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Report on South American Bus Rapid Transit Field Visits:

Tracking the Evolution of the TransMilenio Model

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December 2007

Report on South American Bus Rapid Transit Field Visits:
Tracking the Evolution of the TransMilenio Model

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This report summarizes the background, status, and lesson from BRT plans and operations in three South American cities—Bogotá, Colombia; Pereira, Colombia; and Guayaquil, Ecuador— gathered through independent research, technical visits, and meetings with operators and officials on February 11-16, 2007. Pereira's Megabús and Guayaquil's Metrovía represent the latest generation of BRT systems in South America being modeled after Bogotá's very successful TransMilenio system. The findings of this report focus on observations about cost-effective investments and standards, service and operations models, and institutional models to improve the performance and sustainability of BRT. The findings of these visits were presented to technical audiences and the data collected will be incorporated into forthcoming BRT planning guidance for the Federal Transit Administration.

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1 inch (in)	=	2.5 centimeters (cm)
1 foot (ft)	=	30 centimeters (cm)
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1 mile (mi)	=	1.6 kilometers (km)

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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)
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LENGTH (APPROXIMATE)

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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)
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1 tonne (t)	=	1,000 kilograms (kg)
	=	1.1 short tons

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1 milliliter (ml)	=	0.03 fluid ounce (fl oz)
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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)

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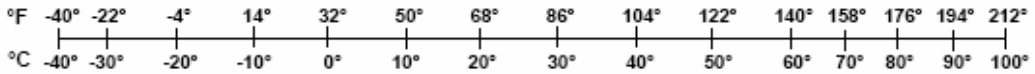

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Foreword

This report summarizes the background, status, and lessons learned from Bus Rapid Transit (BRT) plans and operations in three South American cities—Bogotá, Colombia; Pereira, Colombia; and Guayaquil, Ecuador. The information for this report was gathered through independent research, technical visits, and meetings with operators and officials on February 11-16, 2007. Pereira's Megabús and Guayaquil's Metrovía represent the latest generation of BRT systems in South America modeled after Bogotá's very successful TransMilenio system. This report points out some of the most notable similarities and differences between these systems and institutional models. 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.

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- The U.S. delegates, particularly Mr. Bill Vincent of Breakthrough Technologies, Ms. Lurae Stuart of APTA, and Ms. Pilar Rodriguez of TranSystems Corporation for helping organize the technical field visits and meetings
- The representatives from the Federal Transit Administration, Federal Highway Administration, Office of the Secretary of Transportation, and Department of Commerce in attendance during the briefing given in Washington DC on March 20, 2007
- The Honorable Jaime Nebot, Mayor of Guayaquil
- Mr. Federico von Buchwald, Mr. James Casteline, and Ms. Paola Carvajal from Metrovía
- Ms. Monica Vanegas and other managers from Megabús
- The Honorable Enrique Peñalosa, former Mayor of Bogotá, and Mr. Oscar Diaz
- Ms. Angelica Castro and other managers of TransMilenio
- Mr. Dario Hidalgo, formerly the Deputy General Manager of TransMilenio and Booz Allen Hamilton in Bogotá, Colombia
- Mr. Victor Raúl Martínez, CEO of Si99 in Bogotá
- The staff of UITP for organizing the successful conference in Bogotá

Finally, a special thanks to Mr. Venkat Pindiprolu and Ms. Helen Tann from the Federal Transit Administration for their guidance and oversight of this effort.

Executive Summary

This report summarizes the background, status, and lessons learned from Bus Rapid Transit (BRT) plans and operations in three South American cities—Bogotá, Colombia; Pereira, Colombia; and Guayaquil, Ecuador. Pereira's Megabús and Guayaquil's Metrovía represent the latest generation of BRT systems in South America modeled after Bogotá's very successful TransMilenio system. This report points out some of the most notable similarities and differences between these systems and institutional models. The information for this report was gathered through independent research, technical visits, and meetings with operators and officials on February 11-16, 2007.

Given the success of TransMilenio and Bogotá becoming a model for other cities throughout the world, the Colombian national government instituted a program to replicate the experience in at least six other Colombian cities suffering from over-saturation of colectivos, under-investment in infrastructure and/or inefficient operations. Pereira's Megabús is the first system to be delivered through this program. Most of all, Megabús demonstrates that the TransMilenio model can be successfully scaled down and adapted to a metropolitan area of less than 1 million without an adverse impact on performance or the economic viability of the system. In Guayaquil, as with Bogotá, the BRT system became the centerpiece of an urban renewal program that redeveloped public spaces and improved living conditions for its residents. The Metrovía Foundation represents a very lean institutional model with several advantages but also potential risks.

The lessons from TransMilenio are also important for adapting the model to local conditions and ensuring the sustainability of the system. In general, the implementation of the first phase was completed in a very short timeframe and several system details had to be adjusted after the start of operations. There are also ongoing discussions in Bogotá about how to improve TransMilenio operations and ensure the success of its planned expansion. Overcrowding in certain lines and hours of the day is degrading passenger comfort, thereby feeding competition from colectivos and unsupported or politically motivated statements for replacing TransMilenio. TransMilenio's management is currently evaluating a number of technically sound strategies to relieve overcrowding and improve operations in both the short and long-term. The TransMilenio institutional and business model has shown to be innovative and robust but may now face additional challenges as the network is extended.

This report also finds that the recent experience of Bogotá's TransMilenio and the evolution of this model in smaller cities of South America can offer valuable lessons for BRT planners and operators in the United States. The key findings include observations about the following:

- **Standardization and Cost Effectiveness**: As the TransMilenio model of BRT is further developed in Bogotá and replicated in other cities, there is increasing standardization of certain BRT elements while there are notable adjustments to others. Among the elements being implemented with increasing standardization are certain aspects of station, vehicle, and running way designs. The primary reason for standardization is to increase the cost effectiveness of capital and operating investments, but also to greatly simplify the design and implementation of the project.

- **Service and Operational Models**: Experience from the three cities visited and other BRT systems in the U.S. and abroad show that service and operational models can have an important impact on system success from the perspective of the authority, operator,

customer and the public. Specifically, service and operational models can differ in (1) the network approach, (2) service integration approach, and (3) operations strategy.

- **Institutional Models**: A literature review and the recent experiences of the South American BRT systems suggest the importance of institutional, regulatory and business issues from planning and implementation to operations. The different institutional models can be distinguished by the quality and scope of (1) leadership, (2) authority to regulate and implement, (3) funding and financing, (4) organization and management, and (5) education and marketing.

1. Introduction

The National Bus Rapid Transit Institute (NBRTI) of the Center for Urban Transportation Research, in collaboration with the American Public Transportation Association (APTA) and Breakthrough Technologies Institute (BTI), organized technical tours and meetings in three cities operating the latest generation of Bus Rapid Transit (BRT) systems in South America. The program focused on opportunities to maximize capital and operating efficiencies with BRT and was made available to representatives of the U.S. transit industry to participate at their own cost.

1.1 Purpose and Objectives

Among the objectives of the field visits and meeting was to document best practices and lessons learned in BRT infrastructure and service planning to improve performance and financial sustainability. The findings of these visits were presented to technical audiences at the Federal Transit Administration, the annual APTA bus conference, and at other industry events to maximize dissemination. The data collected is also to be incorporated into the Federal Transit Administration (FTA) planning guidance for BRT, including the "Characteristics of Bus Rapid Transit for Decision-Making," being updated in 2007 by NBRTI.

1.2 Program

The one-week program included technical visits and meetings with a number of key government officials, project representatives and system operators in the following three cities:

- February 11-12, 2007 – Guayaquil, Ecuador
  - Technical tour of Metrovía BRT system, control center, and terminals
  - President of Metrovía, Mr. Federico von Buchwald, and key managers
  - Mayor of Guayaquil, Hon. Jaime Nebot
- February 13, 2007 – Pereira, Colombia
  - Technical tour of Megabús BRT system, control center, and depot
  - General Manager of Megabús, Ms. Monica Vanegas and key managers
  - Megabús operating companies
- February 14-16, 2007 – Bogotá, Colombia
  - Technical tour of TransMilenio BRT system and its largest depot
  - Former Mayor of Bogotá, Hon. Enrique Peñalosa
  - General Manager of TransMilenio, Ms. Angelica Castro and key managers
  - CEO the largest TransMilenio bus operator, Mr. Victor Raul Martinez
  - Fare Collection and Control System Operators for TransMilenio
  - International Union of Public Transportation (UITP) 5th Bus Conference on "Bus Systems without Limits" in Bogotá

1.3 Delegates

Among the 12 delegates who participated in these field visits were planners and engineers representing diverse organizations throughout the U.S.:

- Public Transit Agencies:
  - David Tomzik, Pace Suburban Bus, Chicago, IL
  - John Cullen, TARC, Louisville, KY
  - Paul Bignardi, San Francisco MTA, CA
  - Ron Garrison, StarMetro, Tallahassee, FL
- Industry Consultants:
  - Pilar Rodríguez, TranSystems Corporation, Puerto Rico
  - John Mason, HDR Inc., Atlanta, GA
- Researchers and Other Industry Representatives:
  - Alasdair Cain, NBRTI, University of South Florida
  - Georges Darido, NBRTI, University of South Florida
  - Lurae Stuart, APTA, Washington DC
  - Nancy Schneider, South Florida Regional Planning Council, FL
  - Scott Rutherford, University of Washington, Seattle, WA
  - William Vincent, Breakthrough Technologies, Washington DC

2 Background

2.1 Characteristics of Bus Rapid Transit (BRT)

The seminal guidance documents[1] on Bus Rapid Transit define it as an integrated system of high-performance and cost-effective transit elements that are designed and implemented to best fit local conditions. The following sub-sections describe the elements, performance, and benefits of BRT.[2]

2.1.1 Major Elements of BRT

The National Bus Rapid Transit Institute (NBRTI) is currently updating the "Characteristics of Bus Rapid Transit" document for the Federal Transit Administration (FTA). This document identifies the major elements, performance measures, and benefits of BRT as the following:

1. Running Ways – BRT systems can operate on a variety of running way types that range from mixed flow arterials and freeways, dedicated arterial and shoulders lanes, exclusive at-grade busways, to fully grade-separated transitways above or below the surface.
2. Stations – Aesthetically designed stations enhance the permanence and attractiveness of the system and station areas with passenger amenities such as shelters, benches, lighting, ticket vending machines, security features, and next vehicle arrival information.
3. Vehicles – Stylized and specialized buses provide comfort, modern design, accessibility, maintainability, good passenger circulation, and environmentally-friendly propulsion.
4. Intelligent Transportation Systems – Applications such as transit signal priority (TSP), advanced communication systems, automated scheduling and dispatch, and real-time traveler information at stations and on vehicles allow faster and more convenient trips.
5. Fare Collection – Electronic fare cards, off-board fare collection, or proof-of-payment options allow for shorter dwell times and shorter overall travel times.
6. Service and Operations Plan – BRT systems generally include rapid transit features like more frequent service than local bus service, all-day service spans, and greater spacing between stations. The flexibility and lower-cost of BRT allow it to provide greater network coverage.
7. Branding and Marketing – Distinctive logos, colors, styling and technologies for vehicles and facilities help develop a system identity. BRT services can be marketed as a new tier of service or as part of a multi-modal rapid transit network.

The selection and integration of these elements and their implementation over the length of the alignment and over time is also an important consideration in BRT planning. As with any truly integrated system of elements, the whole is greater than the sum of the parts.

[1] The reader is referred to the "Characteristics of BRT for Decision-Making" (Diaz et al., 2004) and TCRP Report 90 Volume 2: BRT Implementation Guidelines (Levinson et al., 2003).
[2] For additional information on the state-of-practice for BRT, the reader is referred to Cain, Darido et al. (2007) in the May 2007 issue of *Mass Transit* magazine.

2.1.2 BRT System Performance

Among the most important measures of performance for a BRT system are:

- Increased capacity – The maximum number of passengers carried by a critical segment of the BRT system in a period of time is a function of the size and design of the vehicles, stations, running way and the level of service. For instance, the maximum number of passengers carried per hour per direction typically ranges from 10,000 on arterials to more than 40,000 on exclusive running ways, which is comparable to the capacities of some rail-based transit systems.
- Decreased travel time – Exclusive busways have been shown to operate at an average of 30 miles per hour or more with travel time savings as high as 55 percent compared to regular bus services.
- Increased reliability – The use of exclusive running ways, level boarding, off-board fare collection and automated vehicle location technologies allow for greater service reliability in terms of running time, dwell time and recovery.
- Improved accessibility – The design of vehicles, stations, ITS, and fare collection systems can greatly influence the accessibility of a BRT system to the mobility impaired and the general ridership as well.
- Increased safety and security – The combination of modern technologies, facilities, and personnel can improve the customer perception of safety and security and reduce the number of incidents.
- Enhanced identity and image – The effective integration of the various elements can foster a quality image and unique identity for the BRT system as measured by public perception.

2.1.3 BRT Potential Benefits

The potential benefits of a BRT system depend on the element and performance, and can be characterized by the following measures:

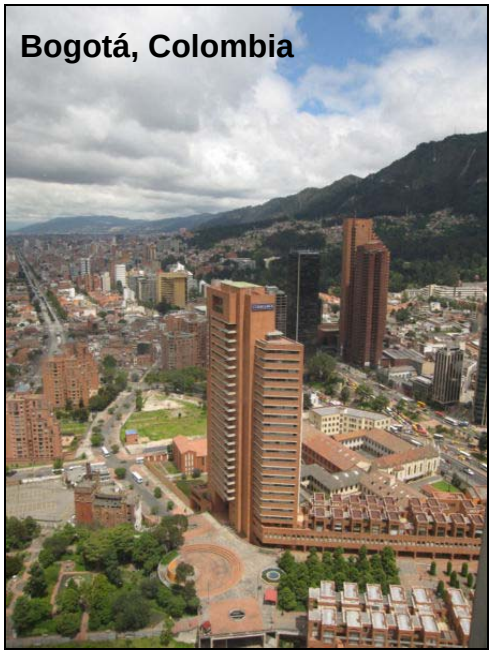
- Increased ridership – BRT systems have been shown to attract choice ridership and increase total corridor ridership. As much as one-third of BRT riders have been shown to previously use private automobiles. Corridor ridership gains of 20 percent to 96 percent have also been recorded.
- Improved capital cost effectiveness – BRT systems can use less costly or existing infrastructure compared to other rapid transit modes. BRT can also reduce fleet requirements with better vehicle utilization.
- Improved operating cost efficiency – Indicators of operating efficiency such as passengers per revenue hour, subsidy per passenger mile, and subsidy per passenger can improve when BRT service is introduced to a corridor.
- Improved environmental quality – By attracting choice riders and using advanced vehicles with cleaner propulsion systems and emissions controls, BRT may improve air quality, noise level and help reduce overall congestion.
- Transit-supportive land development – Investments in BRT infrastructure and related streetscape improvements may result in positive development effects much like other high-quality transit modes.

2.2 Cities Visited

The cities visited range in size from less than a million to over 8 million. **Exhibit 1** presents a map of the Andean region of South America and photographs of the three cities:

1. **Bogotá** is the capital of Colombia and the country's most populous city with 8 million inhabitants in its metropolitan area. The Gross Domestic Product (GDP) per capita in Colombia considering purchasing power parity is US$8,400 in 2006 or about 1/5th of the United States (CIA World Factbook, 2007). This is higher in Bogotá as it is the business and commercial center of the country. TransMilenio began operations in December 2000 and is one of the premier BRT systems in the world. TransMilenio currently includes over 50 miles of exclusive busways carrying 1.3 million passengers per day.
2. **Pereira** is a provincial capital of about 550,000 inhabitants in the coffee growing region of Colombia's western Andes. The metropolitan area of 700,000 inhabitants includes the neighboring cities of Dosquebradas and Cuba. In October 2006, the Megabús BRT system began operations with 17 miles of exclusive lanes now carrying over 100,000 passengers per day.
3. **Guayaquil** is a port city of 2.5 million inhabitants is the most populous city in Ecuador. The Gross Domestic Product (GDP) per capita in Ecuador considering purchasing power parity is US$4,500 in 2006 or about 1/10th of the United States, although it tends to be higher in larger cities such as Guayaquil (CIA World Factbook, 2007). BRT operations started in August 2006 on the first 10-mile segregated corridor, which now carries over 100,000 passengers per day. Two additional corridors are planned by 2008 as part of the Metrovía BRT system.

Exhibit 1: Map of Andean Region of South America and the Cities Visited[3]



2.3 Urban Transportation Prior to BRT

In many cities of Latin America and other cities of the developing world, the traditional system of urban transportation is loosely regulated and privately-owned vehicles (referred to here as *colectivos*) dominate public transportation services. An unregulated or open market existed in some form in Bogotá, Pereira and Guayaquil before the implementation of BRT. Such an environment encourages on-the-street competition for passengers, known as "penny wars," and low occupancies drive down fares to levels insufficient for reinvestment in vehicles and infrastructure. The vehicles tend to stop anywhere to pick up and drop off passengers, which create unpredictable congestion in mixed traffic and poor service quality. Although the typical wait times for service is relatively short because of the large demand in these cities, in-vehicle

[3] Images courtesy of the CIA World Factbook maps, Metrovía Foundation (Guayaquil) and wikipedia.org public domain photo gallery (Bogotá and Pereira)

travel times can be very long. This inefficiency in operations using older and poorly maintained vehicles emits more pollutants and is less safe than a more modern and orderly BRT system.

2.4 Regulatory Models

Exhibit 2 characterizes the wide spectrum of regulatory models from an open market to a monopoly by public transportation function. The models in between the extremes are, in fact, variations of public-private partnerships (PPP). Moreover, some functions in these PPPs may require public and private agents to work together under a pre-defined agreement or overarching regulation.

There are a number of successful examples of BRT implementation acting was a mechanism for allowing local governments to establish effective regulatory control over largely privatized transit systems. Most of these examples came about with the transformation of the regulatory and institutional model over the public transport sector. In fact, Hook (2005) uses Bogotá TransMilenio as a prime example of this. **Exhibit 2** highlights the regulatory model in effect in Bogotá with TransMilenio, which lies between "Regulated Competition" and a "Tendering/Contract Management" approach. Both Pereira and Guayaquil also demonstrated this by reforming from a largely "Unregulated/Open Market" to a model very similar to Bogotá's. These similarities and differences are discussed in the next section.

In some cities, as documented by Hidalgo et al. (2007), there were initial problems that were quickly resolved within the first few months of operations. In at least one case, that of Transantiago in Chile, there were problems with the implementation of key components of the BRT plan which are still to be resolved.

Exhibit 2: Regulatory Models for Public Transport
Adapted from Darido (2003)

Public Transport Function:	**Unregulated/ Open Market**	**Regulated Competition**	**Trans-Milenio Model**	**Tendering/ Contract Management**	**Performance Agreement**	**Public Monopoly**	**Private Monopoly**
Financing	Private	Private	***Private/ Public***	Private/ Public	Public	Public	Private
Ownership of Infrastructure	Private	Private	***Public***	Private/ Public	Public	Public	Private
Ownership of Rolling Stock	Private	Private	***Private***	Private/ Public	Public	Public	Private
Planning/Service Definition	Private	Private/ Public	***Public***	Public	Public	Public	Private
Fare Setting	Private	Private/ Public	***Public***	Public	Public	Public	Private
Revenue Collection	Private	Private	***Private***	Private/ Public	Public	Public	Private
Labor Contract Management	Private	Private	***Private***	Private/ Public	Public	Public	Private
Operations and Maintenance	Private	Private	***Private***	Private	Private	Public	Private

3 Summary of BRT Systems Visited

The following sections describe the BRT systems operating in Bogotá, Pereira, and Guayaquil. **Exhibit 3** summarizes the principal characteristics of the 3 systems and **Exhibit 4** summarizes select performance measures.

Exhibit 3: Summary of BRT System Elements

System (as of 2/2007)	**Bogotá TransMilenio**	**Pereira Megabús**	**Guayaquil Metrovía**
Start of Operations	Phase I: 2000 Phase II: 2003	10/2006	8/2006
Running Ways	52 miles of exclusive median busways (one and two lanes in each direction)	17 miles of exclusive busways (median and one-way streets)	10 miles of exclusive busways (median and one-way streets)
Stations	- 117 stations (high platforms, enclosed with sliding doors) - 13 terminals	- 35 stations (high platforms, enclosed with sliding doors) - 2 terminals	- 34 stations (high platforms, enclosed with sliding doors) - 2 terminals
Vehicles	- 900 articulated (approx.) - 400 feeders (approx.)	- 51 articulated - 81 feeders	- 40 articulated - 40 conventional buses - 44 feeders
ITS	- Control center tracking vehicle location using loop detector and station sensors - Passenger information signs	- Control center tracking vehicle location using transponders on trunk-line buses - Passenger info. signs	- Control center tracking vehicle location using transponders on trunk-line buses - Passenger information signs
Fare Collection	- Approx. US$0.55 flat fare (30 percent premium over traditional services) - Contactless fare cards (entry and exit validation)	- Approx. US$0.45 flat fare (same as traditional services) - Contactless smartcards (entry-only validation)	- Approx. US$0.25 general (approx.) and discounted fares - Cash (95 percent) and Contactless smartcards (5 percent)
Service and Operations Plan	- 9 routes (zones) on 7 busways with express services and integrated feeder network - Typical headways 1-3 minutes	- 3 routes (1 city, 1 city circulator, 1 express) through downtown and integrated feeder network - Typical headways 3-5 minutes	- 1 line (10 mile exclusive); 1 route (splits in downtown) - Typical headways 4-6 minutes (peak and off-peak)
Marketing and Branding	- Branded vehicles, stations, running way, fare cards, and different levels of service - Red trunk-line articulated buses - Green feeder buses	- Branded vehicles, stations, running way, and fare cards - Green trunk-line articulated buses - Yellow feeder buses	- Branded vehicles, stations, running way, and fare cards - Blue trunk-line articulated buses

Exhibit 4: Select Performance Measures and Other Characteristics

System (as of 2/2007)	Bogotá TransMilenio	Pereira Megabús	Guayaquil Metrovía
Ridership (Boardings)	1.26 million daily	>100,000 daily	>100,000 daily
Capacity (Maximum)	45,000 pax in peak direction in peak hour	5,000 pax in peak direction in peak hour	5,000 pax in peak direction in peak hour
Average Operating Speed	22-26 kph (14-16 mph)	20 kph (13 mph)	22 kph (14 mph)
Accessibility	Stations are fully accessible with ramps from streets and level boarding between the stations and vehicles	Stations are fully accessible with ramps from streets and level boarding between the stations and vehicles	Level boarding between the stations and vehicles
Infrastructure Capital Cost per Mile (without vehicles)	Phase I: US$9.4 million Phase II: US$21.3 million	US$3.8 million	Phase I: US$2.1 million
Financing of System	- Infrastructure: 25 percent National Government (including World Bank loans), 80 percent Local Government revenues - Vehicles: Private	- Infrastructure: 70 percent National Government (including World Bank loans), 30 percent Local Government - revenues - Vehicles: Private	- Infrastructure: City financing first 3 routes using CAF loan (70 percent) and local revenue - Vehicles: Private
Administrative Employees	About 280 employees (80 office and 200 in field)	22 employees overseeing 940 contract employees	12 employees
Capital Cost Efficiency (Boardings per Vehicle per Day)	1000 (approx.)	750 (approx.)	1250 (approx.)
Operating Cost Effectiveness (Boardings per Vehicle Km)[4]	5.3	6.0	8.0
Planned System	241 miles total by	Additional infrastructure	7 routes (100 miles); routes 2 and 3 by 2008

Bogotá

Pereira

Guayaquil

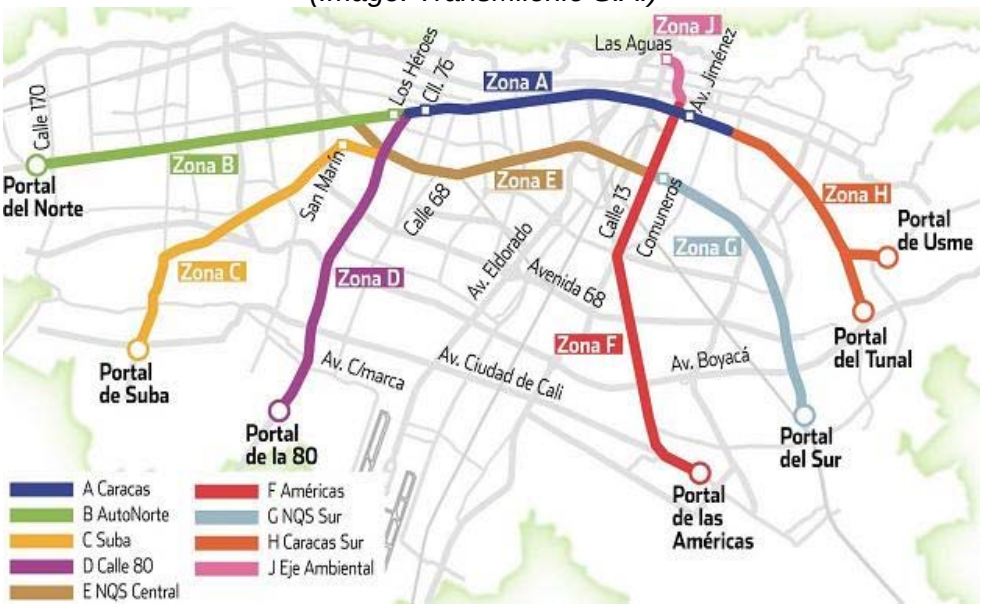
[4] Hidalgo et al. 2007

3.1 Bogotá, Colombia – TransMilenio

TransMilenio is one of the premier BRT systems operating in the world. Before TransMilenio, private buses and mini-buses known as busetas or colectivos dominated transit services in Bogotá. The TransMilenio system replaced a significant number of older colectivos on major corridors with newer or larger vehicles. The result has been a more efficient system that has improved the mobility of millions of people without any operating subsidies. TransMilenio was also part of an urban renewal program led by then Mayor Enrique Peñalosa bringing other improvements to the city such as new public spaces, pedestrian streets, and about 150 miles of bicycle paths connecting with the TransMilenio system (Vincent, 2007).

Like Curitiba's Integrated Transport Network, TransMilenio in Bogotá is described as a high-quality surface metro operating rubber tire vehicles. The first two phases of TransMilenio, including some 52 miles of median busway (pictured in **Exhibit 5**), are currently in operation carrying about 1.26 million passengers on an average weekday or about one-quarter of all transit trips. TransMilenio is one of the highest capacity bus systems in the world carrying a maximum 45,000 passengers per hour in the peak direction (pphpd) on its busiest trunk-line segment according to its operation managers.

Exhibit 5: Current TransMilenio System Network (Phases I and II)
(Image: TransMilenio S.A.)



TransMilenio's remarkable performance in terms of capacity and operating efficiency is due to a trunk and feeder design serving very high demand corridors throughout the city with the following features:

- Exclusive running ways with one or two lanes in each direction permit high operating speeds, passing, and interlining of local, limited stop, and express services. According to TransMilenio, about 75 percent of passengers use limited stop and express services (Vincent, 2007).
- Articulated, 18-meter vehicles with multiple doors have a capacity of 160 passengers using a standard of 7 passengers per square meter. An adjustment can account for the lower U.S. or European loading standard of about 3 or 4 passengers per square meter. Cain et al. (2007) estimate the capacity of TransMilenio using a U.S. loading standard of 100 passengers per bus at approximately 28,000 pphpd, which is two to three times larger than previous estimates for busway system.
- Service frequencies are as high as 280 buses per hour per direction on the busiest trunk-line segments (Cain et al., 2007). A control center regulates the operations using proven technologies. The frequency of service determines average passenger wait times and overall system capacity. In Bogotá, headways are as low are two to three minutes for individual routes, resulting in combined headways as low as 13 seconds for the busiest sections.
- The stations are enclosed with multiple glass doors that open upon bus arrival, high platforms to allow level boarding, electronic information signs to inform passengers and other amenities found in a typical urban rail station. Most stations are 5 meters wide with modular construction using metal and glass.
- Off-board fare collection using a contactless smart card at the station entrance minimizes dwell times. As of this writing, fare cards can be recharged in cash only and by attendants at station entrances.
- Feeder routes and transfers within the system are free. Feeder buses serve terminal stations, where passengers can easily transfer to a trunk line and vice versa. About half of all passengers access the system via feeder buses (Vincent, 2007).

As with any transit system, there are ongoing discussions about how to improve TransMilenio operations and ensure its planned expansion is successful. The following sections summarize the operational, user information, contractual and implementation issues currently in discussion.

3.1.1 Operational Issues

Current ridership is lower than was projected for phase II (1,260,000 versus 1,400,000 passengers per day). Ironically, this is in part because of overcrowding in certain lines and hours of the days and the potential degradation of the passenger experience, but also from competition by busetas and colectivos. TransMilenio fares are 30 percent higher than most colectivos (1300 versus 1000 Colombian pesos). These traditional vehicles were supposed to be restricted from TransMilenio corridors, but are competing for the most cost-sensitive passengers on some parallel roadways.

Overcrowding during peak periods has gotten worse because a more advanced control system based on vehicle location technology has not been operational since May 2006. TransMilenio has had to rely solely on infrared sensors at stations. The lack of precise location information makes it more difficult to balance transportation supply and demand, so there are larger variances in passenger loads per vehicle as some buses run extremely full while others have

excess capacity. At the same time, the contractor has been asked to provide more buses to alleviate the overcrowding thereby increasing operating costs, but overall vehicle occupancies have not improved. According to some operators, this reduced efficiency threatens the profitability of TransMilenio.

In fact, overcrowding has become a political issue with candidates campaigning for the October 2007 mayoral election. The former mayor Enrique Peñalosa is among the candidates running for mayor. Opponents have attacked TransMilenio as Peñalosa's "pet project" while proposing a multi-billion dollar subway as the only solution to overcrowding, particularly on the "Septima" corridor that is part of TransMilenio's Phase III. It is important to note that subway proposals in Bogotá have been rejected several times and most recently in the late 1990s in favor of BRT on the grounds of capital cost effectiveness and the insufficient coverage a rail network would provide (Cain et al., 2006).

Peñalosa characterizes overcrowding not as a capacity issue, but as an operations and financial issue. TransMilenio could provide more express services, but current operating costs are too high. Therefore, he believes TransMilenio should reduce travel times and operating costs by implementing grade separation (e.g. underpasses) or prioritization at key intersections. The savings would allow for more express and super-express services, which can utilize the excess capacity in the outer lane. In the longer term, he also proposes better integration with traditional system and implementing additional parallel trunk corridors as planned in future phases.

TransMilenio's management is currently evaluating a number of proposed short-term strategies to relieve overcrowding and improve operations. First, they hope have an upgraded control system fully operational with cameras and citywide coverage to reduce bus bunching and the resulting load imbalances. Second, they are investigating transit signal priority and coordination to allow for shorter delays at intersections. This strategy will only be effective at intersections not already operating at capacity. Third, they are considering larger stations and longer vehicles (bi-articulated) for express services, but this will require significant capital investment. Fourth, they are looking to increase short-turning capabilities for greater operational flexibility. Fifth, they plan to diversify the points of sale for fare cards by installing machines in convenience stores and other locations frequented by passengers. Placing fare machines outside the stations would reduce wait times to purchase or reload cards.

3.1.2 Implementation Issues

The capital cost for the TransMilenio infrastructure was between US$9.4 million and US$21.3 million per mile for Phases I and II, respectively. This is a fraction of the cost for a comparable rail system, even considering the total lifecycle costs (Cain et al., 2007). Some of this difference between Phases I and II can be explained by the level of investment in other infrastructure (e.g., right-of-way acquisition, general traffic lane improvements, intersections, sidewalks and utilities) rather than the TransMilenio costs themselves (i.e., exclusive lanes, stations, terminals, pedestrian overpasses, and studies and designs). However, some observers believe that better control of the design and construction could reduce lifecycle costs further.

The implementation of the first phase in general was done in a very short timeframe and several system details had to be adjusted after TransMilenio started operations. Hidalgo et al. (2007) identify several implementation issues with TransMilenio that perhaps could have been improved upon. For example, some segments of pavement are deteriorating prematurely because of inadequate design, installation or maintenance. Secondly, the metal flooring and 5-meter width of certain stations have proven to be inadequate for the high passenger flows.

Thirdly, there were initial problems with fare collection system that could have been mitigated with more time and greater supervision. TransMilenio is currently reevaluating its system of selling and recharging fare cards to allow for an external network. Moreover, TransMilenio managers now recognize the importance of bicycle facilities as feeders to the system and would have made use of more extensive network of bikeways.

As TransMilenio moves forward on expanding the network of trunk corridors, there is a need to better integrate the traditional bus system, which still carries 75 percent of the city's transit trips. For instance, the corridors in the second phase could perform better with further reorganization of the feeders and enforcing the restriction on colectivos competing with TransMilenio. TransMilenio is currently planning a third phase of expansion (pictured in purple in **Exhibit 6**) with the goal of reaching a majority of the city's population within half a kilometer from a trunk line. The 241-mile master plan has an ambitious goal of serving 85 percent of the city's transit trips, which would be the vast majority of all trips in all modes.

Finally, many TransMilenio passengers were confused by service changes that occurred after the opening of Phase II. In 2006, revised maps and other public information attempted to reorganize the corridors into nine zones as illustrated in **Exhibit 5**. Additional user education efforts before the opening of Phase II and the service changes would have lessened the confusion (Hidalgo et al. 2007). Service maps for terminal stations, such as the one picture in **Exhibit 7**, are particularly complex.

Exhibit 6: TransMilenio System and Feeder Network (Phases I, II, and III)
(Image: TransMilenio S.A.)

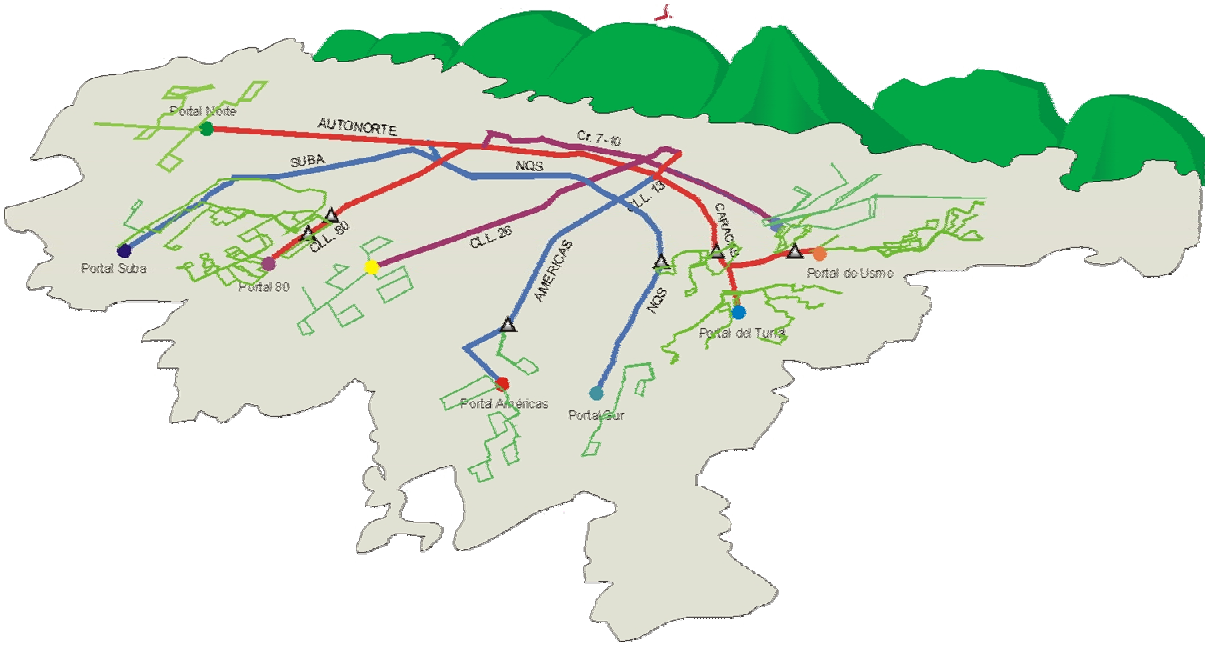
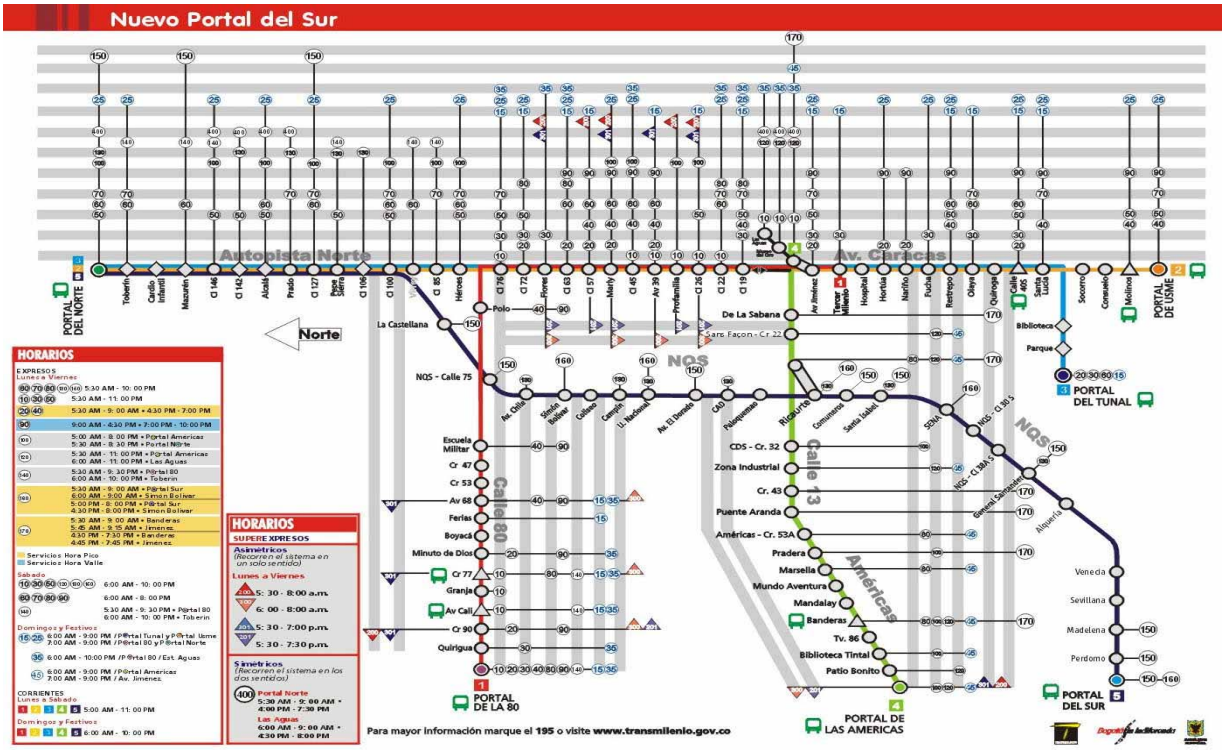


Exhibit 7: Terminal Station Map of Services
(Image: TransMilenio S.A.)



3.1.3 Contractual Issues

The TransMilenio institutional and business model is innovative for several reasons. The local government recognized early on the importance of creating a separate and dedicated team and organization for the planning, implementation, and regulation of the system. TransMilenio S.A. was able to tender and currently manages a total of 7 trunk-line and 6 feeder zone concession contracts for bus operations. Five private companies were formed with participation from traditional colectivo operators. According to TransMilenio, operators are currently paid about $2.2 per kilometer of service provided and about 240,000 km of service is provided on the trunk lines every weekday. The contracts between TransMilenio and the private operators require specific maintenance procedures and do not allow the fleet average to exceed 850,000 km per vehicle, which is roughly equivalent to 10 years under the current average of kilometers per year.

According to some bus operators, there were significant changes in the contracts between Phase I and Phase II. First, the contracts for Phase I took only 7 months to negotiate while the contracts for Phase II took 32 months. Second, the percentage of fare revenue to TransMilenio S.A went up from 4 percent to about 7 percent. Third, the percentage of revenue set aside for the fare collector was also increased to over 10 percent. Fourth, the ratio defining the replacement of old colectivos for a new TransMilenio bus was increased from 3:1 to 8:1. Fifthly, the security function, which was a TransMilenio responsibility under Phase I, became a contractor responsibility under Phase II. Finally, the coverage of the feeder network was

increased by raising the share of total fare revenue used to subsidize this free service. In essence, feeder bus operators are remunerated through the fares collected at the trunk stations and up to 20 percent of total fare revenue can now be used to support feeder bus operations.

Contractors have expressed concern that the terms of the Phase II have become less favorable for bus operators and may threaten profitability. The more extensive feeder networks are more expensive to operate and need to be subsidized by the trunk services. Feeders often get stuck in traffic like colectivos because of the lack of dedicated running ways. Operators have suggested that a possible solution is to provide “pre-trunk” bus lanes for feeders to lower their operating costs. Moreover, revenues are lower than expected because ridership has not met projections. The national government may also put additional pressures on profitability by reducing subsidization of diesel prices for large consumers such as bus companies and mandating discounts to special groups such as students, the elderly, and the disabled.

3.2 Pereira, Colombia – Megabús

In contrast to Bogotá, Pereira is a much smaller metropolitan region of about 700,000 people but with a similar integrated BRT system of dedicated lanes, stations, vehicles, services, and systems branded as Megabús. Megabús opened in 2006 being modeled after the highly successful TransMilenio system. As with many other Latin American BRTs, Megabús is a public-private partnership using a contract management model to replace colectivos at a predetermined ratio with a newer and more efficient system. In this case, the goal was eight colectivos for every new BRT vehicle. To date, some 280 colectivos have been replaced out of a fleet of 113 colectivos operating in the city before Megabús (Vincent, 2007).

Megabús has proven to be a successful adaptation of the TransMilenio system. There are some notable differences between the system that are driven in part by differences in the market size, the availability of right-of-way, and key lessons from the TransMilenio experience. Among the similarities and differences are:

- As with TransMilenio, Megabús is a closed (i.e., trunk and feeder) system with terminal stations where passengers can transfer between feeder buses and trunk lines. It includes 17 miles of exclusive busways (one lane in each direction) not only in the median of large boulevards, but also in narrow downtown streets. Providing bus-only lanes in each direction required innovative network design and considerable reallocation of road space. First, Megabús uses three color-coded routes—one local direct (red), one circulator (blue), and one express (green) as shown in **Exhibit 8**— to serve the downtown area and corridor between two municipalities. The local route separates in the downtown area to take advantage of narrow one-way or bus-only streets that were created after removing some parking space and one lane of traffic. Secondly, some sidewalks were also widened and cars on those streets were prohibited except for access to off-street parking in existing buildings and alleys (see **Exhibit 9**).
- Like TransMilenio, Megabús has a flat fare (no discounts) collected using contactless smartcards with off-board sales at stations. However, fare cards can also be reloaded at 60 external locations around the city (including lottery machines and pharmacies) as part of a point-of-sale network managed by a single fare system contractor. Another innovation involving the private sector was to sell advertising space on the back of the fare cards which covered their wholesale cost (about US1.50 each).
- Cash and paper tickets were used in first month of operations as initial problems with the fare system and a shortage of fare cards were being resolved (Hidalgo et al. 2007). About 200,000 fare cards were initially distributed free with purchase of four trips or more. After that, some 50,000 additional smartcards were sold for US$2.00. Passengers also have the option of registering their fare cards, which allows additional security and one trip of negative balance.
- The Megabús feeders are not free as with TransMilenio. The benefit of this strategy is that the feeder network is not subsidized by the trunk-line services, thereby lessening the potential financial pressure of network expansion. On the other hand, on-board smartcard readers and turnstiles had to be installed on board feeders and require passengers to board through one door and alight through the other door at stations (see **Exhibit 10**). The tradeoff is in the additional dwell time for feeders.
- As in Bogotá, the vehicles are color-coded. Trunk line vehicles are green articulated buses while feeders are yellow mini-buses. The feeder vehicles are smaller (approximately 25 feet in length, as pictured in **Exhibit 10**) and more maneuverable than conventional buses so they are better able to serve the demand in neighborhoods and activity centers and operate

in mixed traffic. The trunk-line articulated vehicles are essentially identical to those used by TransMilenio.

- Megabús currently has two private operators under 12-year contracts each company running both trunk services and feeders. This is different from TransMilenio where different companies run trunk and feeder vehicles. This mixed approach ensures that the operators have similar cost structures to promote cross-subsidy if one type of route is less profitable than the other.
- Like TransMilenio, stations are of a uniform high-platform design and enclosed with automatic glass doors corresponding to bus doors opened by the driver (see **Exhibit 9**). Stations also include electronic signs with bus arrival information based on bus locations tracked by infrared sensors and a fiber optic network linking the stations. Among the 35 stations, there are two types— simple and double. The simple stations are narrower at about 3 meters wide (see photograph in **Exhibit 4**) are used primarily by the city and circulator routes in the space-limited downtown. Although very similar to TransMilenio, the station design was improved with sturdier floors and an overhang to cover passengers as they board the bus.

Exhibit 8: Map of Megabús Routes

Images: Megabús S.A.

Exhibit 9: Downtown Bus-Only Lane and Typical Enclosed Station

(Images: Bill Vincent)

Exhibit 10: Typical Feeder Vehicle, On-Board Fare Collection System and Feeder Network
(Images: Bill Vincent and Megabús S.A.)

Megabús currently carries more than 100,000 passengers per day and is expected to carry more than 140,000 when all infrastructure is completed. It became apparent that two terminal facilities were not going to be completed in time for the system opening in October 2006, so smaller temporary structures were built that are currently limiting the capacity of the system. Hidalgo et al. (2007) identify other issues with the implementation that threatened to delay the project. First, the approvals from the national government and World Bank for funding and local approval for the utility work were delayed. The inexperience of the implementation team and discussions with the local engineering trade union may have also impacted the project. Finally, changes in project scope after the design phase also delayed the project. Although no other implementation problems were reported, it remains to be seen if premature pavement deterioration will become a problem as with TransMilenio.

Most of all, Megabús demonstrates that the TransMilenio model can be successfully scaled down and adapted to smaller cities without an adverse impact on performance or the economic viability of the system. As with TransMilenio, Megabús operates with no subsidies. The capital cost of the infrastructure was US$60 million, 70 percent of which came from the national government and 30 percent was financed using a local gasoline tax.

The Megabús project required resolute political will from three different mayoral administrations, and Colombian government support through the National BRT Policy and Urban Transport Program. The project complemented urban renewal initiatives by creating transit and pedestrian-friendly environments. According to Hidalgo et al. (2007), resettlement policies minimized social disruption and gave fair compensation to affected residents. Good coordination was especially necessary as more than one jurisdiction was involved.

According to the city, Megabús also enabled a 2 percent mode shift from private cars to transit citywide and about 10 percent of Megabús users have access to a car. These are impressive figures particularly considering that about half of all trips in the region are already made on transit. In fact, Megabús is seeking approval of a methodology to trade CO_2 emissions under the Kyoto protocol as TransMilenio has done.

3.3 Guayaquil, Ecuador – Metrovía

Guayaquil is a port city of about 2.5 million people located on the banks of the River Guayas in Ecuador. After many years of worsening poverty and deteriorating infrastructure, Guayaquil has made significant progress to redevelop public spaces and improve livability for its residents since the 1990s. As with Bogotá, a BRT system was the centerpiece of the urban renewal program in Guayaquil. The current mayor, Jaime Nebot, came into office in 2000 with the goal of prioritizing and improving public transportation. The result was the establishment of the non-governmental Metrovía Foundation charged with BRT system planning, administering contracts with private sector partners, and controlling system operations and quality.

The Metrovía BRT is a trunk and feeder system, like TransMilenio, intended to replace a traditional system of colectivos along major corridors. Planning for Phase I was started in 2001 with support from the United Nations Development Program and consultants from Bogotá and Curitiba. Construction began in 2003 and the first line began operation in August 2006 with 10 miles of exclusive bus lanes serving a north-south route with 34 high-platform stations and two terminals at Rio Duale and El Guasmo as illustrated in **Exhibit 12**. Among the more significant and innovative characteristics of Metrovía are:

- The stations stops are more narrowly spaced (i.e., less than 500 meters) and the route splits along two one-way busways in order to maximize the coverage in the dense and narrow downtown area.
- The stations and terminals were key investments in terms of both function and design. Not only are they aesthetically pleasing, but also appropriately sized for the system. The terminals in particular are large and open with architecture reminiscent of old train stations in Europe (see photo in **Exhibit 12**). As in Pereira, transfers between trunk and feeder buses are free. Metrovía reported that all 34 stations, the terminal at Guasmo, and the terminal at Rio Duale cost US$3.2 million, US$5.5 million, and US$8.3 million and were constructed in 12, 16, and 9 months, respectively.
- According to Metrovía, 83 percent of trips in Guayaquil are made by transit. Of the 5,000 colectivos competing for passengers on the streets before Metrovía, about 250 have been replaced by the first line that operates 40 articulated buses and 40 standard buses.
- Although the Metrovía Foundation was chartered by the city, it is able to maintain a level of independence by funding its own operations from space rents and advertisement on the Metrovía system as opposed to city funds or fare revenue.
- Metrovía in general has only one dedicated lane in each direction. However, future lines currently being planned and constructed will have two dedicated lanes per direction in critical areas to allow passing and express services.
- The fare and control system procurements were combined to encourage integration and design efficiency. Metrovía received two bids, and the selected contractor was made up of a consortium between a Brazilian fare equipment company and an Ecuadorian telecommunications company. This consortium financed the implementation of a dedicated fiber optic network connecting all stations and terminals. The functions of this network include telecommunications, fare collection equipment data, and bus monitoring data such as on-time performance (reported as 97 percent).
- All fare revenues are deposited in a trust fund and distributed based on actual fare revenue (not per km or per service hour). The trust is provided essentially at no cost by a third party. In this case, a bank earns interest on the revenues until contractors are remunerated according to a set schedule. This arrangement provides Metrovía some additional independence from political pressures and outside influences.

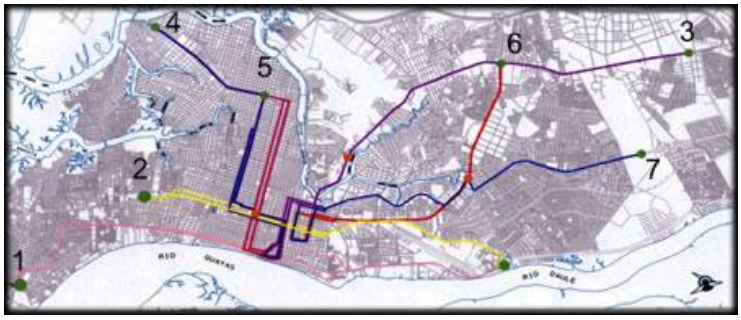
- Metrovía's Phase I has already achieved a remarkable improvement in the level of service and performance compared to traditional system. The average operating speed is 14 mph and passenger capacity is higher than before Metrovía. Hidalgo et al. (2007) show that capital and operating productivity in terms of passengers per vehicle per day and passengers per vehicle kilometer are quite high compared to other BRT systems (see table in **Exhibit 4**).

Exhibit 12: System Map and Photos of Metrovía's First Route
(Images: Metrovía Foundation and author)

The first route had a total capital cost of about US$25 million and carries about 100,000 passenger trips per day according to Metrovía. Seven lines are planned in all as shown in **Exhibit 13**. The first three lines are to be completed by 2008 at a cost of US$100 million to the

city for the infrastructure (including the running way, stations, terminals, and signals), of which 70 percent is being financed by a loan from the Andean Development Corporation (CAF). The first three lines are expected to eventually carry 600,000 passengers per day. Future transfer terminals are expected to be financed in partnership with the private sector in exchange for land concessions and development rights at the terminal. There are some initial examples of this approach being tried in Brazilian cities, such as Belo Horizonte (Hook, 2005).

Exhibit 13: Seven Planned Routes of Metrovía
(Image: Metrovía Foundation)



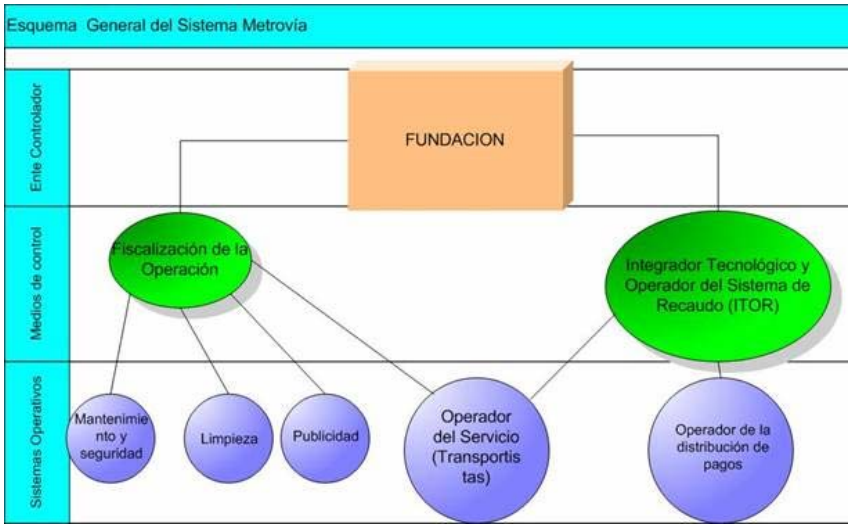
Another achievement of Guayaquil's urban renewal program has been the remarkable redevelopment of its riverfront since 1999, known as the Malecón project, into a vibrant pedestrian promenade including restaurants, monuments, a theater, and parks (pictured in **Exhibit 14**). The Malecón runs within walking distance of the Metrovía BRT system in the downtown riverfront area. The success of these two projects as well as others earned the city of Guayaquil the Sustainable Transport Award during the Annual Transportation Research Board (TRB) Conference in January 2007. This international award is given each year by the Institute for Transportation and Development Policy, Environmental Defense, TRB Committee on Transportation in Developing Countries and other partners to a city that has enhanced livability by reducing transport emissions and accidents, increased access for non-motorized modes, or improved mobility of the poor.

Exhibit 14: Guayaquil's Riverfront Promenade
(Image: Metrovía Foundation)

The Metrovía Foundation represents a very lean institutional model with several advantages and potential risks. First, the Foundation employees a staff of 12 professional while outsourcing nearly all other services using 12-year binding contracts. As illustrated in **Exhibit 15**, Metrovía is the official regulatory agency while the actual operations management of the other services is performed by a separate control contractor and a technology integrator and fare system contractor (in green). Other services such as maintenance and security, cleaning, advertising, bus operations, and fare collection are performed by separate concessionaires (in blue). This innovative arrangement appears to have been robust enough to deliver the project and cost effective for operating the system. It is also instructive to point out several business and institutional issues that exist:

- Most notably, there is only one concessionaire for all bus operations employing all former colectivo drivers. This was done to minimize the project's opposition of the colectivo sector but presents more risk for the continuity of operations in the event of an emergency.
- The technology integrator and fare system contractor takes a fixed 9.3 percent share of total revenues. The remainder goes to the bus operator and other contractors. When the additional planned routes and operators become operational, fare revenue will have to be distributed based upon some measure of service provided (most likely on a per kilometer basis like TransMilenio).
- An additional risk is that the fare (currently US$0.25) is officially set by the national government and does not reflect actual system costs. This could create financial pressure on the system.
- To some extent, the Metrovía business model depends on the future expansion of the system. The contractor responsible for technology integration and operations of the control and fare collection systems has made most of the capital investment the first three routes has been made. However, the contractor claims that this arrangement can only be profitable when additional routes are in operation and revenues increase as projected.

Exhibit 15: Contractual Structure of Metrovía Functions
(Image: Metrovía Foundation)



According to Hidalgo et al. (2007), there were other implementation issues with Metrovía that point to some important lessons. First, the implementation was made under a fixed political timeline that created some tight deadlines and initial problems with operations. For example, the station turnstiles were acquired directly by the city for expediency and there were problems with integrating them with the other fare systems. Moreover, despite Metrovía's lean institutional model, sequential approval of infrastructure design by outside government agencies (public works, urban planning and utility companies) may have caused unnecessary delays. The reorganization of existing routes and feeders also created initial confusion and frustration for passengers at the start of operations because of the lack of adequate user education before opening.

3.4 Colombian National BRT Program

After 2001, the tremendous success of the TransMilenio BRT system in Bogotá strengthened the national government's resolve to replicate the experience in several other Colombian cities suffering from over-saturation of colectivos, underinvestment in infrastructure and inefficient operations. 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." The passing of this legislation and the support of a national BRT program resulted in a TransMilenio extension, Pereira's Megabús, and five other cities committing to BRT projects:

- Barranquilla Metropolitan Area (Transmetro)
- Bogotá–Soacha (TransMilenio extension)
- Bucaramanga Metropolitan Area (Metrolinea)
- Cartagena (Transcaribe)
- Pereira-Dosquebradas (Megabús)
- Santiago de Cali (Mio-Metrocali)
- Valle de Aburrá-Medellín (Metroplus)

Each project is based on the TransMilenio model but with a variety of adaptations based on local conditions and goals. As summarized in Cain et al. (2006), each city is at a different stage in the implementation process. **Exhibit 16** is an update of each project's name, location, and basic operational data based on presentations given by the Colombian Deputy Minister of Transport (Garcia, 2007).

Specifically, the National BRT Program provides institutional support, training and assistance in traffic and transit planning, management and control. The Program is paired with a national law (Ley 310 de 1996) establishing a regulatory framework over the competitive tendering of concession contracts and the policies to improve the use of road and public spaces. Moreover, the institutional framework for BRT development is shown in **Exhibit 17** and the following components for BRT are defined by the national policy:

- High-capacity buses for trunk-line and feeder services
- Dedicated infrastructure (exclusive lanes with segregation, bus stations and terminals)
- Demand adjusted services and schedules
- Contracts for fare collection and control systems
- A separate "Delivery Agency" for planning, delivery, operation and control of the system
- No operational subsidies

It is important to mention that public-private partnerships are an integral part of this policy. In general, the public sector is in charge of the delivery of infrastructure, busways, and stations, and the planning and control of operations. The private sector is contracted to acquire and operate the vehicles and some supporting infrastructure like maintenance yards, the fare collection and control systems, and the operations monitoring equipment. Most of the funding for the national BRT program comes from loans by CAF (US$45 million for Bogotá's Avenida Suba), the Inter-American Development Bank (US$200 million for the Cali project), and the World Bank (US$250 million for the projects in Cartagena, Barranquilla, Bucaramanga, Pereira, Valle de Aburrá, Bogotá NQS).

Exhibit 16: Colombian BRT Projects Being Implemented

City/Metropolitan Area	Operational Data						
	Length of trunk corridors (km)	Number of transfer stations	% of transit demand served	Sector with highest load	Pax/day	BRTS fleet	Current fleet
AMCO (Pereira - Dosquebradas)	16	2	46%	7,000	142,000	137	1,100
Cartagena	14.9	1	70%	11,200	334,000	373	1,900
Barranquilla	13.2	2	28%	10,300	300,000	294	4,300
Valle de Aburrá (Medellín)	13	1	30%	8,000	170,000	1,485	7,500
Bucaramanga	8.6	4	63%	10,000	600,000	302	1,900
Bogotá	84	7	25%	35,000	1,400,000	1,265	21,000
Soacha	5.9	2	75%	12,400	150,000	215	3,000
Cali	49.5	8	92%	12,000	875,000	913	4,200

metrolínea
Área Metropolitana de Bucaramanga

TRANSMILENIO
Bogotá

metrocali
Santiago de Cali

Municipio de Soacha

METROPLÚS S.A.
Valle de Aburrá

MIO

TransCaribe
Cartagena Distrito Turístico y Cultural

Transmetro
Distrito de Barranquilla y Área Metropolitana

MEGABÚS
Área Metropolitana del Centro Occidente

Exhibit 17: Institutional Framework for BRT Development in Colombia

Adapted from Garcia (2007)

INSTITUTIONAL FRAMEWORK (Infrastructure delivery)	IN CHARGE OF
Ministry of Finance ↔ Ministry of Transport – Office of the Deputy Minister ↔ DNP; Co-ordination Unit	Establish National Policies on Transit Follow-up and monitor compliance of national policies by local authorities and delivery agencies.
Local authorities; Delivery Agencies	Define, deliver and manage their respective transport and transit agendas, in observance of national policies. Sign, together with Delivery Agencies and Federal Government, BRTS co-financing agreements.
Fiduciary	Receives and administers municipal and federal funds and pays contractors.

4 Key Findings

As one of the premier BRT systems in the world, TransMilenio has become a model for cities of various sizes planning and implementing high-capacity bus systems. Pereira, Colombia and Guayaquil, Ecuador are two such cities. While this report points out some of the most notable differences between the design of these systems and their institutional models, in essence Pereira's Megabús and Guayaquil's Metrovía are both successful adaptations of the TransMilenio model in smaller metropolitan areas. In Guayaquil, as with Bogotá, the BRT system became the centerpiece of an urban renewal program that redeveloped public spaces and improved living conditions for its residents. The Metrovía Foundation represents a very lean institutional model with several advantages but also potential risks.

The tremendous success of TransMilenio in Bogotá strengthened the Colombian national government's resolve to replicate the experience in at least six other cities suffering from over-saturation of colectivos, under-investment in infrastructure and/or inefficient operations. Pereira's Megabús is the first system to be delivered through a national BRT program. Most of all, Megabús demonstrates that the TransMilenio model can be successfully scaled down and adapted to a metropolitan area of less than 1 million without an adverse impact on performance or the economic viability of the system.

The lessons from TransMilenio are also important for adapting the model to local conditions and ensuring the sustainability of the system. In general, the implementation of the first phase was completed in a very short timeframe and several system details had to be adjusted after the start of operations. There are also ongoing discussions in Bogotá about how to improve TransMilenio operations and ensure the success of its planned expansion. Overcrowding in certain lines and hours of the day is degrading passenger comfort, thereby feeding competition from colectivos and unsupported or politically motivated statements for replacing TransMilenio. TransMilenio's management is currently evaluating a number of technically sound strategies to relieve overcrowding and improve operations in both the short and long-term. The TransMilenio institutional and business model has shown to be innovative and robust but may now face additional challenges as the network is extended.

This report also finds that the recent experience of Bogotá's TransMilenio and the evolution of this model in smaller cities of South America can offer valuable lessons for BRT planners and operators in the United States. First, they suggest the types of BRT investments and design standards that are cost effective given a particular context. Second, they provide insight into the extent and effectiveness of service and operational models combined with other mobility and urban development measures. Lastly, they underscore the advantages and risks of different institutional models for BRT with public and private sector participation. These findings are described in the following sections.

4.1 Standardization and Cost Effectiveness

As the TransMilenio model of BRT is further developed in Bogotá and replicated in other cities, there is increasing standardization of certain BRT elements while there are notable adjustments to others. Among the elements being implemented with increasing standardization are certain aspects of station, vehicle, and running way designs. The primary reason for standardization is to increase the cost effectiveness of capital and operating investments, but also to greatly simplify the design and implementation of the project.

Most new BRT systems in Latin America use high-platform, enclosed stations with multiple doors controlled by the bus operator or an automated system. The station designs for Megabús were very similar to TransMilenio but included some important improvements in floor strength, roof design, and appropriate sizing. Most permanent intermodal terminals provide additional amenities and allow free and unimpeded transfers between trunk-line and feeder services. The stations and terminals are usually considered key investments, particularly for high-capacity systems constrained by their size and design including all three cities visited. The aesthetic quality of the stations and terminals is also important for system identity and image. As a case in point, the terminals in Guayaquil are large and have a very distinctive architecture.

More advanced BRT systems classify stations and their level of passenger amenities based on the function, ridership, and type of land use being served. Consequently, it may be easier to justify large station investments in South American cities than in most U.S. cities because of the very high level of transit demand. However, the cost of terminal capital investments in Guayaquil does not appear to be prohibitive for lower volume BRT system in the U.S.

High-floor, high-capacity articulated vehicles are also standard for trunk-line service in most Latin American BRT systems. Common interior and exterior designs can be seen in Colombia, Ecuador, Brazil and other countries. There are at least three manufacturers in South America that specialize in this design now being used in Bogotá, Pereira, Guayaquil, Curitiba and other cities. Moreover, simple and proven technologies for fare collection and control systems are also becoming standard. Contactless smart cards are used in latest generation of BRT systems but some systems also allow cash payment. Pereira is one of the first systems to implement 100 percent utilization of contactless smart cards and equip feeder buses with readers and turnstiles for on-board payment. Bogotá, Pereira and Guayaquil also use infrared sensors or loop detectors at stations to locate and regulate vehicle movements.

Median arterial busways of at least one lane in each direction are also becoming a standard design in recent BRT systems of Latin America. A second lane is sometimes provided to allow passing at stations or critical segments depending on right-of-way availability and constructability. There is significant but decreasing variation in intersection signaling and geometric designs between BRT systems due in part to country-specific laws and standards. In the same vein, there appears to be a lack of standards in the design, implementation and maintenance of pavement systems for BRT running ways. Traditional roadway standards for passenger vehicles or trucks have been adapted unsystematically, resulting in pavement deterioration within a short time after the start of operations.

4.2 Service and Operational Models

Experience from the three cities visited and other BRT systems in the U.S. and abroad show that service and operational models can have an important impact on its success from the perspective of the authority, operator, customer and the public. In specific, service and operational models can differ in the following ways:

- The **network approach** may differ when planning or implementing a single route versus a network of routes or corridors. First, the network includes not only trunk and feeder facilities but also other infrastructure that provides access to the BRT system by walking, bicycling or driving. In fact, the most successful BRT systems, such as TransMilenio, have been implemented as part of or as the centerpiece of a package of urban renewal or mobility

management strategies that include non-motorized access, parking policies, redevelopment of public spaces, and reallocation of valuable road space. Second, most cities in South America implement BRT in phases from single corridors into networks depending on the availability of funds and other factors. These phased implementations require careful service integration and a well-defined operations strategy as described below. Lastly, each phase or change in the network requires new and updated passenger information and extensive public education. According to Hidalgo et al. (2007), this critical activity is often underestimated thereby contributing to initial problems and confusion.

- **Service integration and coordination** between trunk-line and feeder services is also very important. BRT services may co-exist, complement, or replace pre-existing or local services. First, a new BRT service may be overlaid or simply added without changing pre-existing services. This approach may minimize opposition to the project but may also create duplication or competition. Second, a BRT service may complement pre-existing services that have been modified maximize the opportunities for creating a more efficient network. As indicated, this approach requires extensive passenger information and education. Moreover, system success can be hampered by institutional barriers and poor reorganization of the pre-existing system, as was the case in Pereira initially according to Hidalgo et al. (2007). Finally, BRT services can replace pre-existing services. This was the approach in Bogotá but it is not been completely executed in the newer corridors because of opposition from traditional operators and some politicians.

- The options for **operations strategy** include an open architecture (i.e., multiple routes and vehicles sharing infrastructure as in Ottawa or Brisbane), a closed architecture (i.e., trunk and feeder operations as in Bogotá, Pereira and Guayaquil), or a hybrid approach. In South America, trunk and feeder operations are apparently most economical for high-volume systems with a capacity of 5,000 pphpd or more. Innovations were implemented in Pereira and Guayaquil by splitting routes along one-way bus lanes in narrow and dense downtown areas to maximize coverage. The current operational issues with TransMilenio may also help prioritize strategies to improve capacity in a closed system. A research question remains-- what context and level of demand makes an open architecture become more economical to build and operate?

4.3 Institutional Models

The institutional, regulatory and business issues involving BRT have been explored by some experts and identified as critical to the overall success of the project or system. Miller et al. (2001) analyzed a survey of U.S. and Canadian agencies implementing BRT and identified the following issues as the most important and difficult to resolve: “Local and business community opposition to the removal of/restrictions on parking spaces for BRT use; Availability and acquisition of right-of-way or physical space; Integration of multiple priorities, objectives, and agendas; Concerns over long term funding commitments to BRT; Impacts of BRT on roadway operations; Finding political champions to support BRT; Gaining community support for transit-oriented development; Educating the public on BRT, and managing perceptions and expectations.”

Hook (2005) explored the link between BRT and the implementation of transit sector regulatory reforms in developing world cities using Bogotá as a prime example. Hidalgo et al. (2007) identifies several institutional enablers and barriers for each city. The culmination of this brief literature review and the recent experiences of the South American BRT systems is the

following discussion of major factors that can be used to distinguished different institutional models:

- **Leadership**: The three cities visited each counted on strong leadership to see the BRT project through to successful operation. For example, TransMilenio was planned and implemented in a very short timeframe during the term of Bogotá Mayor Enrique Peñalosa but required vision, political will and persistence. Guayaquil has a similar experience with Mayor Jaime Nebot. Project champions also emerged to lead the organizations planning and implementing the project such as Pereira's Megabús General Manager, Ms. Mónica Venegas. Leaders and champions not only had to find the political will to allocate funding, space, and other resources to these projects, they also had to manage expectations and any political opposition. One effective strategy for this applied by all cities visited was linking the BRT project to larger urban renewal or mobility programs.

- **Authority**: The authority of a public agency to regulate and implement plans was imperative in all the cities visited. Public agencies were allowed to acquire right-of-way, reallocate valuable road space and parking, and impose car restrictions when warranted. Public-private partnerships were used to achieve optimal operating efficiency, but contractual and operational risks between regulators and operators had to be managed. Binding contracts and regulation were necessary to establish balanced responsibilities, incentives, and risks between the parties under a form of the "Contract Management/Tendering" model as presented in **Exhibit 2.** Hidalgo et al. (2007) find that in the three cities there was adequate distribution of responsibilities, incentives and risks for public and private participation using binding contracts awarded in a competitive process with priority given to existing operators. However, contractual issues since the implementation of Phase II of TransMilenio persist. And in Guayaquil, a very lean institutional model presented some advantages but also additional risks.

- **Funding and Financing**: For most BRT systems in Latin America, including TransMilenio, Megabús, and Metrovía, capital infrastructure costs including running ways and stations are funded and provided by the public sector. The private sector participants provide the vehicles and other equipment (i.e., fare and control systems, etc.), which are typically financed over the life of the contracts for operations. There are no operational subsidies, so fare revenue must cover all operating and maintenance costs for the contractors. The involvement of the private sector in capital investment is likely to grow. From both a technological and partnership standpoint, Metrovía was unusual in that the technology and fare system contractor financed the dedicated fiber optics network connecting all Metrovía stations. Moreover, Metrovía envisions private partners financing the construction of future terminals with retail spaces and other revenue opportunities as has been tried in Brazilian cities.

- **Organization and Management**: The organizational structure appears to be an important factor in the successful delivery and operations of a BRT system. In all three cases, a new planning and implementation organization was created separately from existing institutions. First, this allows for the appropriate dedication of time and effort to design the technical, financial, legal, regulatory aspects of the system. The size of the organization varied for the three cities, with as few as 12 employees for Metrovía overseeing several contracts for all services including control and supervision. In contrast, the Megabús administration included 22 employees overseeing 940 contract employees. Second, a new organization may also be better able to insulate itself from political and other external influences, as was the case with Metrovía in Guayaquil regarding the source of administrative funds and contracting

arrangement. Third, a new organization can also help foster a more results-oriented culture to accommodate a new mode, operating procedures or workforce with minimal institutional biases. The TransMilenio S.A. experience was so successful that the national government of Colombia instituted a program to replicate and support similar BRT projects in six other cities. One of these cities was Pereira, where Megabús S.A. adapted the lessons from TransMilenio and delivered a successful BRT system in a smaller city context. Nevertheless, Hidalgo et al. (2007) point out that Megabús may have been hampered by poor reorganization of the traditional bus system and a lack of coordination with the existing transport authority. Therefore, new interagency and multi-jurisdictional issues may arise with a new organization.

- **Education**: The scale and quality of training and information provided to contractors, operators, customers, and the general public is important for successful BRT development. Hidalgo et al. (2007) contends that many of the initial problems or significant changes with BRT systems could have been mitigated with a larger public education campaign. For example, electronic fare systems as used in all three cities often require some guidance for new customers to avoid long lines and delays. Also, the initial confusion over the reorganization of the TransMilenio route structure and service maps in 2006 may have been reduced. The marketing and branding of a system is also essential to developing an integral and positive identity and image. Moreover, existing operators must be trained if they are to successfully assimilate to the new organization.

Further investigation into these issues would be beneficial to develop an institutional framework best suited for U.S. transit agencies to ensure effective implementation and operation of BRT services.

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