

TransMilenio: A high capacity – low cost bus rapid transit system developed for Bogotá, Colombia

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ABSTRACT: TransMilenio is a bus rapid transit system resulting from a successful public-private partnership. The system comprises specialized infrastructure including exclusive lanes for high capacity articulated buses, efficient private operation, advanced fare collection system, and a new public authority for planning, developing and controlling the system. TransMilenio started operations in December 2000. By March 2002 it moved 635,000 pax/day in 38 Km exclusive busways, 62 stations, 470 articulated buses, and 300 feeder buses operating 125 Km routes. Extensions will continue in the upcoming 16 years to cover 85% of the daily trips in the city. TransMilenio is a high quality and sustainable transport solution, at a very low cost for the tax payers and the direct users. This paper presents the situation of Bogotá, the overall mobility strategy in which the mass transit system is embedded, the components of TransMilenio, the implementation strategy, and the results after fifteen months of operation.

RESUMÉ: TransMilenio est un système rapide de bus qui résulte de l'union du secteur public et privé. Le système comprend une infrastructure spéciale qui inclue des voies qui permettent seulement le transit de bus articulés de grande capacité, un système de recollection automatique et une nouvelle autorité qui planifie, développe et contrôle le système. TransMilenio est rentré en opération en décembre de l'an 2000. Vers mars 2002 il a transporté 635,000 pas/jour en 38 Km de chemins exclusifs, 62 stations, 470 bus articulés, et en 300 bus opérants dans la périphérie sur 125 Km de routes. Les extensions du système vont continuer pendant 16 ans jusqu'à couvrir le 85% des voyages de la ville. TransMilenio es une solution de transport d'haute qualité et peu coûteuse pour les payeurs d'impôts et pour ceux qui l'utilisent. Cet article présente la situation de Bogotá, l' stratégie de mobilisation dans laquelle le système se développe, les composants de TransMilenio, l'implémentation de l' stratégie et les résultats après 15 mois d'opération.

1 INTRODUCTION

Bogotá, Colombia, initiated an ambitious mobility strategy to overcome its outstanding transportation problems, resulting from very fast and disorganized population growth and rapid increase in property and use of automobiles. The mobility strategy set forth by the city government is aimed to promote non motorized transportation, to reduce automobile use and to give priority to public transportation.

For non motorized transportation and extended network of pedestrian and bicycle ways have been recovered and built. For automobile reduction several administrative and fiscal measures have been taken. The most relevant is a city wide restriction for 40% of the automobiles according to plate numbers during the

peak hours. For public transportation, the city initiated TransMilenio.

The TransMilenio Bus Rapid Transit System seeks significant reductions in travel time, accidents and air pollution. The system is design to provide full accessibility to disabled, elderly and youngsters. Service is provided with high quality standards at a reasonable price for users and low capital costs to taxpayers. The buses are operated by private companies without public subsidies, under control by a newly created public transit authority.

Following, a short diagnostic of transportation in Bogotá is presented, with a summary of mobility strategies currently under implementation. Then, there is a description of the mass transit system and the process

followed to make it possible. Finally the achievements and impacts of the first five months of operations are discussed.

2. TRANSPORT IN BOGOTÁ, COLOMBIA

Bogotá is a 6 million people metropolis sharing most problems of megacities all over the world. Relevant characteristics of transportation in 1988 were:

- Slowness: average trip was 1 hour and 10 minutes long.
- Inefficiency: despite the modal share of 72%, transit routes were 30 Km on average, with buses 14 years old on average and 45% mean occupancy.
- Inequity: 95% of available road space used by private vehicles moving 19% of motorized trips.
- Contaminating: 70% of particles released to the atmosphere come from mobile sources; 1,200 deaths per year resulting from pneumonia associated with air pollution.
- Unsafe: 52,764 reported accidents in 1998, resulting in 1,174 deaths.

To initiate a structural change, the local administration set forth an integral mobility strategy to promote non motorized transportation, reduce automobile use, and encourage public transportation. Actions include recovery and construction of pedestrian walkways and malls, building a 200 Km bikeways network, a city wide vehicle restriction using plate numbers in peak periods, increase in parking prices, day-long automobile prohibitions, and development of a bus rapid transit system, among others.

The final objective is to improve quality of life and city competitiveness. The goal, is that the city will be able to ban of circulation all the private vehicles during peak hours starting 2015.

3. ¿WHAT IS TRANSMILENIO?

TransMilenio is a bus rapid transit system –BRT- developed for the existing conditions in Bogotá. The system was designed and developed under the following principles:

- Respect to life: reduce fatalities due to traffic accidents and reduce harmful emissions.
- Respect to users' travel time: reduce average trip time by 50%.
- Respect to diversity: full accessibility to young, elderly and handicapped.

- Quality and consistency: use of advanced transit technologies, providing a world class system city wide.
- Affordability: possibility for the government to afford infrastructure costs, for the private sector to recover buses acquisition and operations from fares (without public subsidies), and for the users to pay the fares.

TransMilenio encompasses specialized infrastructure for bus rapid transit, a very efficient privately provided operations scheme, a state-of-the-art fare collection system, and a new public company in charged of planning, developing and controlling the system. Infrastructure, planning, developing and controlling the system are provided by public entities, while operations and fare collection are provided by private companies through concession contracts.

3.1. Specialized infrastructure for bus rapid transit

It includes dedicated busways, stations, pedestrian ac-



cess facilities, streets for feeder buses, depots for bus parking and maintenance, and an advanced control system (See Photo 1)

Photo 1. TransMilenio busway and station

Busways are the central lanes of urban highways, longitudinally segregated from general traffic.

Stations are located in the median, every 500 m, with pedestrian access provided through overpasses, tunnels, or signalized intersections. Station length vary from 30 m to 140 m depending on the number of berths. Stations have high platforms, and automatic doors coordinated with those of the buses. Terminal and some intermediate stations have integration facilities with feeder buses.

Walkways, plazas, and sidewalks are also constructed to supply pedestrian and bicycle access. Parking and maintenance areas for the buses, close to terminal stations, are also built with public moneys and conceded to private concessionaries. Infrastructure also includes an advanced control system, using GPS in each bus and trunking and cellular communications for real time supervision.

The busway network is planned to cover all the demand for transit. A total of 22 busways, covering 388 Km are expected to be in operation in a 15 year period, moving 85% of the total trips (Figure 1).

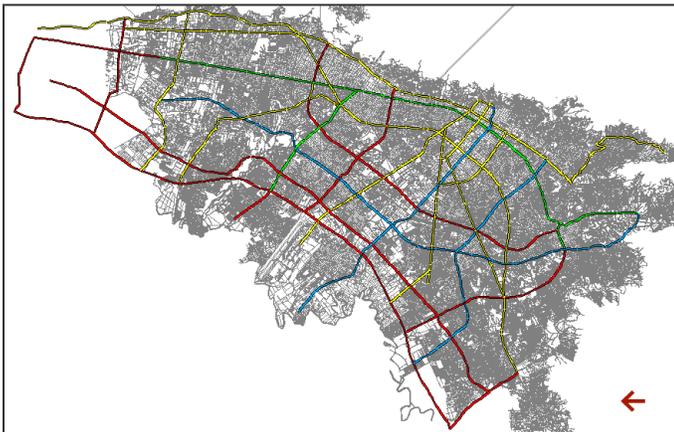


Figure 1. Projected TransMilenio Busway Network for 2015

3.2. Operational System

As opposed to the previously existing system in Bogotá, TransMilenio operates with the right number of buses to cover the demand, with very efficient planning and centralized control. The system includes trunk line and feeder buses operated by private companies, controlled by a specialized public agency.

Trunk line routes include express and local services sharing the exclusive busways. This combination allows a capacity up to 45,000 passengers/hour/direction. Having a high number of buses serving express routes also provides travel time reductions for most users. Trunk line services are provided with articulated buses for 160 passengers each. These buses have advanced characteristics: pneumatic suspension, automatic transmission, and low emission internal combustion engines fuelled with Diesel or Natural Gas.

Feeder buses are assigned to routes in the periphery, mostly inhabited by low income population. These routes are fully integrated to trunk lines using terminal stations. A flat rate has been set for the system. New

or recent model buses are used in feeder lines, with a capacity up to 80 passenger each.

Operations are contracted with private companies with conditions set forth in concession contracts for trunk line services or operations contracts for feeder buses. Private operators are consortiums of traditional transportation local companies, associated with national and international investors. Operators are selected through open bidding processes, and they are in charged of bus fleet acquisition, operation and maintenance, and hiring drivers, mechanics, staff, etc. They are paid as function of the kilometres served by their buses.

3.3. Fare Collection System

TransMilenio uses a prepaid scheme. Passengers use contact-less electronic cards to access stations where they load the buses through multiple doors. The fare collection system includes providing and selling electronic cards, acquiring, installing and maintaining equipment for access control and validation, information processing, and money handling. Fare collection is also provided by a private concessionaire selected through an open bidding process. Moneys from fare collection are deposited daily in a trust fund, which is in charged of paying weekly to the companies involved.

3.4. Public company for system planning, development and control

The new public company TRANSMILENIO S.A. is the city mass transit authority. Its structure and staff is small given that it develops its charter through third parties, focusing its activity in planning the system and supervising the contracted activities. Its operation is mainly funded with 3% of the fare revenues, as well as ancillary activities.

The company operates a Control Centre which allows real time supervision of the bus operations. The Control Centre receives reports on the number of passengers entering and leaving the stations in real time, consolidates the communications from the vehicles and stations, reports the accomplishment of the service orders by the private operators, and makes real time adjustments to the service.

4. HOW TRANSMILENIO WAS DONE

In January 1998 most of the components required to start up the system were missing. The first decision of

the local government was to give TransMilenio a very high priority in the city plan, as the main piece of the mobility strategy. Important resources were earmarked to fund capital investments and a specialized group, directly reporting to the City Mayor, was created. This group managed the project preparation promoted the creation of a mass transit authority, and coordinated the efforts of several local and national agencies involved with the project implementation. The main actions were required to start up the system are described in the following sections.

4.1. Preparing system components in detail

The project was prepared with the participation of local and international consultants. The process took one year and a half, from idea to presentation of detailed plans for each element. Studies were prepared to put the project in place, not to evaluate whether such a system should be implemented or not.

Information from other transit systems based on buses was collected through visits to Quito (Ecuador); Curitiba, Sao Paulo and Goiania (Brazil); Santiago (Chile); and Mexico City and Puebla (Mexico), which were very helpful in identifying key elements for systems design.

4.2. Creating a transit authority to develop the system

A new transit authority dedicated exclusively to planning, developing and controlling the system was required. The transit authority could be created only if the City Council gives the required authorization, which took six months, from the preparation of the ordinance project presented to the council, until its approval in February 1999. Once the ordinance was approved, the charter was prepared and local public agencies were called to act as partners of the authority. The partners created the new transit authority in October 1999, under the name of TRANSMILENIO S.A.

4.3. Facilitating participation of local traditional transportation companies

From the beginning of the preparation process it was considered important that the local private transportation companies participate as operators of the new transit system. Mechanisms to facilitate their participation were of two kinds: showing up their opportunities for participation, and recognition of their local experience as a factor for bid evaluation in the concession process. As a result of these activities, 62 out

of 66 local transport companies acquired stock in the four companies that were awarded with the trunk lines concession contracts.

4.4. Contracting and developing the infrastructure

Infrastructure was built by local contractors under supervision by the local public works agency (Instituto de Desarrollo Urbano – IDU). Their performance is summarized in very high indicators: 35 Km of busways and complementary lanes, 4 terminals, 4 parking and maintenance yards, 58 stations, 17 pedestrian overpasses, plazas, sidewalks, 126 Km of roads for feeder services built or rehabilitated, in just 24 months. It is estimated that more than 17,000 people directly worked in the infrastructure development.

4.5. Contracting and starting up the concessions for operations

In November 1999, TRANSMILENIO S.A. initiated the bidding processes for trunk line operations. The requests for proposals included requirements on the organization and financial capabilities of the proponents. Bid evaluation included points for local experience in transit operations, environmental performance, and cost per kilometre. All the commercial risks, including passenger demand, were assigned to the private operators.

The bidding process was successful: in April 2000 four different companies created by local transportation companies, associated with national and international investors, were awarded with concession contracts to provide and operate 470 new articulated buses.

Simultaneously, TRANSMILENIO S.A. worked out a bidding process for the concession of the fare collection system. The requests for proposals also included requirements on the technical and financial capability. The concession contract was awarded in April 2000 to a local company supported by an experienced fare collection systems provider.

On the other hand, the Control Centre was bid during 2000, and awarded to a Spanish technology group. Afterwards, feeder service contracts were bid for seven zones. The processes were also successful; traditional transit companies participated, and the bus fleet offered assured bus renovation.

4.6. Assuring continuation of the system

TransMilenio oughts to cover 85% of the urban area and to transport most of the daily trips. The proposed system has 388 Km of exclusive busways, to transport more than 5 million trips per day, with a capital investment exceeding US\$2,300 million. This figure does not include bus acquisition and fare collection system implementation, which are provided by private concessionaires.

To assure its continuation, 50% of the revenues from a local tax on gasoline were earmarked by the City Council, and a grant from the National Government was provided through 2006.

4.7. *Communicating the new transit concept and educating users*

System implementation faced scepticism from public opinion and caused traffic disturbances due to mayor streets closures. At the same time, the transit concept was new to potential users and required an education process on its usage and advantages. To face these issues, a communications strategy, including media campaigns and several activities for user education was developed. The strategy included:

- A promotional campaign in TV, radio and newspapers, which stressed the benefits of the system and usage instructions.
- 450+ community workshops directed to local organizations and education institutions, with participation of 18,000 persons that became multipliers.
- Direct on street information through 150 guides distributing handouts with usage instructions.
- A user information telephone service and a web page (www.transmilenio.gov.co).
- Three weeks of free educational service between December 18th, 2000 and January 5th, 2001 attending more than a million passengers.

5. IMPLEMENTATION OF TRANSMILENIO SYSTEM PHASE I DURING 2001

5.1. *Infrastructure*

Phase I includes three trunk corridors covering 38 Km and seven feeder zones with routes covering 100 Km. The system has 4 terminal stations, 4 intermediate integration stations and 53 stations. Additionally, there are 17 pedestrian overpasses, plazas and sidewalks.

Infrastructure has been completed by the Institute for Urban Development (IDU). Total investment was US\$213 million, financed with a local fuel surcharge (46%), general local revenues specially from a capital

reduction of the partially privatised Power Company (28%), a credit from the World Bank (6%), and grants from the National Government (20%). Infrastructure was completed through 58 construction contracts with national firms, and 48 supervision contracts.

5.2. *Operations*

The system started operations in December 18th 2000, with 15.5 Km and 21 stations moving 18,618 passengers. Demand grew to 700,000 passengers per weekday in May 2002 with 38 Km of busways, 125 Km of feeder routes, 62 stations, 470 articulated buses and 300 feeder buses. By the end of March the system operated 18 hours per day, with 7 express services and three local services.

Maximum capacity was 35,000 passenger/hour/direction. In the most heavily loaded section average load was 82% with a maximum of 96% in the most intense 15 minutes.

Some indicators after the first 12 months of operation show a high operational efficiency. The number of passengers per kilometre have been around 5,6; and each bus moves 1,776 passengers in average. Kilometers per bus have been growing from 216 to 320 as a result of the system expansions, extended hours of attention, and a higher number of express services being served.

5.3 *Ticketing*

Operations started with manual procedures for verification. Tests with intelligent contact-less cards started in February 2001. These tests also helped in user education on the procedures for entering and leaving the system. In March 2001 a multiple trips electronic card was introduced, and by May 2001 tickets were completely abandoned.

The ticketing system includes 90 selling booths, 359 barriers, and more than one million intelligent contact-less cards. Daily revenue is around US\$300,000.

5.4. *Control Systems*

The control centre is equipped with 6 workstations, each able to control 80 articulated buses. The system has voice and data permanent communication with all the articulated buses and system supervisors.

Each bus has a logic unit connected with a GPS, the odometer and the door opening system. The logic unit reports the location of the bus each 6 seconds

with a 1 meter precision. Information is processed with specialized software, which is able to verify schedule compliance, giving the controllers the opportunity to make adjustments in real time.

Implementation started with radio (trunking) verification by supervisors along the trunk corridors during the first weeks. Continuous and complete operation of the control system was achieved in April 2001.

6. IMPACTS

6.1. *Accidents and Air Pollution*

A comparison between statistics before and after system implementation indicate an important reduction in accident and air pollution levels. A reduction of 92% in fatalities and 75% in injuries resulting from traffic accidents, given a reduction of 79% in collisions in the corridors served by the system have been observed with the system implementation. Reported robberies in the area of influence of the busways have also declined in 47%.

Pollutant levels for 2000 and 2001 from a monitoring station close to Av. Caracas Busway have been reduced in 43% in Sulfur Dioxide SO₂, 18% in Nitrogen Dioxide, and 12% in particulate matter (less than 10 micras).

6.2. *Travel Time*

Commercial speed of traditional public transit were 12 Km/h and 18 Km/h in Calle 80 and Avenida Caracas, respectively. These speeds increased to 26,7 Km/h. This allowed for a 32% reduction in average trip times for the users of the system. This has been reflected in the system perception: 83% of the persons answering a poll, indicated that fast service was the main reason for using TransMilenio.

6.3. *Equal opportunity access*

Trunk system is fully accessible for users with disabilities, elderly, youngsters and pregnant women. About 1% of the users (63,000 persons per day) is among these categories of users. They find in TransMilenio an accessible option for their condition.

6.4. *Quality and Consistency*

The system has very high acceptance levels as a result of the very strict standards required to build the infrastructure and operate the articulated and feeder buses. Satisfaction polls show that 49% of the users find the

system very good and another 49% find the system good.

6.5. *Affordability*

The system is affordable to the users and local and national government, and, most importantly to the users. A trip in TransMilenio cost US\$0,40 and totally covers capital investment, operation and maintenance of the bus fleet and ticketing system; supervision and control of the system; administrative costs of the trust fund used to deposit the revenues; and the stations cleaning and maintenance. This cost is 6% higher than the average cost of traditional public transport, which is currently operating with a 14 years old fleet.

7. CONCLUSIONS

The bus rapid transit system TransMilenio, as one component of the Mobility Strategy, is part of a structural change in the transportation system in Bogotá. The first year of operation show the very high possibilities of the system to provide efficient and high quality mass transportation at a very low cost for the users and the government. It is also shows that it is possible to introduce innovative private participation mechanisms, under sustainability of the system and its components.

Project implementation was very fast. The project changed from a well defined, but very general, idea to commissioning in 36 months. This was possible thank to a strong political will, adequate financial support for infrastructure development, a lot of work from a committed and enthusiastic technical team, as well as a great deal of luck.

System productivity is very high compared to traditional public transit; 5,4 passenger per kilometre, 1.772 passengers per bus per day, and 320 kilometres per day per bus. Fullfillment of the objectives is underway, and achievements are already evident: reduction of 92% in fatalities, decline of 32% in average travel time, with 98% acceptance level and a affordable cost of travel (US\$=0.40) .

The system future, along with the one of the city, are promising. Bogotá experience can be taken into account to improve transport conditions in other cities. TRANSMILENIO S.A., which is the company in charged of planning, developing and controlling the system, and is able to share its experience with any interested party.

For more information check www.transmilenio.gov.co, or contact Dario Hidalgo at dario-hidalgo@transmilenio.gov.co.

