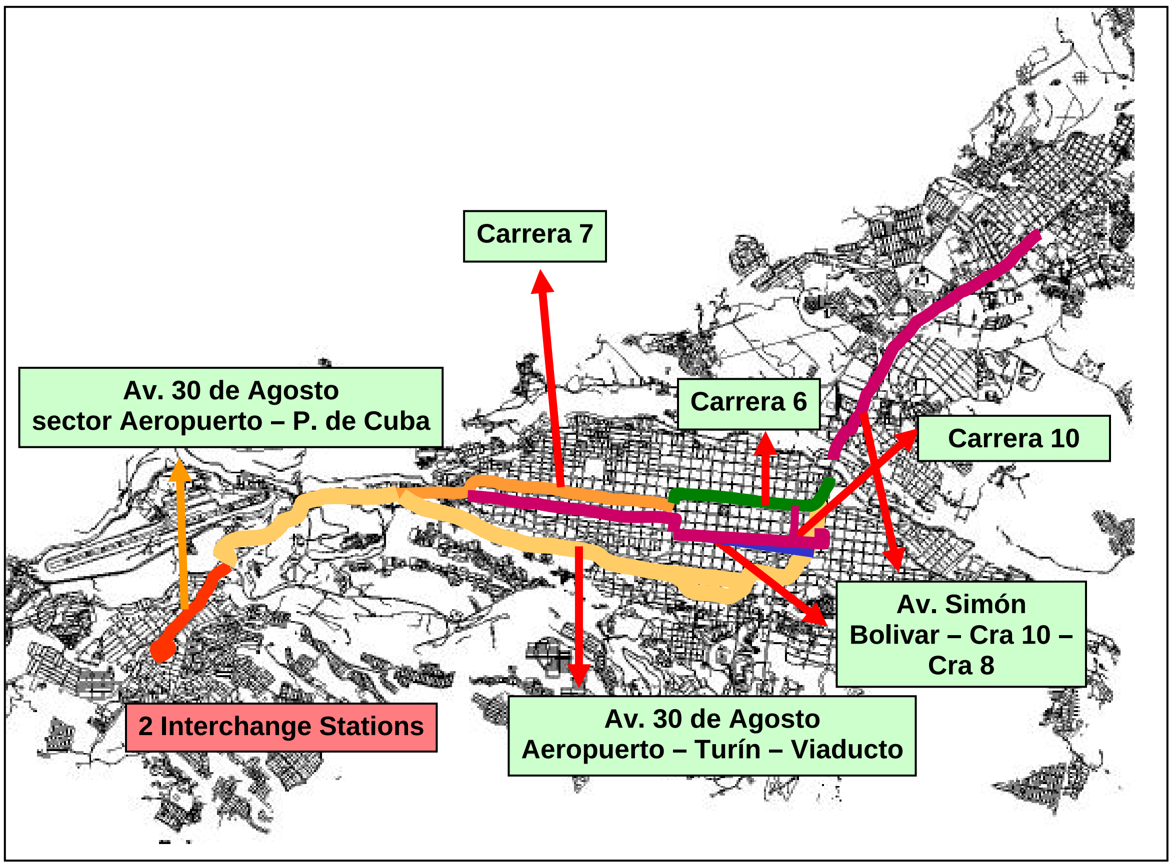

FIGURE IV.4 – Pereira BRT System

Source: Colombian Ministry of Transport

There will be 40 stations along the trunk corridor approximately 500 meters apart and two main stations at the end of the route. The stations are equipped with ramps and entryways especially designed for use by people with physical limitations. Safety components are a key aspect to every station and include such things as video cameras, guards, and turnstiles. The method of payment would be an electronic card that works similar to a debit or credit card. It contains a certain amount of trips on it. The passenger may pay at the individual stations or while aboard one of the feeder buses. Only one payment is required once within the system, and this one payment can take the passenger to over 550 destinations.

Megabus is expected to indirectly benefit over 80 percent of the inhabitants in Pereira and 70 percent of public transit users. The new system will cut the number of trips, travel time, and cost for the passengers in half. The old transit system consumed 20 percent of a traveler's income, and the new system is expected to utilize only 10 percent.

TABLE IV.4 - Capital Infrastructure Works and Bid Timing in Pereira

	Length	Bid	Work
Av. 30 de Agosto Aeropuerto – P. de Cuba	1.4 km	Apr/05	Jul/05 – Jan/06
Carrera 7	2.0 km	Jun/04	Sept/04 – Apr/05
Carrera 6	1.2 km	Jun/04	Sept/04 – Mar/05
Carrera 10	Sector built through the "Ciudad Victoria" Project		
Av. 30 de Agosto Aeropuerto – Turín – Viaducto	5.7 km	Mar/05	Aug/05 – Nov/05
Av. Simón Bolivar – Cra 10 – Cra 8	5.7 km	Apr/05	Sept/05 – May/06
2 Interchange Stations	NA	Apr/06	Jul/06 – Dec/06

IV.5 Metrolínea – Bucaramanga

The city of Bucaramanga developed Metrolínea as their way to achieve an integrated mass transit system. The plans are to have the system cover 76 percent of the city's public transit needs with two phases of construction. The system plans to use trunk corridors, pre-trunk corridors, feeder routes, and complimentary routes. The trunk corridors would have center lanes exclusive to Metrolínea articulated buses only. Feeder buses with a capacity of 100 passengers will be used as well. Stations with 90 cm high platforms will be located every 600 meters along the center median in the trunk corridors. Transfer stations and portal stations at the end of routes will also be available. There will be local offices with centralized control of the trunk corridor buses. The specific payment system is still under design but it is expected to be a pre-payment method using smart card technology. Total trunk corridor length is 44.8 km, of which 8.6 km is a dedicated busway and 36.2 km is in mixed traffic. Total project cost is $267M, with 66 percent ($178M from central government and $89M (34 percent) from local government.

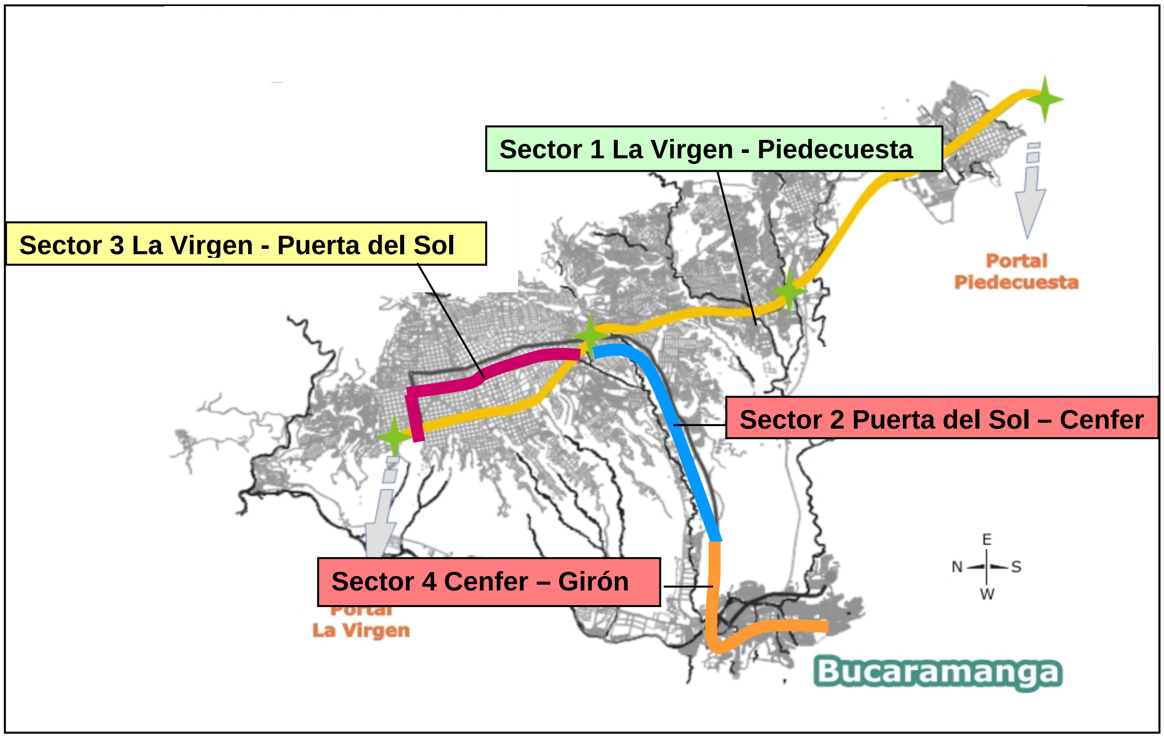

FIGURE IV.5 – Bucaramanga BRT System
Source: Colombian Ministry of Transport

TABLE IV.5 - Capital Infrastructure Works and Bid Timing in Bucaramanga

	Length		Bid	Work
	Segregated	Shared		
Sector 1 La Virgen – Piedecuesta	8.6 km	13 km	Sept/05	Dec/05 – Nov/06
Sector 2 Puerta del Sol – Cenfer	-	5.1 km	May/06	Nov/06 – Sept/07
Sector 3 La Virgen - Puerta del Sol	-	5.5 km	Nov/05	Jan/06 – Aug/07
Sector 4 Cenfer – Girón	-	4.5 km	May/06	Nov/06 – Sept/07

IV.6 Transmetro - Barranquilla

Barranquilla is a major contributor of Colombia’s commerce and industry. It is a city with over two million inhabitants, two thirds of whom currently use the unsafe and inefficient public transit system. In 2000, Transmetro was formulated by local urban planners and professionals in order to find a way to improve the quality of life in Barranquilla. Planning and design is still currently being developed. The system consists of two phases. Phase I will encompass Carrera 46. Phase two will cover Carrera 30. Phase I cost is estimated at $193M ($125M from central government, $68M from local government) and total trunk corridor length of 13.2 km, with 3.6 km currently under construction.

The system will consist of trunk corridors as well as feeder routes, which will cover different zones of the city. Regular service will stop from station to station, while the express service will stop only at selected stations. Determination of the selected stations is flexible and will be adjusted with demand. Articulated buses of about 18 meters in length will run on the trunk corridors carrying a capacity of approximately 160 passengers. Regular buses will travel the rest of the routes. These will be 12 meters in length with a capacity of 110 passengers.

Transmetro stations will be designed in a way that represents the city's culture while providing a safe and comfortable environment for the passengers. All stations will be covered and placed along the intersections of major streets that cross the trunk corridors.

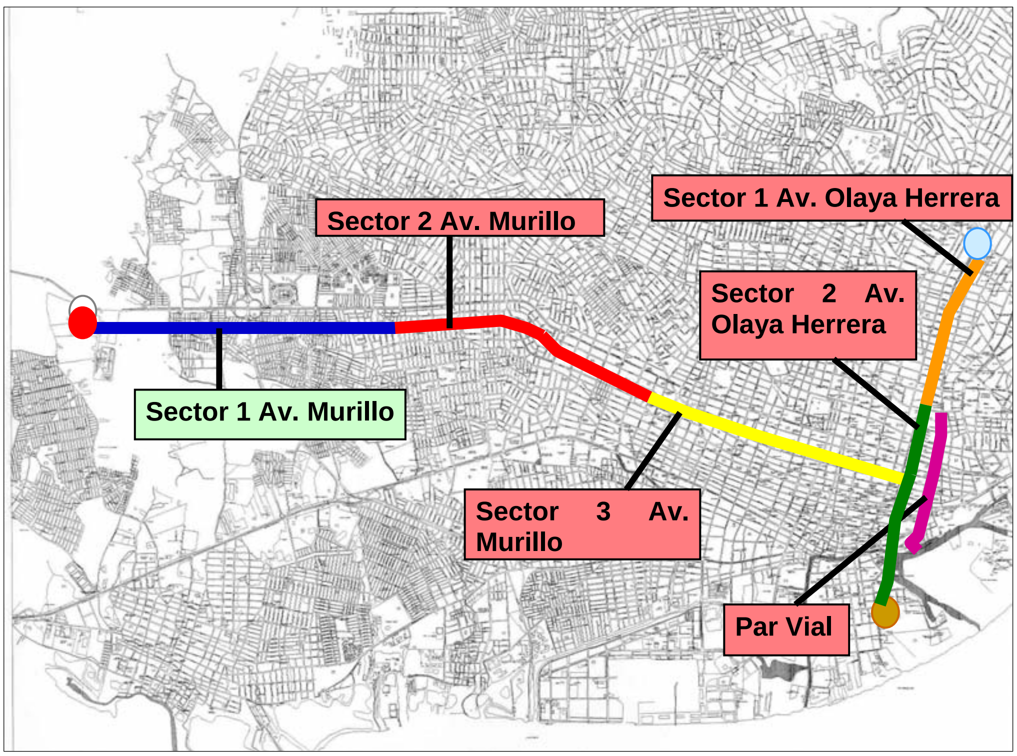

FIGURE IV.6 – Barranquilla BRT System
Source: Colombian Ministry of Transport

TABLE IV.6 - Capital Infrastructure Works and BidTiming in Barranquilla

	Length	Bid	Work
Stations	-	Apr/06	Jul/06 – Jun/07
Portal	-	May/06	Aug/06 – Apr/07
Sector 1 Av. Murillo	3.6 km	Aug/05	Dec/05 – Sep/06
Sector 1 Av. Olaya Herrera	1.8 km	Jan/06	May/06 – Nov/06
Sector 2 Av. Murillo	2.7 km	Mar/06	Jul/06 – Apr/06
Sector 2 Av. Olaya Herrera	2.2 km	Sep/06	Jan/07 – Jul/07
Sector 3 Av. Murillo	2.8 km	Jun/06	Sep/06 – Jun/07
Par Vial	2.0 km	Apr/06	Jul/06 – Mar/07

IV.7 Transcaribe – Cartagena

Cartagena is located on the north coast of Colombia. Because of its proximity to the Gulf of Mexico, Transcaribe is the only system that has considered integrating a bus rapid system with water transit. Many of Cartagena's people use boats to move up and down the coast, so the combination of these two systems would be most beneficial.

The buses used will be articulated buses that hold 160 passengers and regular buses that hold 105 passengers. The doors will be located on the left side for easy exit and entrance. The articulated buses will operate on exclusive center corridors. There will be 99 new articulated buses, 64 new regular buses, and 462 older smaller buses within the system.

The stations will contain new technology for fare payment. Transfers within the system are free, but once a passenger exits the system any re-entry will incur a new charge. The form of payment will be through pre-paid cards that can have one, two, or four trips charged. All stations will include pedestrian cross walks and some pedestrian cross lights.

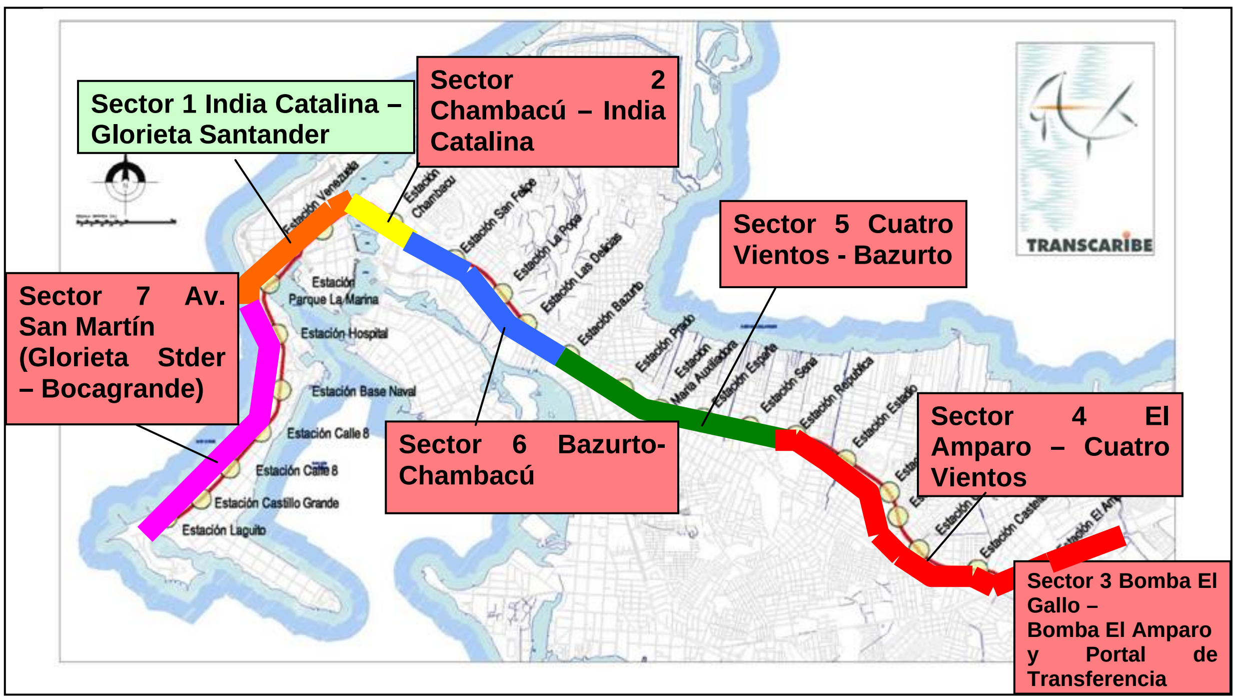

FIGURE IV.7 – Cartagena BRT System
Source: Colombian Ministry of Transport

Total length of the trunk corridors is 14.9 km, of which 1.3 km is already under construction. Total system cost is estimated at $229M, 60 percent to be provided by national government ($137M) and 40 percent to be provided by local government ($92M).

TABLE IV.6 - Capital Infrastructure Works and Bid Timing in Cartagena

	Length	Bid	Work
Stations	NA	Mar/06	May/06 – Mar/07
Sector 1 - India Catalina – Glorieta Santander	1.2 km	Aug/05	Oct/05 – Jul/06
Sector 2 - Chambacú – India Catalina	0.6 km	Nov/05	Jan/06 – Aug/06
Sector 3 - Bomba El Gallo – Bomba El Amparo y Portal de Transferencia	0.8 km	Mar/06	May/06 – Mar/07
Sector 4 - El Amparo – Cuatro Vientos	2.7 km	Nov/05	Jan/06 – Oct/06
Sector 5 - Cuatro Vientos – Bazurto	2.4 km	Jan/06	Mar/06 – Dec/06
Sector 6 - Bazurto-Chambacú	2.4 km	Mar/06	May/06 – Mar/07
Sector 7 - Av. San Martín (Glorieta Stder – Bocagrande)	4.9 km	Jan/06	Mar/06 – Jan/07