# TRANSMILENIO BUSWAY-BASED MASS TRANSIT, BOGOTÁ, COLOMBIA

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**CITY AND TRANSPORT CONTEXT**

<table>
<thead>
<tr>
<th>City context</th>
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<tbody>
<tr>
<td>• <strong>Bogotá</strong> is the Capital and most important city in Colombia. It covers an area of 1,737 km² and has a density of 3,717 inhabitants per km². It lies at an altitude of 2,600 m above sea level. Most of the urban area is flat, with some informal development in the hilly areas in the southern part of the city.</td>
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<td>• <strong>Population:</strong> Approximately 6.5 million inhabitants reside in the metropolitan area.</td>
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<td>• <strong>Car ownership:</strong> There are an estimated 1 million registered private vehicles in Bogotá and surrounding municipalities.</td>
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<thead>
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<th>Table: Modal split in 1995²</th>
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<tr>
<td>• <strong>Modal split</strong> in 1995²</td>
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<tr>
<td>o Bus: 55.7%</td>
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<tr>
<td>o Car: 14.9%</td>
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<td>o Taxi: 4.0%</td>
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<tr>
<td>o Truck: 2.5%</td>
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<tr>
<td>o Motorcycle: 0.4%</td>
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<tr>
<td>o Walking: 22.5%</td>
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| Table: In 1995 the total number of bus trips/day was 8.3 million. In early 2004, TransMilenio carried about 0.9 million passengers/day. |

<table>
<thead>
<tr>
<th>Public transport context</th>
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<tr>
<td>• Urban public transport is privately delivered by various bus and service types; there are no other public mass transport modes. Underground systems have been studied and discussed; “letters of intent” have been signed for at least the last 10 years, but high costs, political issues and the experience of cost over-runs and delays for the Medellin Metro have hindered any final decision. However, the latter led to the enactment of a law requiring the National Government to finance 70% of the investment costs of mass transit projects.</td>
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<td>• Traffic conditions are congested in the center and on main arterial roads. Severe transport problems stem from a very fast and disorganized population growth³, rapid increase in poverty, and car use.</td>
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<td>• Since 1999, Bogotá has demonstrated a radical approach to transport and has sought to widen transport provision with broad social goals. In particular, Bogotá has actively promoted car-free days, bicycle schemes, pedestrian and public space improvements, peak hour car restrictions (<em>pico y placa</em>), and other measures.</td>
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<thead>
<tr>
<th>Bus transport context</th>
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<td>• Prior to the implementation of the TransMilenio mass transit system in December 2000, the existing bus system comprised a wide range of bus types and services. Some agencies placed the “legal” bus fleet at about 21,000-22,000 vehicles, and even in the “post TransMilenio” the city government reports 18,000 “legal” buses. “Pirates”, as they are locally known, comprise an unknown but very high number of all types of buses. Some estimates indicate that the bus fleet is between 30% to 50% larger when the “pirates” are included. “Cloning”, i.e., duplicating the license plate and vehicle documentation, is common, which is a way of avoiding government controls and not paying motor vehicle taxes.</td>
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<tr>
<td>• Buses were, and outside the TransMilenio system still are, of various types and capacities, and were and are operated at different fares set by the Ministry of Transport including: (i) <em>busetas</em> (capacity: 24), (ii) <em>buses</em></td>
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(capacity: 60 – 120), (iii) *buseta super ejecutiva* (capacity: 30), (iv) *bus ejecutivo* (capacity: 40), (v) *colectivo* (capacity: 5 - 15), (vi) *flota* for interurban service only (capacity: no standard). Most, although not all, buses stop on passenger demand, both for boarding and alighting, and operate with little regulation.

- The system resulted in some of the largest bus flows and congestion in the world; during rush hours, bus flows of over 1,000 buses/hour/direction were recorded on a single road.

**Congestion on Carrera Decima in Bogotá’s city center**

![Congestion on Carrera Decima in Bogotá’s city center](By courtesy of Bogota-DC, www.bogota-dc.com/trans/bog-tra.htm)

- In many areas of Bogotá, bus competition for passengers still results in extreme and inconsiderate operations and bus-bus congestion at stops; service levels are poor in terms of speed, reliability, comfort and security. However, due to the very large bus fleet, it must be recognized that the city route coverage by buses is good.
- Conventional and TransMilenio buses are privately owned and operated. Although route franchises are licensed, there used to be little difficulty in obtaining an operating license.
- The old, poorly maintained diesel and gasoline bus fleet caused air pollution and noise problems.
- In 1989-90, a centrally located busway of about 13 km was implemented along Av. Caracas, a main axis adjacent to the city center. This scheme was subsequently extended by 8 km to a total of 21 km. The busway was initially highly successful in improving bus performance, and a maximum peak throughput of about 22,000 passengers/hour/direction was recorded for the first phase. The extended scheme carried about 35,500 passengers and 620 buses per hour/direction\(^4\). The particular feature of the scheme was that it provided two bus lanes in each direction throughout its length, which allowed bus-bus overtaking at stops and throughout the route. Stop platforms were long and were divided into 3 or 4 discrete sections to be used by groups of buses on similar routes so that the whole stop platform length was used. However, over a few years, the scheme became anarchic as, for example, (i) buses competed for passengers and this, together with
little effective stop regulations, resulted in bus stop congestion and hazardous operating conditions, (ii) the scheme deteriorated physically due to lack of maintenance, (iii) buses without a license to operate on Av. Caracas were attracted to the busway seeking passengers, (iv) the bus volume was so big and bus standards were so poor that air pollution became a serious issue, and (v) the wide right of way devoted to buses resulted in local severance.

- Improvements in public transport became a political imperative, and the Mayor adopted an enlightened policy with the objectives (i) to improve bus service quality to passengers, (ii) to improve the environment by reducing bus-caused emissions, and (iii) above all, to develop a more civilized city. Thus, the foundation of the TransMilenio bus mass transit was laid.

- The TransMilenio system is an integrated bus rapid transit system, using busways, stations and terminals adapted for large-capacity buses, and fare integrated operations with smaller buses on the outskirts of the city. The first phase of the system, which is described in detail below, was implemented between 1999 and 2002, with operations starting in December 2000 (see map below for Phase 1 in Chapter “Description of the TransMilenio Busway Scheme”).

- The system is under expansion for 40 additional kilometers, with 60 stations, including three terminals and five integration stations (2 trunk line – trunk line and 2 feeder – trunk line), 470 articulated buses and 170 feeder buses, and 4 workstations in the control center. The first of the three new trunk lines (Av. Américas) started operation in December 2003, and construction was about to begin on the other two corridors (Norte-Quito-Sur (NQS) and Suba). The second phase system expansion should be completed by 2005. At that moment, the overall system is expected to daily cater for 1.6 million passengers totally (see map below for Phase 2 in Chapter “Description of the TransMilenio Busway Scheme”).
DESCRIPTION OF THE TRANSMILENIO BUSWAY SCHEME (PHASE 1)

Busway scheme

By courtesy of Dario Hidalgo Guerrero.

Phase I of the TransMilenio system consists of a trunk-and-feeder bus system in which:

- Trunk line buses operate on 41 km of segregated busways on three major roads: Av. Caracas, Autopista Norte (Autonorte) and Calle 80 (see map above for phase 1);
- 25.4 km of the busway system has two lanes per direction; 12.5 km has one lane per direction with two lanes at stations; about 1.5 km runs through a pedestrianized area in the city center; and 2.7 km runs in mixed traffic;
- 7.5 km of the busway system is in asphalt and the remaining parts are in concrete, i.e., “white-topping” construction method;
- The busways are positioned in the center of the wide major arterial roads;
- The busways may only be used by authorized trunk line buses. They may not be used by any other bus on the corridors;
- Trunk line buses currently operate both 12 express services, which stop only at a limited number of stops, and three local services which serve all stops along the trunk line corridors. To facilitate this type of operation, most parts of the busway system are provided with two lanes in each direction, allowing continuous bus-bus overtaking (Photos 1, 2, 3 and 7);
- Trunk line buses are articulated diesel vehicles (Euro 2 standard), with a capacity of 160 passengers per bus. Feeder buses are conventional;
- Bus stops vary from major transfer terminals at the ends of the trunk routes to simple mid-route stations. Along busways, bus stop platforms are located on central median islands, and this one platform serves both directions of bus travel. To allow this form of operation, trunk line buses are equipped
with doors on the “wrong” side, i.e., on the left (Photo 22). The arrangement requires less width than for conventional bus stop platforms on the “conventional” right side of the busways serving one direction of bus travel. The arrangement compensates, to some extent, for the extra width required to provide two bus lanes in each direction;

- There are 61 stations, including four terminals and four intermediate (integration) stations;
- Feeder buses serve terminals located at the ends of the busways and at selected stations along trunk lines;
- There are 39 feeder bus routes that are operated by conventional buses;
- Passengers pay a unique flat fare at entry to the stations or at terminals when transferring from feeder buses. Since all stations and terminals are “fully closed”, this permits interchange between routes, and feeder and trunk buses in all stations;
- A contactless fare collection system for prepayment is in place in all stations, and an advanced technology-based control center with six workstations assures the planning, on-line controlling and reporting, using automatic vehicle location, advanced communications, hardware and software.

### BUSWAY DESIGN

#### Road width and configuration

<table>
<thead>
<tr>
<th>Basic mid block cross section</th>
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<tr>
<td><img src="image" alt="Diagram of busway design" /></td>
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<tr>
<td>Footway</td>
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</table>

- The overall width varies between 29.5 – 57.0 m:
  - traffic lanes 4-6 @ 3.25 = 13.0 - 19.5 m
  - busway 2-4 @ 3.5 = 7.0 - 14.0 m
  - median (varies) = 3.0 m
  - bus-traffic divider (curb) 2 @ 0.25 = 0.5 m
  - pedestrian and bicycle lanes 2 @ 3.0 – 10.0 = 6.0 – 20.0 m

- This is an example of a typical cross section. Measures and characteristics vary with road conditions along the corridors and are adapted to demand. For instance, on Av. Caracas there are only four lanes for general traffic. On Autopista Norte, the busway has a second bus lane per direction only at stations. In the 2.7-km-section between Molinos and Partal de Usme, the TransMilenio buses operate on a four-lane road in mixed traffic. There are no stations on this section, which is generally free of traffic congestion. Along the approximately 1.5-km-long Eje Ambiental, passing through the historical city center, which was completed at the end of 2002, the
TransMilenio buses run through fully pedestrianized streets from which other motor traffic is barred.

**Typical cross section at stations**

- The overall width varies between 31.5 – 59.0 m:
  - traffic lanes 4-6 @ 3.25 = 13.0 - 19.5 m
  - busway 2-4 @ 3.5 = 7.0 - 14.0 m
  - station = 5.0 m
  - bus-traffic divider (curb) 2 @ 0.25 = 0.5 m
  - pedestrian and bicycle lanes 2 @ 3.0 – 10.0 = 6.0 – 20.0 m
- This is again an example of a typical cross section at station. Measures and characteristics vary with road conditions along the corridors and are adapted to demand.

**Bus – traffic segregation**

- Along running sections
  - Bus-traffic segregation varies according to constraints imposed by road width. It is either continuous or partly continuous with gaps to permit drainage. In most cases, it is provided by a raised physical separator of about the width of a single curb.
  - Bus-bus segregation for each direction along the busway usually comprises the median between bus flow directions. For the two-lane busway, a white line road marking is provided to define the lanes (Photo 3).

- At stations
  - Stations located on the median provide the segregation between buses in opposing directions (in the same way as the median noted above for running sections) (Photo 18, 1 and 2).

**Passenger facilities**

- Location of stations
  - As stations are located on the median for both directions of bus travel (Photos 1 and 2), passenger journeys are from the same location for the inward and outward journeys. This is extremely convenient to passengers, but may result in passenger congestion at busy bus stops.
  - Stations are spaced at about 500 – 750 m; local buses stop at each station, and express buses stop at selected stations depending on the route.

- Access to stations
  - Passenger access to/from bus stations vary. Along urban roads in the city center, such as in Av. Caracas, passenger access is via pedestrian crossing phases incorporated into the main traffic signal arrangements at intersections (Photos 4 and 6).
  - Outside the city center, where roads assume a more urban motorway character, passenger access is normally via grade-separated pedestrian crossings (footbridges – Photos 25, 26, 27 and 28).
Boarding and alighting facilities

- The system includes three types of stations:
  - Terminals (portales) are located at the end of the trunk lines where trunk-feeder interchange can take place (Photos 24 and 25);
  - Intermediate interchange stations (intermedias) situated at a few locations (four in the phase 1 and one in the phase 2 networks), which also allow interchange with feeder buses; and
  - Simple stations (sencillas) located approximately every 500 - 750 m (Photos 1 and 3).

- Platforms of simple stations are usually about 5 m wide but, depending on available right of way, can be reduced to 3.5 m. They vary in length from 40 m, accommodating 1 or 2 buses, to 193 m accommodating up to 5 buses.

- Transfer terminals and some intermediate stations have a number of platforms, depending on passenger demand, and can be 8 m wide.

- Passengers are effectively separated from moving vehicles. All stations are provided with fully enclosed passenger shelters of modernist design (Photo 17) to protect passengers from weather. This also allows the operation of the “fully closed” system in which bus-bus interchange can take place without fare payment.

- All station shelters have access doors to buses spaced to correspond to 3 sets of wide doors (2 single = 1.10 m each, 1 double + 2.20 m) on the articulated buses that serve the route. Some major stations have multi-stopping baysdoors to accommodate up to 5 buses (Photo 1). Since only the trunk line articulated buses can use the busway, bus headways can be controlled more readily than with a free-entry busway system and any possible bus-bus congestion, i.e. buses waiting to reach stop doors can be managed. Along any individual station, if the upstream stop/bay is occupied, the downstream bays must be sufficiently widely separated to allow adequate maneuvering length for buses to access the downstream stopping bay, to get parallel to the passenger platform and to use the doors (36 m minimum separation between berths).

- The trunk line articulated buses are high floor, and level passenger boarding and alighting has been achieved by raising the station platform to the same floor height as the buses. Passengers access the raised station platform (about 0.9 m high) via a low-gradient ramp. While this is a simple low-cost facility, the ramps increase the length required for stations, which may be an issue in sections where intersections are more closely spaced, such as in a city center. Unlike the Quito or Curitiba busways, there is no fold down ramp from buses to stop platforms (Photos 13 and 14). Thus the gap between the bus and the platform depends on the driver’s expertise. Drivers in Bogotá are trained and supervised for this purpose. In addition, front doors that are always closer to the platform (about 10 cm) are designated for wheelchairs, disabled, and elderly access.

- Passenger entry to and egress from stations is via turnstiles, which accept pre-paid tickets at entry (see “Ticketing and fare collection” in Chapter "Bus System"). In the beginning tickets had to be presented at entry and egress, but in 2003 the requirement of ticket control at egress was lifted to ease the passenger flow. Exit counts are reported electronically.

Passenger information

- Stations and terminals are provided with extensive information on routes, connections and tickets, and staff is available to respond to passenger
queries; with an aim to provide a “metro-like” environment.

- During planning and implementation of the system, customer service and convenience were stressed, and this attention has proved a major factor in the systems success.

| Disabled access | The ramp access to station platforms and level boarding of high floor buses (Photo 16) provides disabled passenger with good access to the trunk line buses. Even though there is no automatic fold down step to the passenger platform (Photo 13), Bogotá reports no safety problem. (See Boarding and alighting facilities in this Chapter.)
- Where station access is via footbridges over major roads, ramps connections are provided in addition to staircases (Photo 18).
- At Jimenez station, where the Av. Caracas and Calle 13 busways intersect, elevators are provided to give access to the underground passageway used by transferring passengers (Photos 15 A and B).
- Two out of seven feeder areas of phase 1 are served by feeder buses equipped with elevator ramps to allow for disabled access. Expansion is expected in the near future. |

### Arrangements for general traffic

| Moving vehicles | Typically, two or three lanes each way (Photos 7 and 8) are provided outside the central busways for residual traffic. Provision of more than one lane for residual traffic means that vehicles stopping to load, legally or illegally, pick-up/set down, such as taxis, or in emergency situations, for example, break down, can do so without affecting busway operations. Thus, curbside obstructive parking and in-coming and out-coming traffic (right turns) has no impact. |

| At major intersections | **Spacing of intersections:** The average spacing is 650 m. On Av. Caracas (Photo 4), which runs close to the city center, intersections are usually encountered at each station. On Calle 80 intersections are rare and require traffic lights, except for three grade-separated crossings with other main roads. On Autopista Norte, a type of motorway, there is only one intersection and all other roads are grade-separated (Photo 7).

- **General arrangement:** Generally left turns are banned, and thus signal operations are simple and typically include: (i) main road traffic and busway straight ahead, (ii) side road 1 and (iii) side road 2. There is good traffic light coordination in the bus corridor, but traffic programming favors vehicles rather than people. General traffic that needs to cross the intersections has similar delays as before the TransMilenio system implementation.

- **Signal control:** Bus actuation does not take place because the very heavy bus traffic (one bus every 11 seconds during peak hours) would otherwise risk interrupting completely transverse crossing.

- **Turning facilities:** On Calle 80 four major intersections are not at grade, thus turning is no issue. In the other cases left turns are generally banned, and Q or G turns help to maintain access. |

| Frontage servicing and local access | **Frontage servicing:** For a short connection to downtown (1.5 km) where TransMilenio passes through a pedestrian area in the city center, frontage servicing requires small non-motorized carts, or has to wait until service is closed (midnight to 5 am). For the remaining corridors there is access to parking places in front of the buildings without restriction, given that there |
are two lanes for general traffic.

- **Local access:** The TransMilenio scheme uses extensive continuous central islands, creating physical barriers which makes it difficult to cross from one side to the other (for example, on Av. Caracas, where stations are 180 m long). Nevertheless, there are signalized pedestrian crossings at each extreme of the stations. On Calle 80 and Autopista Norte, the problem may not be TransMilenio but the fast general traffic lanes. Access has been improved from one side to the other with new pedestrian overpasses that also give access to the stations.

**Enforcement of the busway**
- A specific group of traffic police has been designated to enforce the busway and specially prevent blockage of signalized intersections. Heavy fines (US$20) and vehicle impounding are applied to violators.

**Taxis**
- Taxis are not permitted in the busway and remain with the general traffic. However, with two or three residual lanes outside the busway, there is little obstruction from a stopped vehicle (taxi) and no special facilities or restrictions are required.

**Cycles**
- Bicycles are not permitted in the busway. Special cycle facilities have been provided on sections of the corridor, for example, Calle 80, and Autonorte, or nearby, for example, Carrera 13. Open bicycle parking facilities are available at terminals, but are not heavily used. Enclosed facilities will be provided in the expansions currently underway, for example, in Calle 80.

**INSTITUTIONAL ARRANGEMENTS**

By courtesy of TransMilenio, [www.transmilenio.gov.co/transmilenio/frameset_gneral_us.htm](http://www.transmilenio.gov.co/transmilenio/frameset_gneral_us.htm)

The main elements of the institutional structure are outlined in the figure shown above. Key points are as follows:

- **Bus operations:** Bus services are provided by the private sector working under strict controls defined in the concession contracts. The bus operators are consortia of local transport companies associated with national and international investors and they own the buses, hire drivers and maintenance personnel. They operate both trunk and feeder buses. Service concessions were awarded following an open and competitive bidding process. Payments to bus operators are based on (i) the number of route kilometers produced by each trunk line operator and (ii) the number of passengers carried by the feeder buses. No minimum revenue guarantee exists.
• **Fare collection and management:** The fare collection system is privately operated and includes the production and distribution of simple and stored value tickets (*Tarjeta Capital, Tarjeta Propia*) – (see “Ticketing and fare collection” in Chapter "Bus System"), installation and maintenance of passenger access controls (such as turnstiles at stations), checking and validating system statistics, passenger information and revenue handling. The system was awarded as a concession contract to Angelcom following an open and competitive bidding process. The fare collector receives up to 11% of the ticket revenue. The daily revenue collected from ticket sales is deposited in a trust fund, which pays the system agents on a weekly basis in accordance with the conditions set out in their contracts.

• **Infrastructure:** The city government is responsible for the provision and maintenance of the trunk line busways, stations, terminals and other complementary infrastructure, such as necessary road works and the control center.

• **System planning and control:** TransMilenio S.A. is a company owned by the city government. Its responsibilities are, among others, to plan and ensure service delivery, to control compliance of operators’ performance with the contract, to manage the system’s maintenance, and to plan improvements and expansions. TransMilenio S.A. has a highly qualified planning staff, who provides operators with compulsory instructions on the service on a daily basis. It also operates a control center to supervise day-to-day operations and passenger handling. Its structure is small, as most online functions have been contracted out. It is financed with 4% of ticket sales revenue, other charges fixed in the contracts, and income from ancillary activities, for example, publicity, technical assistance and consulting.

### BUS SYSTEM

#### Characteristics of buses

- Buses operating the trunk line service are dedicated to the busway and comprise:
  - A fleet of 470 articulated buses (before the busway on Av. Américas started operations at the end of December 2003);
  - Buses are about 18 m long;
  - Maximum capacity is about 160 passengers per bus, with 49 seats and 111 standees;
  - Buses are equipped with 4 doors in 3 sets.

- The feeder services serving end-of-route terminals and intermediate stations comprise a fleet of 241 conventional diesel buses, mainly 14-m buses, for 90 passenger each, with two or three doors, some with an elevator for wheelchair access.

- All articulated buses are equipped with GPS-based tracking system and a processing unit that reports its location every 6 minutes. Feeder buses are controlled at terminal stations using transponders. Both trunk line and feeder buses use radio communication to receive instructions and report incidents.

#### Operational system

- The TransMilenio system operates as trunk-and-feeder system, similar to the Curitiba system. Trunk bus routes use three types of stations (see “Boarding and alighting facilities” in Chapter "Busway Design").
- Passenger demand along main corridors is consolidated onto the high
passenger capacity trunk line buses, which allows maintaining the bus frequency on the busway at a level that permits good commercial speeds and does not cause busway congestion.

| Services operated | • The trunk line buses operate both express and stopping services. This is facilitated by the fact that in most parts there are two busway lanes in each direction, allowing for continuous bus-bus overtaking.  
• Both express and stopping services operate at about 3 minutes frequency in peak periods.  
• Feeder buses operate at about 5 minutes frequency.  
• The system operates most of the working day with express services from 05:30-22:00, stopping ones from 05:00-23:00 and feeder services from 04:30-23:45 with slightly reduced time coverage at weekends (70% service on Saturday and 50% on Sundays and official holidays). |
| Ticketing and fare collection | • TransMilenio is fully integrated between trunk and feeder buses, with closed terminals. Passengers pay a flat fare of about US$0.42 as of December 2003, no matter if they use the feeder system or not.  
• Only contactless technology is used in Bogotá. These contactless stored value tickets (*Tarjeta Capital, Tarjeta Propia*) allow prepayment for a number of journeys. The ticket may be used to enter into stations or on the feeder buses. The cost of each trip is deducted from the ticket when passengers enter the trunk line station. Exit validation has been eliminated.  
• Fare collection is carried out by the private sector company Angelcom (see “Planning, implementation and operation” in Chapter “Institutional Arrangements”). |
| Bus breakdown | • The altitude and operations caused some breakdowns during implementation, which have been corrected by bus operators. Breakdowns trigger contract penalties, i.e., the reduction in the number of kilometers paid. |

### PERFORMANCE AND COSTS

| Throughput | **Maximum passenger throughput:**  
• Passenger throughput on the system is reported as 900,000 paid passenger trips/weekday (1st quarter 2004); this is estimated to be about 16% of public transport trips in Bogotá.  
• Busway maximum observed passenger throughput has been 35,000 passengers/hour/direction on the most heavily loaded section.  
**Bus throughput:**  
• Busway peak period bus flow is about 280 buses/hr/direction.  
• Busway inter peak period bus flow is about 190 buses/hr/direction. |
| Bus commercial speed | • Busway commercial speed is 20 kph for stopping services and 32 kph for express services. The average is 26.2 kph. |
| Average bus productivity | • On a typical weekday in 2002, trunk line buses were reported to run 370 km/day and to carry up to 1,598 passengers/day/bus.  
• Peak occupancy is 90% and off-peak occupancy 60%. |
| Safety | • In 1998 (before TransMilenio), there were 865 collusions, 936 injuries, and 66 deaths reported on the roads adapted to the system.  
• Reports for 2002 included 50 collusions, 174 injuries and 8 fatalities.  
• Most accidents occurred on the mixed-traffic road, away from the busways. |
involving pedestrians, cyclists and general traffic at intersections. Only two out of 17 accumulated fatalities were TransMilenio passengers.

- However, the increased safety along the TransMilenio busways corridors, particularly on Av. Caracas, is accompanied by an increase in accidents on other corridors to which the old buses that previously served the TransMilenio corridors had been displaced.

Environmental performance

- In the first 12 months of operation, TransMilenio reported a decline in air pollutants of 40% in their busway corridors. This positive impact on air pollution is mainly due to the fact that major trunk line passenger movements to/from the city center are now catered for with considerably fewer and cleaner buses than previously.
- Nevertheless, Bogotá has still too many buses for its size, and the requirement by TransMilenio to scrap 2.7 old buses for each new articulated bus was not enough to curtail the oversupply. For the second phase, TransMilenio is requiring operators to scrap about 6 old buses per new articulated bus.
- Except for the Eje Ambiental in the city center, the busway system did not re-allocate road space from cars to buses and on some occasions the general traffic even gained space. Calle 80 had ample medians and was widened. Thus, general traffic continues to have three or even four lanes per direction, but now has not to share them with buses, which have their own lanes. Av. Caracas had, and still has, two lanes in each direction for general traffic. Autopista Norte had three lanes for both cars and buses, and has now three lanes for cars and a separate lane for buses. Hence, in the short run, car-traffic congestion has been reduced and average speed increased. However, eventually this additional road capacity is likely to be used up, resulting in traffic congestion on the mixed-traffic lanes, while the dedicated busways will be free of congestion.

Costs

- **Operating costs and financial performance:**
  - TransMilenio system standard fare in December 2003 was 1,100 pesos per trip (approximately 0.42 US$).
  - The first two years of operation TransMilenio S.A. required subsidy by the city government. Since then, TransMilenio’s fare box revenue has been adequate to cover bus operating and maintenance costs. In the future it is expected to have gains to be given back to its public shareholders.

- **Construction and vehicle costs:**
  - Infrastructure construction costs in gross terms for the current stage of the TransMilenio system are reported at about US$210 million or US$5.0 million per km.
  - Construction and vehicle costs are reported at about US$8 million per km.

**DISCUSSION**

TransMilenio provides a successful, high quality bus-based mass transit system with many positive attributes. It should be stressed that TransMilenio is not just a busway; it is a bus-based mass transit system. While it does not yet cover the whole city to the extent of Curitiba, TransMilenio embodies all the elements of mass transit:

- high capacity vehicles;
- frequent services provided by trunk line buses;
• services, both express and stopping, geared to meet passenger demand;
• rapid (commercial speed of over 26 kph) and reliable services obtained through the use of exclusive and segregated lanes (busways);
• integrated fares and efficient fare collection;
• high level image and the appearance of a “quality mode” with well designed bus stations with appropriate signage, bus livery, publicity, passenger assistance etc. (these aspects are often missing in bus schemes);
• rapid passenger entry, facilitated by high-level platforms, prepayment and multiple doors.

Among the many positive attributes TransMilenio strikes for:
• its efficient and equitable use of road space. Over 70% of travelers in Bogotá use public transport, while it is estimated that prior to TransMilenio public transport was allocated only 5% of road space. Therefore, the re-allocation of road space to TransMilenio busways and bus stations is both efficient and equitable;
• its high cost effectiveness and the provision of a service quality which is at least equivalent to any tram or LRT at a fraction of the cost – about US$5 million/km for civil works and US$8 million/km, including vehicles and infrastructure;
• its attractiveness to the traveling public, resulting in greater passenger demand than originally predicted. The original forecast for TransMilenio was 600,000 passenger trips/day, while it carried 800,000 passengers/day at the end of phase 1.

One key lesson from the TransMilenio experience is the manner, in which the institutional problems of implementing the system were overcome. Before TransMilenio, the Bogotá bus system was a de facto unregulated system with bus license/franchise conditions barely enforced and with services delivered by a large number of small, poor-quality, polluting buses. The creation of a single agency (TransMilenio S.A.) with powers to plan, design, implement and regulate the new bus system was a fundamental reason for its successful introduction. However, the resolution of technical issues was only part of the answer. The city government actively sought the participation and collaboration of the existing transport companies and operators in the new system. It was a bidding condition for the services on the three first trunk lines that existing operators should be majority shareholders. This requirement forced a fundamental change in the structure of the existing bus service supply industry. It has been reported that a large number of bus companies/operators have merged into larger companies, in which companies, other than previous bus operators, also have a share. Thus, through this approach, the initial resistance from existing private bus operators could be overcome. It should be highlighted that the innovative TransMilenio system, although its bus services are operated by the private sector, could only have been implemented under a regulated bus system environment and with a strong political will. Finally, it is interesting to notice some first signs of the impacts of TransMilenio on land use in Bogotá, with new shopping centers being constructed next to some busways (Photos 36, 37, and 38).

TransMilenio has many similarities to the Curitiba model. However, TransMilenio, like Quito’s Trolebus, is a “retrofit” system with its main feature, the busways, introduced into an existing road network. Although TransMilenio lacks the integrated land use transport approach, which makes Curitiba unique, the first phase of TransMilenio was introduced over a very short time (3 years), whereas Curitiba was a slower, long-term development. TransMilenio has demonstrated that it is possible to develop a bus based, high capacity, high quality mass transit system in a very short time. Some of the operational features should be of great interest to other cities, and while some of the features exist in other cities (such as the use of buses with doors on the “wrong” side in Brazil or overtaking bus-bus within busways), TransMilenio has integrated all the features
system-wide. They include:

- median bus stations, which are used by buses in both directions; this is made possible by providing doors on the “wrong” side of buses. The advantage is that road space requirements for bus stop platforms is less than for conventional layouts, where bus stop platforms are provided for each direction of travel. The disadvantage is that these buses cannot be used on other routes where bus stops/stations are located on the “conventional” side which, in the TransMilenio system, is of little importance since the trunk buses are never intended for use outside the busways;
- the use of 2 bus lanes in each direction to permit a mix of stopping and express services; this has been possible in Bogotá because of the very wide road rights of way (rights of way of 25-40 m are not available in many cities) and by the willingness of the city to widen roads, where it was/is necessary;
- the use of ramped stops to allow level passenger boarding/alighting to/from high floor buses;
- the use of stored value tickets as part of the system, which do not only make the trunk and feeder system more convenient to users, but speeds passenger boarding/alighting.

The system is undoubtedly a great success and can be a model to other cities. However, there are, of course, some aspects, which may not be directly translated to other cities and for which a specific city-based solution will be needed. For example:

- Centrally located busways, particularly with physical bus-traffic separation, can result in severance by preventing traffic movements across the main corridor – both by left turns at main intersections and directly across the busway at local roads;
- The system with long bus stops, ramps to passenger platforms, double width bus lanes, etc., may require more road space, both laterally and longitudinally, than it is available in some cities, and city specific proposals will be needed;
- The axle weight of the large articulated buses can go up to 12 tons, which is a lot for normal pavements. Tracking is, in fact, occurring on the asphalt pavement of the Calle 80 busway. To avoid this problem, the Autonorte and Av. Caracas busways were designed to have a "white-top ping" concrete pavement. However, it also included the use of cement slurry inlay, which led quickly to widespread failures of the concrete slabs (Photos 31 – 35). The incorrect design of the busway pavement has become a major embarrassment for the city administration and TransMilenio S.A. The design of the Av. Américas busway, on which bus operations started in late 2003, has reportedly corrected these earlier mistakes. It is clear, however, that great importance must be given to the structural pavement design of heavily used busways;
- Long queues of passengers at turnstiles and ticket booths used to be a big concern in Bogotá in late 2002. Since then ticketing has greatly improved with better detection technology, better cards, prepayment, and the elimination of exit validation. Prepayment is the first step to cope with congestion at peak hours in ticketing booths. Expanded use of the prepaid cards (i.e., in public phones), and re-charging facilities off the system may come later.

As with any scheme, there is a need for constant upgrading, management and improvement and, in this regard, Curitiba sets a model example. Current indications are that the structure of the TransMilenio organization and system set up can match that example.
PHOTO GALLERY

1. Layout of Busways (Photos 1-12)
2. Boarding and Access (Photos 13-15)
3. Stops and Stations (Photos 16-18)
4. Station Facilities and Services (Photos 19-21)
5. Vehicles (Photos 22-23)
6. Terminals and Bus Depot (Photos 24-30)
7. Problems with Road Surface (Photos 31-35)
8. Developments (Photos 36-38)

1. Layout of Busways (Photos 1-12)

**Photos 1 and 2 – General View of Busway/Busway Station**

By courtesy of Gerhard Menckhoff

Key points:

- Median station between busways serving both directions of bus travel; necessitates doors on left side of buses
- Articulated trunk line bus
- Double width busway at stations permitting bus-bus overtaking and thus express and stopping bus services
- Three lanes for residual traffic
- Fully enclosed passenger shelter with doors on bus side (synchronized with bus doors), giving waiting passengers protection from weather and creating “metro-like” image
- Long bus station length - about 60m including access ramp
Photo 3 – Av. Caracas TransMilenio Busway

By courtesy of the Unofficial TransMilenio Page
www.angelfire.com/ny5/transmilenio

Key points as Photo 1 and 2 plus:

- Wide right-of-way – approx 30m curb-to-curb
- Narrow physical island (of one curb width) separating busway from traffic
- Ramp for passenger access to platform area giving level, efficient boarding-alighting with high floor buses
- Closed doors – position synchronized with bus doors
- High level platform and guard rails providing secure environment for passengers

Photo 4 – Av. Caracas at the crossing with Av. Jimenez

By courtesy of the Unofficial TransMilenio Page
www.angelfire.com/ny5/transmilenio

Key points are as Photo 1 to 3 plus:

- Passenger access to station by use of signals at main junction
- No left turn for traffic across the busway
### Photo 5 – Av. Caracas TransMilenio Busway

By courtesy of Gerhard Menckhoff

**Key point:**
- Double lane busway on an elevated level compared to the lanes for general traffic (found on certain sections of Av. Caracas)

### Photo 6 – Av. Caracas TransMilenio Busway

By courtesy of Gerhard Menckhoff

**Key points:**
- Double lane busway on an elevated level compared to the lanes for general traffic
- Pedestrian crossing at grade

### Photo 7 – General View of Busway “Troncal Americas”

By courtesy of Gerhard Menckhoff

**Key points:**
- Double lane busway each way with three lanes for residual traffic for each way
- Passenger footbridge
**Photo 8 – General View of Busway**

By courtesy of Gerhard Menckhoff

Key point:
- Double lane busway each way with three lanes for residual traffic for each way

**Photo 9 - TransMilenio**

By courtesy of Gerhard Menckhoff

Key point:
- TransMilenio buses passing in the pedestrian area

**Photo 10 - TransMilenio**

By courtesy of Gerhard Menckhoff

Key point:
- TransMilenio buses passing in the pedestrian area
Photo 11 – TransMilenio in shared traffic between Molinos and USME

By courtesy of Gerhard Menckhoff

Key points:

- Bus-bus separation through curbs
- No separation from general traffic
- Passenger footbridges

Photo 12 – TransMilenio in shared traffic between at Molinos Station

By courtesy of Gerhard Menckhoff

Key point:

- TransMilenio buses in shared traffic
2. Boarding and Access (Photos 13 - 15)

**Photo 13 - Disabled Access to Platforms**
By courtesy of TransMilenio
www.transmilenio.gov.co/transmilenio/
frameset_gneral_us.htm

Key points:

- Bus-station door synchronized and platform height gives level boarding; this makes wheelchair access possible but there is no fold down steps as Curitiba and Quito

**Photo 14 – TransMilenio Bus**
By courtesy of Gerhard Menckhoff

Key point:

- Level boarding
Key point:

- Elevators for disabled access
3. Stops and Stations (Photos 16 - 18)

<table>
<thead>
<tr>
<th>Photo 16 – Boarding Platform</th>
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<tbody>
<tr>
<td>By courtesy of Gerhard Menckhoff</td>
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<tr>
<td>Key points:</td>
</tr>
<tr>
<td>• Level boarding at the terminal</td>
</tr>
<tr>
<td>• “Metro” like appearance</td>
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<table>
<thead>
<tr>
<th>Photo 17 – TransMilenio Station</th>
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<tbody>
<tr>
<td>By courtesy of Gerhard Menckhoff</td>
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<tr>
<td>Key points:</td>
</tr>
<tr>
<td>• Level boarding at the terminal</td>
</tr>
<tr>
<td>• Doors on the left side coordinated with station doors</td>
</tr>
<tr>
<td>• “Metro” like appearance</td>
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<tr>
<th>Photo 18 – Autopista Norte: Typical Station</th>
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<tbody>
<tr>
<td>By courtesy of Gerhard Menckhoff</td>
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<tr>
<td>Key point:</td>
</tr>
<tr>
<td>• Ramp for passenger access to platform area</td>
</tr>
</tbody>
</table>
4. Station Facilities and Services (Photos 19 - 21)

**Photo 19 – TransMilenio Bicycle Facilities at Portal de las Américas**

By courtesy of Gerhard Menckhoff

Key point:
- Bicycle parking facilities in terminal

**Photo 20 – TransMilenio Bicycle Facilities at Plaza Bandeiras**

By courtesy of Gerhard Menckhoff

Key point:
- Bicycle parking facilities in terminal

**Photo 21 – Bogotá – Misión Bogotá**

By courtesy of Gerhard Menckhoff

Key point:
- Misión Bogotá assistant advising customers
5. Vehicles (Photos 22 -23)

<table>
<thead>
<tr>
<th>Photo 22 – TransMilenio Articulated Trunk Line Buses</th>
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<tbody>
<tr>
<td>By courtesy of Gerhard Menckhoff</td>
</tr>
<tr>
<td>Key point:</td>
</tr>
<tr>
<td>• Doors on the left side</td>
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<tr>
<th>Photo 23 – Feeder buses at Molinos Station</th>
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<tr>
<td>By courtesy of Gerhard Menckhoff</td>
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<tr>
<td>Key point:</td>
</tr>
<tr>
<td>• Sensors controlling schedule adherence of feeder buses</td>
</tr>
</tbody>
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6. Terminals and Bus Depot (Photos 24 - 30)

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<tr>
<th>Photo 24 – Plaza Banderas Terminal</th>
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<tbody>
<tr>
<td>By courtesy of Gerhard Menckhoff</td>
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<tr>
<td>Key point:</td>
</tr>
<tr>
<td>• Pedestrian area with delivery lane</td>
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</tbody>
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<table>
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<tr>
<th>Photo 25 – Plaza Banderas Terminal</th>
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<tbody>
<tr>
<td>By courtesy of Gerhard Menckhoff</td>
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<tr>
<td>Key point:</td>
</tr>
<tr>
<td>• Stations connected by footbridges</td>
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<tr>
<th>Photo 26 – TransMilenio Calle 80</th>
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<tr>
<td>By courtesy of Gerhard Menckhoff</td>
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<tr>
<td>Key point:</td>
</tr>
<tr>
<td>• Passenger access to station</td>
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<tr>
<td>Photo 27 – Pedestrian access</td>
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<td>----------------------------</td>
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<tr>
<td>By courtesy of Gerhard Menckhoff</td>
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<tr>
<td>Key point:</td>
</tr>
<tr>
<td>• Passenger access to stations</td>
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<tr>
<th>Photo 28 – Pedestrian access</th>
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<tbody>
<tr>
<td>By courtesy of Gerhard Menckhoff</td>
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<tr>
<td>Key point:</td>
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<tr>
<td>• Passenger access to stations</td>
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<tr>
<th>Photo 29 – Pedestrian access</th>
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<tbody>
<tr>
<td>By courtesy of Gerhard Menckhoff</td>
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<tr>
<td>Key point:</td>
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<tr>
<td>• Passenger access to stations</td>
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7. Problems with Road Surface (Photos 31 - 35)

- **Photo 30 – TransMilenio Buses**
  By courtesy of Gerhard Menckhoff
  Key point:
  - Bus depot

- **Photo 31 – TransMilenio Busway in Avenida Caracas**
  By courtesy of Gerhard Menckhoff
  Key point:
  - Failures of the concrete slabs

- **Photo 32 – TransMilenio Busway in Avenida Caracas**
  By courtesy of Gerhard Menckhoff
  Key points:
  - Surface repair after failures of the concrete slabs
  - TransMilenio buses using mixed traffic lanes on a temporary basis
TransMilenio buses using mixed traffic lanes on a temporary basis

Photo 33 – TransMilenio Busway in Avenida Caracas
By courtesy of Gerhard Menckhoff

Key points:
- Busway closed due to surface repair after failures of the concrete slabs
- TransMilenio buses using mixed traffic lanes on a temporary basis

Photo 34 – TransMilenio Busway in Avenida Caracas
By courtesy of Gerhard Menckhoff

Key points:
- Busway closed due to surface repair after failures of the concrete slabs
- TransMilenio buses using mixed traffic lanes on a temporary basis

Photo 35 – TransMilenio Busway in Avenida Caracas
By courtesy of Gerhard Menckhoff

Key points:
- Busway closed due to surface repair after failures of the concrete slabs
- TransMilenio buses using mixed traffic lanes on a temporary basis
8. Developments (Photos 36 - 38)

<table>
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<th>Photo 36 – CARRERA 90</th>
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<tr>
<td>By courtesy of Gerhard Menckhoff</td>
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<tr>
<td>Key points:</td>
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<tr>
<td>• New Shopping Center</td>
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<th>Photo 37 – Portal 80</th>
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<tbody>
<tr>
<td>By courtesy of Gerhard Menckhoff</td>
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<tr>
<td>Key points:</td>
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<tr>
<td>• Shopping Center</td>
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<th>Photo 38 – Portal 80</th>
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<tr>
<td>By courtesy of Gerhard Menckhoff</td>
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<tr>
<td>Key points:</td>
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<tr>
<td>• Shopping Center</td>
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ACKNOWLEDGEMENTS

A first draft of this Fact Sheet on “TransMilenio Busway-based Mass Transit, Bogotá, Colombia,” was prepared by John Cracknell in 2003 for the World Bank. It has been reviewed and integrated by Dario Hildalgo Guerrero, Arturo Ardila, Gerhard Menckhoff and Mauricio Cuellar to whom special gratitude is extended.

We also take the opportunity to express our thank-you to Gerhard Menckhoff, Juan Andrés León, Dario Hildalgo Guerrero, Bogotá DC, and TransMilenio for allowing us to use photos, maps, and other visual material.

5 The implementation of the latter was facilitated by the fact that an extension of the Av. Caracas scheme to Calle 80, another main artery, had already been underway and project financing assured by the World Bank.
7 In Curitiba not all stations are “fully closed” and in theory transfer is only allowed at terminals. Indeed, when passengers exit the bus, they are outside of the tube station. Even if they could exit the bus via the door used for boarding, the recording inside the buses strongly advises against this. Bogotá compensates the impossibility of building transfer terminal throughout the city by having “fully closed” stations along the entire system.
8 The stations are modular and can therefore be adapted to all demand conditions. This means that they can easily be extended using the same design. Moreover, if for whatever reason a station needs to be moved, it can be disassembled and moved to a new foundation, which is the only part that has to be rebuilt.