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EMBARQ
The WRI Center for Sustainable Transport

Lessons learned from major bus improvements in Latin America and Asia

MODERNIZING PUBLIC TRANSPORTATION

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cts MÉXICO | cts BRASIL | sum TÜRKİYE | cst INDIA | ctss ANDINO

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The EMBARQ global network catalyzes environmentally and financially sustainable transport solutions to improve quality of life in cities.

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EMBARQ is a member of the Bus Rapid Transit: Across Latitudes and Cultures (BRT-ALC) Centre of Excellence (www.brt.cl), funded by the Volvo Research and Educational Foundations.

FOREWORD

WITH MORE OF THE WORLD'S POPULATION LIVING IN URBAN AREAS THAN EVER BEFORE, and the largest agglomerations now home to more than 10 million people, cities today face urgent and complex development challenges.

In managing growth and providing services, planners and politicians increasingly seek to balance economic priorities with sustainable development that meets social needs and mitigates environmental impacts. This report examines efforts by major cities across Latin America and Asia to apply such approaches to public transport.

Urban transportation systems significantly affect cities' quality of life and, through associated air pollution and greenhouse gases, the wider regional and global environments. These impacts can be mitigated by sustainable transport policies which promote cleaner, more efficient public transport systems in order to reduce congestion, minimize travel times, reduce GHG emissions and local air pollutants, decrease road traffic injuries and deaths and improve public health.

Sustainable urban transport can have measurable positive impacts and externalities, but in order to realize its full potential to transform cities, a transport project must be planned, implemented and operated effectively. This is far from an easy task, involving a myriad political, financial, technical, institutional and communication challenges.

In order to shed light on these challenges, *Modernizing Public Transportation: Lessons Learned from Major Bus Improvements in Latin America and Asia*, presents a comparative analysis of the performance of 13 modernized bus systems in cities including Bogotá, São Paulo, and Santiago, Jakarta and Beijing. The result is an illuminating snapshot of the state of practice of bus transport in Latin America and Asia, highlighting both common hurdles and problems encountered, and positive lessons learned, from recent efforts to make getting around mega-cities more efficient and environmentally-friendly.

EMBARQ, WRI's Center for Sustainable Transport, promotes the use of bus rapid transit (BRT) around the world as a sustainable, high-impact and relatively low-cost transport solution. The data compiled for this report confirms that BRT can provide high-capacity—up to 45,000 passengers an hour in each direction—with comparatively low capital investment—less than US$12.5 million per kilometer. Equally impressively, the modernized or new transit systems we looked at were implemented relatively quickly—in only two to five years from concept to commissioning—and were able to break even or require small operational subsidies.

The report also summarizes common pitfalls and shortcomings encountered in these 13 cities in designing, financing and implementing BRT and citywide bus systems.

We hope our findings will enable urban transportation agencies in cities already pursuing sustainable solutions to learn from others' experiences, improve their systems, and achieve greater transport, environmental and public health impacts. We also hope that cities embarking on new transportation projects can draw on our analysis to avoid the shortcomings of others' approaches in delivering environmentally and financially sustainable transport solutions.

As the world searches for low-cost, low-carbon transport solutions, this report underlines that BRT projects should be championed and prioritized, especially in developing countries where infrastructure financing options are more limited and rapid motorization is exacerbating urban problems of congestion, pollution and road traffic injuries and deaths.

We thank the city officials, experts and professionals who shared their data and were candid about their transport projects' challenges and shortcomings, in order that others may learn from their experiences. We believe their willingness to share processes undergone and lessons learned will give rise to improved urban transport planning, design, implementation and operation, ultimately bringing a better quality of life and cleaner environments to the cities of the emerging world.

Jonathan Lash
President

LEON
Entrada

EXECUTIVE SUMMARY

THE MEGA-CITIES OF LATIN AMERICA AND ASIA rely on public transport to keep their citizens moving and economies working while mitigating the negative environmental impacts of rapid motorization. Increasingly, these cities are upgrading or even transforming their public transport systems to better serve the needs of their populations and the environment. Some of these efforts have been more successful than others and some more widely publicized. To date, however, there has been no synthesis of benefits and shortcomings of the various approaches taken, in order to inform future urban transport projects in emerging nations. There are several studies, for example, about the celebrated successes of the TransMilenio bus rapid transit system in Bogotá, Colombia, and its counterpart in Curitiba, Brazil, but little literature on the shortcomings of these, and similar systems, creating an informational gap in constructive advice on lessons to be learned.

This study seeks to fill that information gap by summarizing key findings and lessons learned from a comprehensive review of major bus improvements in 13 Latin American and Asian cities. In particular, it reviews and synthesizes information regarding challenges experienced by transport system decision makers in three key areas: planning, implementation and operations. In order to assist urban transport planners and implementing agencies, the study also provides recommendations on avoiding or mitigating similar difficulties when introducing bus reforms in developing world cities.

The selected cities were chosen for several reasons including: long-term recognition in urban transport practices, multi-functional land usage practices for urban environments, and/or the recent[1] completion of bus system improvements. The review includes the following cities: Curitiba, Quito, Bogotá, São Paulo, León, México City, Pereira, Guayaquil, Santiago and Guadalajara in Latin America, and Jakarta, Beijing and Ahmedabad in Asia. The cities vary in size and socio-economic characteristics (see table 1), but in each case buses account for a substantial portion of total public transport use and bus rapid transit (BRT) was introduced as a component of reform.

[1] Completion within the past 15 years is considered recent.

Table 1 Key Statistics of Selected Cities

CITY	COUNTRY	METRO AREA POPULATION 2006	METRO AREA POPULATION DENSITY (POP/KM^2)	2009 HUMAN DEVELOPMENT INDEX VALUE (RANK) [a]
Curitiba	Brazil	2,960,000	4,568	0.813 (75)
São Paulo	Brazil	18,610,000	9,456	0.813 (75)
Santiago	Chile	5,700,000	2,896	0.878 (44)
Beijing	China	10,850,000	14,505	0.772 (92)
Bogotá	Colombia	7,800,000	15,058	0.807 (77)
Pereira	Colombia	443,000	631	0.807 (77)
Quito	Ecuador	1,550,000	3,236	0.806 (80)
Guayaquil	Ecuador	2,460,000	7,130	0.806 (80)
Ahmedabad	India	5,340,000	11,459	0.612 (134)
Jakarta	Indonesia	13,670,000	10,051	0.734 (111)
Léon	México	1,470,000	1,205	0.854 (53)
México City	México	19,240,000	9,286	0.854 (53)
Guadalajara	México	3,950,000	6,628	0.854 (53)

Sources: Data from City Mayors, Statistics, http://www.citymayors.com/sections/rankings_content.html; United Nations Environment Programme, Human Development Index (HDI) 2009, http://hdrstats.undp.org; Department of Risaralda, Colombia, http://risaralda.com.co/; City of Guayaquil, http://www.guayaquil.gov.ec/; CST India, EMBARQ Center for Sustainable Transport, "Transport in Cities, India Indicators", 2009, http://www.embarq.org/en/india-transport-indicators; México National Institute for Federalism and Municipal Development, E-Local, http://www.e-local.gob.mx

[a] HDI rank is out of 182 countries.

How to Use this Report

This synthesis report summarizes cross-cutting issues gleaned from an in-depth review of 13 cities based on an analysis of available material, site visits, and interviews with stakeholders, especially members of implementation teams and transit operators. Case studies about several of the reviewed cities have been published on the EMBARQ (www.embarq.org) website. The following three sections of this report provide:

- An overview of transit provision in the target cities, together with technical, financial and performance information about the bus systems;
- A synthesis of lessons learned from addressing issues that arose in the planning, implementation and operation of the bus systems;
- Conclusions and recommendations for urban planners and transit decision makers in developing countries.

Key Findings

The transit improvements in 13 cities reviewed in this report resulted in a variety of improved conditions for city commuters, some of which also benefited the population at large and the environment. These included reductions in air pollutants, greenhouse gas emissions, noise and traffic accidents, and efficiency improvements by bus rapid transit corridors compared with traditional bus services. Corridors in the selected bus systems exhibit very high usage levels (1,780-43,000 passengers/hour/direction), with comparatively low capital investments[2] (US$1.4-12.5 million/km), and little or no operational subsidies.

The review also revealed common challenges and lessons:

- No project was perfectly executed, due to a combination of institutional, technical, financial and/or politically induced time constraints;
- Initial implementation was generally rushed, causing operational and user problems;
- Financial and institutional sustainability was not necessarily assured;
- Bus rapid transit routes were often not fully integrated into the rest of the cities' public transport system;
- Many projects faced extensive challenges in accommodating regular city traffic;
- In cities where BRT services were new, or expanded quickly, public information and user education was critically important to a smooth launch.

Recommendations

PLANNING PHASE

- Institute a comprehensive planning process which combines financial, legal, institutional and environmental concerns with engineering/ technical efforts.
- Improve the quality of information used to make decisions on key building blocks of a new or improved transport system, such as: route selection, basic infrastructure concepts (median lanes, types of stations, terminals), vehicle technologies, and types of operation.
- Dedicate enough resources—time and money— for adequate project preparation, but avoid endless alternatives analysis.
- Use experiences from other cities as a reference, but adapt system components and characteristics to local conditions.
- Seek to create special purpose full-time teams for system planning and implementation, independent from day-to-day responsibilities.

DECISION-MAKING PROCESS

- Get early approval from high-level decision makers as top-down approaches are faster and resolve interagency conflict. At the same time, maintain community involvement through education and participatory processes.
- Maintain and nurture high-level approval and buy-in during the implementation and operation of the system.
- Pay careful attention to regulatory/institutional issues, adapting the existing regulatory framework if required. Where bus improvements are to be integrated with an existing metro system, convince the rail operator that the BRT is complementary, not a competitor.

[2] Not including costs of public space and mixed-traffic road improvements that are sometimes carried out at the same time as BRT construction.

- Create a special purpose agency to plan, oversee and control system development, and provide adequate coordination mechanisms.
- Be creative in funding project development, using new taxes, loans and non-traditional sources such as privatizations and special purpose bonds.
- Involve existing bus operators to mitigate conflicts, but use bidding processes to reduce user costs through increased market competition.

DESIGN PHASE

- Only attempt citywide reorganization of transit services where institutional capacity for regulation is strong and there is broad public support.
- Define clear development objectives, estimate passenger demand and develop a service plan as the basis for physical and operational design.
- Implement gradually, adapting the project on the basis of initial experience.
- Make an effort to use existing right-of-way to reduce land acquisition and involuntary displacement.
- Use sound engineering design for new infrastructure, especially pavement, to avoid rapid deterioration.
- Opt for median lanes and level access platforms with many bus boarding doors to increase speed and reliability.
- Use strong lane dividers to segregate traffic. Focus on physical integration, for instance, by matching the heights of vehicle floors and station platforms.
- Design vehicles in line with a service provision plan.
- Wherever possible, minimize negative effects on mixed-traffic flow as increased congestion can create vociferous criticism and jeopardize support.

IMPLEMENTATION PHASE

- Generate a realistic schedule and manage it to avoid rushed implementation.
- Have contingency plans ready if system components are not complete.
- Dedicate funds to plan and implement user education programs.
- Involve the community in implementation through adequate information and participation/engagement programs.

OPERATIONAL PHASE

- Match service operations to supply and demand, using the intrinsic flexibility of buses.
- Restructure or transform existing bus operations so that they complement rather than compete with the new bus rapid transit system.
- Budget for required infrastructure maintenance such as pavement, stations and terminals.
- Allow time to adapt and implement advanced fare collection systems.
- Use advanced transit management systems if operations are complex to help ensure reliability.
- Promote the system's image, through good public information provision, user surveys, and maintenance of fixed infrastructure and vehicles.

STRUCTURAL ISSUES

- Define user fares according to the actual per passenger cost of providing the transit service (known as the "technical fare"), in order to avoid financial difficulties and political interference.
- Avoid continuous renegotiation of bus operating contracts as this approach has often tipped in favor of operators.
- Integrate the bus system development with other transport initiatives such as rail transit projects.
- Apply transit-oriented urban development concepts to enhance positive impacts and reinforce project sustainability. For example, consider land-use reform, permitting higher densities along the mass transit corridor.
- Have a clear vision for the BRT system's expansion.

OVERVIEW

ALL 13 CITIES REVIEWED IN THIS REPORT EMBRACED BUS RAPID TRANSIT in response to dysfunctional and inefficient transport conditions, public discontent, and critical environmental and road safety conditions (Hidalgo and Graftieaux 2008). With the exception of Brazil, China and India, prior to the implementation of the new bus systems, traditional bus services were operated by private providers under semi-deregulated fares and routes, coupled with weak planning, enforcement, and control strategies (Orrico Filho et al. 2007). While traditional bus transport in the featured cities was notable for its low user fares and extended coverage, it also featured major inefficiencies and negative impacts on the surrounding environment. Weak local government regulation had resulted in excessive bus fleets, inadequate vehicle sizes, obsolete equipment, long routes with inefficient and irregular operation, and minimal vehicle and infrastructure maintenance. The cities also suffered from high levels of congestion, accidents, emissions (of local air pollutants and carbon dioxide, the main greenhouse gas), as well as noise pollution. A common feature of traditional transit services is competition among vehicles for passengers known as "war of the penny", competition on the street, or competition in-the-market[3], which often leads to oversupply of buses and low-quality service.

Compared to the other countries, Brazil had developed stronger institutions and regulations to plan and manage the bus transit services at the local level under private provision by large companies (Orrico Filho et al. 2007). In contrast, China and India had mainly kept transit provision under local public agencies. Despite the differences in regulation and ownership, services in São Paulo, Beijing and Ahmedabad were considered of poor quality before changes were made: crowded, slow, and unreliable due to lack of integration, inadequate infrastructure, and interference from general traffic congestion.

[3] Term commonly used by transport economists as opposed to competition for-the-market which is generated through bidding processes for service or concession contracts. Competition in-the-market often leads to high fares, oversupply of buses and low quality service, while competition for-the-market can result in lower user fares, benefitting the public (Ardila, 2003).

BUS RAPID TRANSIT DEFINED

Bus rapid transit (BRT), as the name suggests, is a rubber-tired mode of public transport that enables efficient travel (Wright and Hook 2007). BRT flexibly combines stations, vehicles, services, running ways, and intelligent transportation system (ITS) elements into an integrated system with a strong brand that evokes a unique identity (Levinson et al. 2003). BRT has the potential to provide a higher quality experience than possible with traditional bus operations due to reduced travel and waiting times, increased service reliability and improved usability (Diaz et al. 2004). BRT is also capable of improving local and global environmental conditions (PNUMA 2010).

The successful system in Curitiba, whose first busway was in operation in 1973 and its full BRT in 1982, has been followed and adapted by 16 cities throughout Latin America and the Caribbean. Today, BRT systems in various forms are in operation in more than 70 cities around the world, and being planned in dozens more. The increased interest in BRT is the result of its ability to deliver high-performance transit services at relatively low costs, with short implementation times and high positive impacts (Wright and Hook 2007; Diaz et al. 2004). Applications of BRT systems range from isolated corridors to integrated transport networks, and in some cases, are a component of citywide transport reforms.

Despite the growing popularity of the concept, BRT implementation faces several obstacles. Since few high-quality applications of BRT exist, there remains a lack of widespread familiarity with the concept. BRT typically uses existing road infrastructure which reduces road capacity for vehicular traffic. Finally, planning and implementing BRT requires the coordination of several agencies and appropriate funding levels.

EMBARQ, the World Resources Institute Center for Sustainable Transport, works to catalyze environmentally and financially sustainable transport solutions to improve quality of life in cities. To that end, EMBARQ has supported the planning, implementation and evaluation of BRT systems in at least 14 cities.

Bus system improvements sought to change the status quo

Bus system improvements reviewed in this study sought to change the status quo of urban transport services in one of two ways: through relatively small-scale corridors[4] or through large-scale reorganizations. Each transport system reviewed used components of BRT to different degrees. Although BRT is the core constituent in most systems, in São Paulo and Santiago it is part of much broader, citywide transit reform. The precise mix and scope of the BRT components applied in each project depended on the local market, physical restrictions and the availability of resources. Table 2 describes the scale, supply and demand of the case study bus systems. For comparative purposes, figures 1-7 then summarize the main indicators of system performance and costs. The scale of systems ranges from six million passengers per weekday in São Paulo, to relatively low-volume corridors such as Ahmedabad's Janmarg with 35,000 passengers per weekday (figure 1 on page 14).

[4] In most cases, small-scale corridors were implemented with the goal of gradual expansion.

TERMS

KEY TERMS DEFINED

ARTICULATED BUS
Typically an 18m-long bus, with three doors, one pivoting joint in the bus body, three axles and a capacity of approximately 170 passengers

BI-ARTICULATED BUS
Typically a 25m-long bus, with five doors, two pivoting joints in the bus body, four axles and a capacity of approximately 250 passengers.

BUS LANE
A traffic lane reserved for buses that may be painted, striped or signed, but is not physically separated from mixed traffic. Buses are given priority in the lanes either throughout the day, or during specific intervals, and sometimes taxis, high-occupancy vehicles and bicycles are permitted to share the bus lanes. Because other traffic is not physically prevented from entering the lanes, the travel time savings is typically small, relative to a busway.

BUSWAY
A priority lane for buses physically segregated from mixed traffic by curbs, rumblestrips, guiderails or other barriers. Many at-grade busways are in the median to minimize conflicts with turning vehicles at intersections, but they can also be elevated or below-grade. An open busway would permit all bus operators to use the lanes, while an exclusive busway would be restricted to a single type of service or operator (for instance to only BRT buses).

CONVENTIONAL BUS
Typically a 12m-long bus, with 1–2 doors and capacity of approximately 80 passengers. Conventional buses can have low or high floors.

ELECTRONIC (OR AUTOMATIC) FARE COLLECTION
Efficient cashless passenger fare payment system, incorporating magnetic stripe fare cards or smartcards, fare validation devices, turnstiles and ticket vending machines. Fare collection can be on-board or off-board the bus, but off-board fare collection reduces passenger boarding times and therefore vehicle delays.

FEEDER BUS
Typically a conventional bus or smaller vehicle that connects, or “feeds” passengers in lower-density neighborhoods to trunk route stations, terminals or integration points where they can transfer to other routes. In a physically integrated system, feeders would stop at the BRT station.

INTEGRATION
Bus systems can have three levels of integration: physical, operational and fare integration. Physical integration refers to infrastructure that allows passengers to transfer between bus routes and other modes of transport; operational integration involves co-ordination of schedules; fare integration involves payment of a single fare or reduced fares for combined services.

INTELLIGENT TRANSPORTATION SYSTEMS (ITS)
A suite of technologies that allows for dynamic control and operation of a transit system, including automatic vehicle locators, centralized vehicle control, integrated traffic signal control, automatic fare collection and real-time passenger information systems.

LIGHT RAIL TRANSIT (LRT)
A railway with less capacity than heavy rail (subway, metro), that may use shared or exclusive rights-of-way, high or low platform boarding and either multi-car trains or single cars (APTA 1994).

TROLLEY BUS
An electric rubber-tired bus drawing current from overhead wires to which it is tethered. Similar to a streetcar or trolley, with rubber tires instead of track (APTA 1994).

TRUNK CORRIDOR
The main spine of a trunk-feeder BRT system, which is typically a segregated busway along a high-density corridor.

Table 2 Overview of Reviewed Bus Systems (2009)

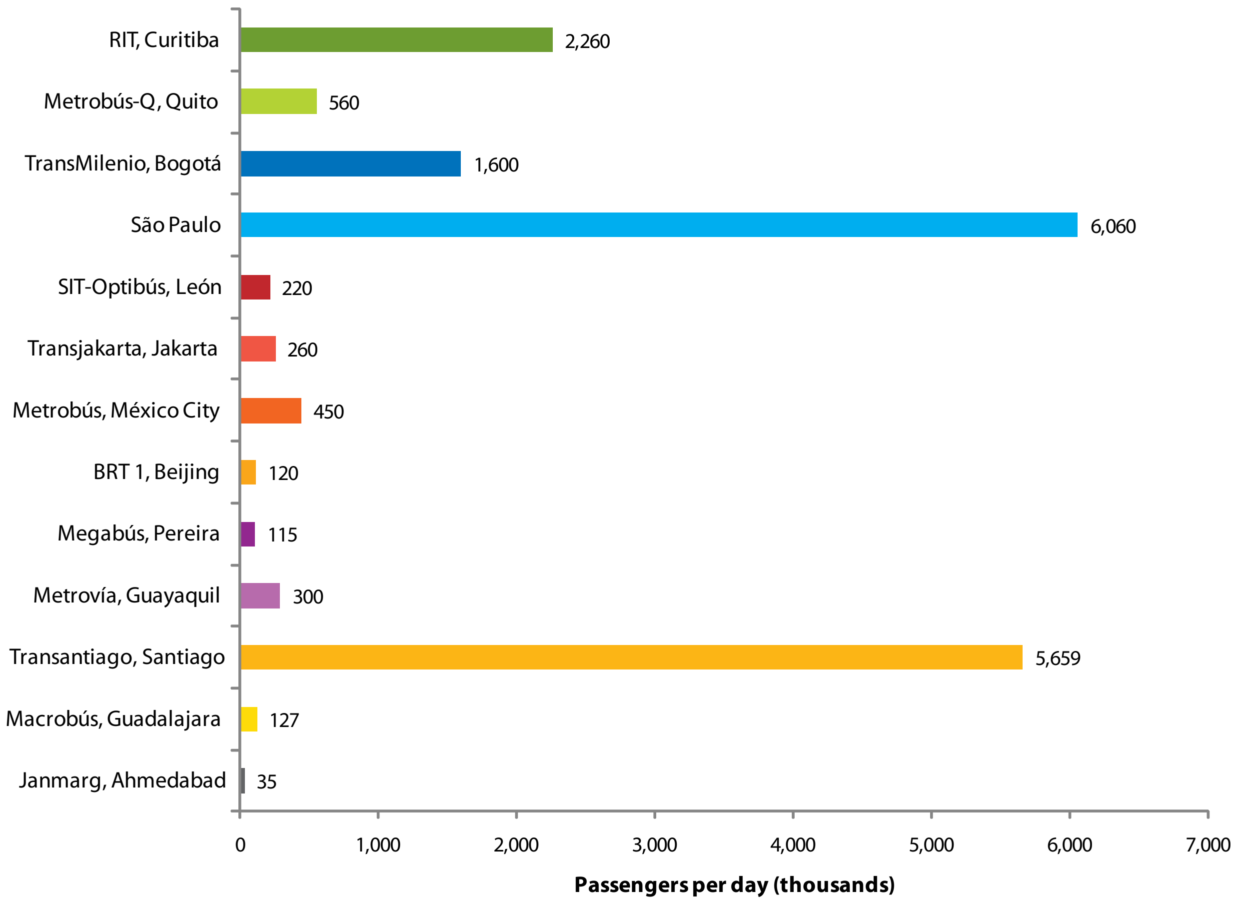
CITY PROJECT (INITIAL YEAR)	GENERAL DESCRIPTION	SUPPLY/ DEMAND	COMMENTS
Curitiba RIT (1973)	Citywide integrated bus system with five BRT corridors (65 km of median busways), 139 stations, 26 terminals, 340 km of feeder routes, 185 km of inter-district circular routes, 250 km of "rapid bus" routes; total of 340 bus lines and 1,100 km of bus routes.	2,200 vehicles, including 114 bi-articulated diesels as well as articulated, conventional, small buses, special service buses; electronic fare collection system. 2.26 million passengers/day.	7 private operators under agreements with a public authority. New 22 km BRT corridor under construction.
Quito Metrobús-Q (1995)	Three BRT corridors (37 km, mostly median busways); 68 stations, 9 terminals; integrated feeder services; centralized control (separately for each corridor)	189 articulated buses (113 trolley buses), 185 feeder buses, coin-based fare collection. 560,000 passengers/day.	Public operator/owner (Trolebús and Ecovía corridors), private operator (North corridor), no fare integration among corridors. Discussion to replace Trolebús with an LRT.
Bogotá TransMilenio (2000)	High-capacity BRT system with 84 km median busways, 104 stations, 10 integration points, integrated feeder services and advanced centralized control.	1,190 articulated buses, 10 bi-articulated buses, 448 feeder buses, electronic fare collection system. 1.6 million passengers/day.	Five private groups, partially formed by some traditional operators, hold concession contracts for 7 trunk and 6 feeder zones. Two new corridors (22 km) under development as well as a citywide reform of traditional bus services. Metro system under study.
São Paulo Integrated System (2002)	Integrated system under single fare with partial BRT treatments in some corridors (e.g. Passa-Rapido corridor).104 km median busways, preferential bus lanes, 327 transfer stations, 24 terminals.	13,711 buses: 1,073 articulated, 5,599 padron (90-passenger), 2,423 conventional, 3,063 microbus (21-passenger), 1,553 minibus (42-passenger), integrated electronic fare collection system. 6 million passengers/day.	Private operators under concession contracts with the municipal public agency SPTrans. Integration has been expanded to regional rail and several municipal services within the metropolitan area.
León SIT-Optibús (2003)	3 BRT trunk corridors with 25km median busways (60% segregated), 3 terminals, 51 stations, integrated feeder services, centralized control.	55 articulated buses; 500 auxiliary and feeder buses; electronic fare collection system. 220,000 passengers/day.	Thirteen existing private concessionaries formed 4 new operators for trunk-ways and continue feeder services operation. System under expansion (Phase II) including reorganization of citywide services.
Jakarta Transjakarta (2004)	Three BRT trunk corridors with 37 km median busway, 4 terminals, 63 stations, poor integrated feeder, centralized control	162 conventional buses (12 m), electronic fare collection system. 260,000 passengers/day.	Two private operators, physical integration with commuter train and local buses.
México City Metrobús Insurgentes (2005)	Two BRT corridors, 50 km median busway, 77 stations, four terminals, centralized control using ITS	209 articulated buses, 12 bi-articulated buses, electronic fare collection system. 450,000 passengers/day.	Eight bus operators, (one public), two fare collection contractors, physical integration with regional buses, regional rail and Metro.

Table 2 (continuted)

CITY PROJECT (INITIAL YEAR)	GENERAL DESCRIPTION	SUPPLY/ DEMAND	COMMENTS
Beijing Beijing BRT (2005)	One BRT trunk corridor with 16 km median busway, one terminal, 19 stations, centralized control.	60 articulated low-floor buses, manual fare collection system. 120,000 passengers/day.	One private operator, and physical integration with Metro.
Pereira Megabús (2006)	16 km exclusive busways (50% in median, 50% on left side on one-way streets in downtown), plus 800m in mixed traffic on a major bridge, 37 stations, two terminals, centralized control.	52 articulated buses, 82 small feeder buses, electronic fare collection and control system. 115,000 passengers/day.	Two private operators of buses, one fare collection concessionaire.
Guayaquil Metrovía (2006)	35 km exclusive bus lanes on the median or left side on one way streets, 60 stations, 3 terminals, centralized control.	92 articulated buses, 80 feeder buses, electronic fare collection system. 300,000 passengers/day.	One private concessionaire for bus operations, one fare collection and technology provider. System expansion in 2007.
Santiago Transantiago (2007)	18.8 km of segregated corridors, 4.6 km of new road connections, 62.7 km of improvements in road geometry and pavements (in seven corridors), 70 large bus shelters along the main corridors, and three intermodal stations. 45 km expansion of Metro network.	1,200 new low-floor articulated buses, 1,500 conventional trunk buses (to be gradually replaced by new low-floor buses), and 2,300 feeder buses. Integrated electronic fare collection system. 5.7 million passengers/day.	Buses privately operated through 14 concession contracts: one private operator for financial management, one private operator for systems integration (control and user information), and one public operator (Metro).
Guadalajara Macrobús (2009)	16km of median busways, 27 stations, integrated feeders, centralized control.	41 articulated buses, 103 feeder buses, electronic fare collection. 127,000 passengers/day.	Good integration with light rail system and feeder routes, one private concessionaire for bus operations.
Ahmedabad Janmarg (2009)	18km of exclusive median busways, 26 stations, centralized control.	25 conventional trunk buses, manual fare collection. 35,000 passengers/day.	One public bus operator, one private fare collection contract and one ITS contract.

Sources: Data from Curitiba http://www.curitiba.pr.gov.br; Quito http://www.quito.gov.ec; Bogotá http://www.transmilenio.gov.co; Prefeitura do Municipio de São Paulo, "O Plano do Transporte Público em Implantacao na Gestao de 2001-04", 2004; Direción General de Transporte, Municipalidad de León, "Sistema Integrado de Transporte Optibús"; Movilidad Amable, Centro de Desarrollo Sustentable, México D.F., "Metrobús: Bienvenidos a Bordo", Septiembre de 2005; Institute for Transportation & Development Policy, "Making Transjakarta a World Class BRT System: Final Recommendations", June 2005; Beijing Transportation Research Center, "BRT Demonstration Project BRT in South-Middle Corridor in Beijing", Brief Report on Feasibility Study, September, 2003; Pereira http://www.megabus.gov.co; Guayaquil http://www.metrovia-gye.com/start.htm; Santiago http://www.transantiago.cl; Santiago interviews, 2006 and 2007; Dario Hidalgo et al, "El Sistema Macrobús de Guadalajara: Un Concepto Avanzado de Planeación e Implantación de Transporte Masivo BRT", March 2010, http://tris.trb.org/view.aspx?id=910301; Centre of Excellence in Urban Transport, "Janmarg: BRTS Ahmedabad, After Five Months of Commercial Operations", April 2010, http://www.ahmedabadbrts.com/Reports/5th_month_report.pdf

Figure 1 Total Passenger Demand (2009)

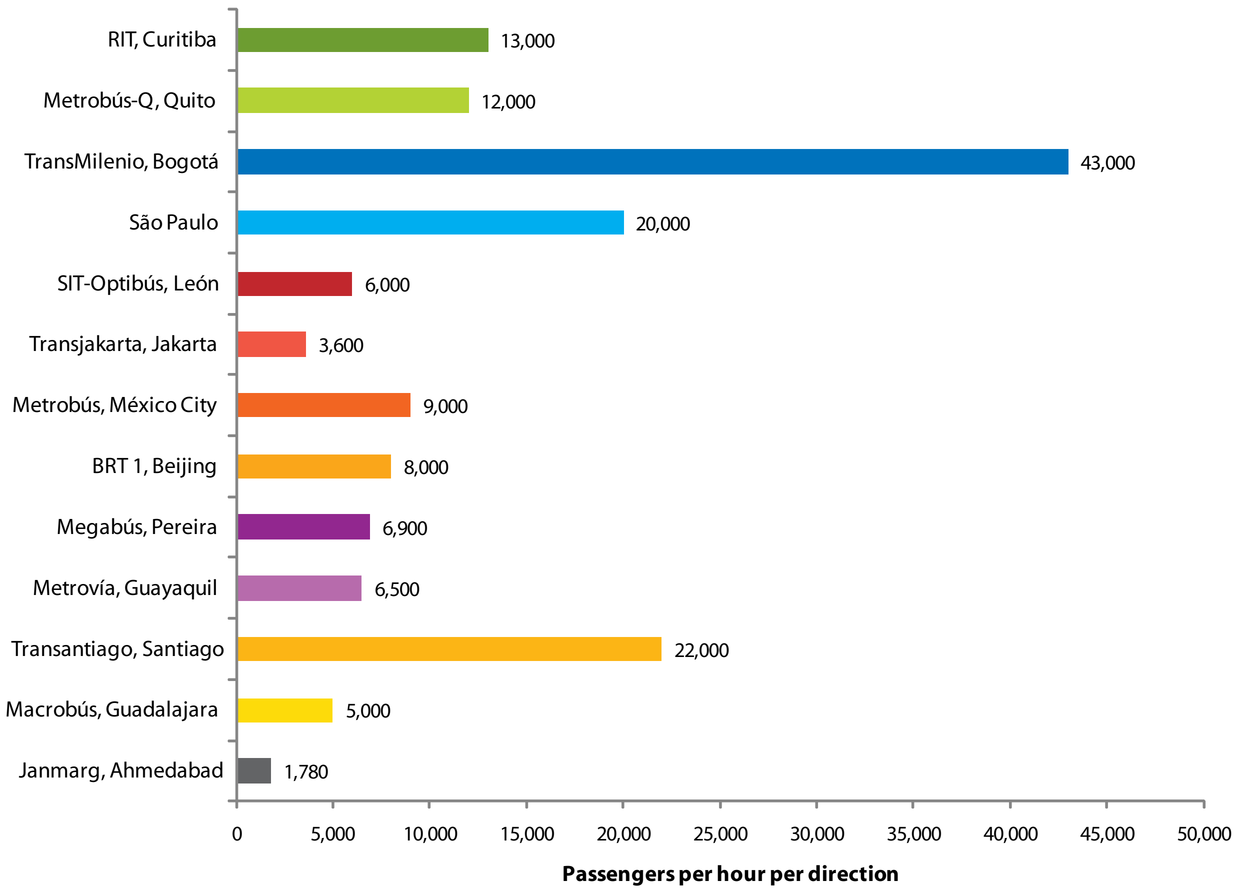


Notes: Scope of the systems varies with respect to inclusion of BRT components and level of integration. For example, the data for Santiago, São Paulo and Curitiba cover the entire citywide integrated bus systems, of which only a small portion is on BRT corridors. For all other cities, passenger data primarily refers to BRT passengers. For Santiago and São Paulo passenger demand data is daily boardings not daily passengers, so each transfer counts as a separate boarding. Bogotá data is from 2010. Colors differentiate each city.

In terms of peak usage on a single BRT corridor, TransMilenio's Avenida Caracas in Bogotá, is the best performing, with 43,000 passengers per hour in each direction. Passa-Rapido in São Paulo and the Alameda in Santiago, with around 20,000 passengers per hour in each direction, also carry very high volumes. High-capacity corridors such as these have additional bus-only lanes at stations to allow buses to overtake each other. Many of the remaining corridors have single lanes and only carry 1,800 to 13,000 passengers per hour in each direction (figure 2).

Average commercial speeds vary from Transjakarta's low speed of 15 km/hour to 28 km/hour in Bogotá's TransMilenio (figure 3). Higher speeds are achieved as more BRT components are integrated. For example, the introduction of segregated busways, platform boarding, prepayment, larger buses, express services, centralized control, and reduced numbers of intersections all contribute to increased average speed and effectiveness.

Figure 2 Peak Loads (2009)



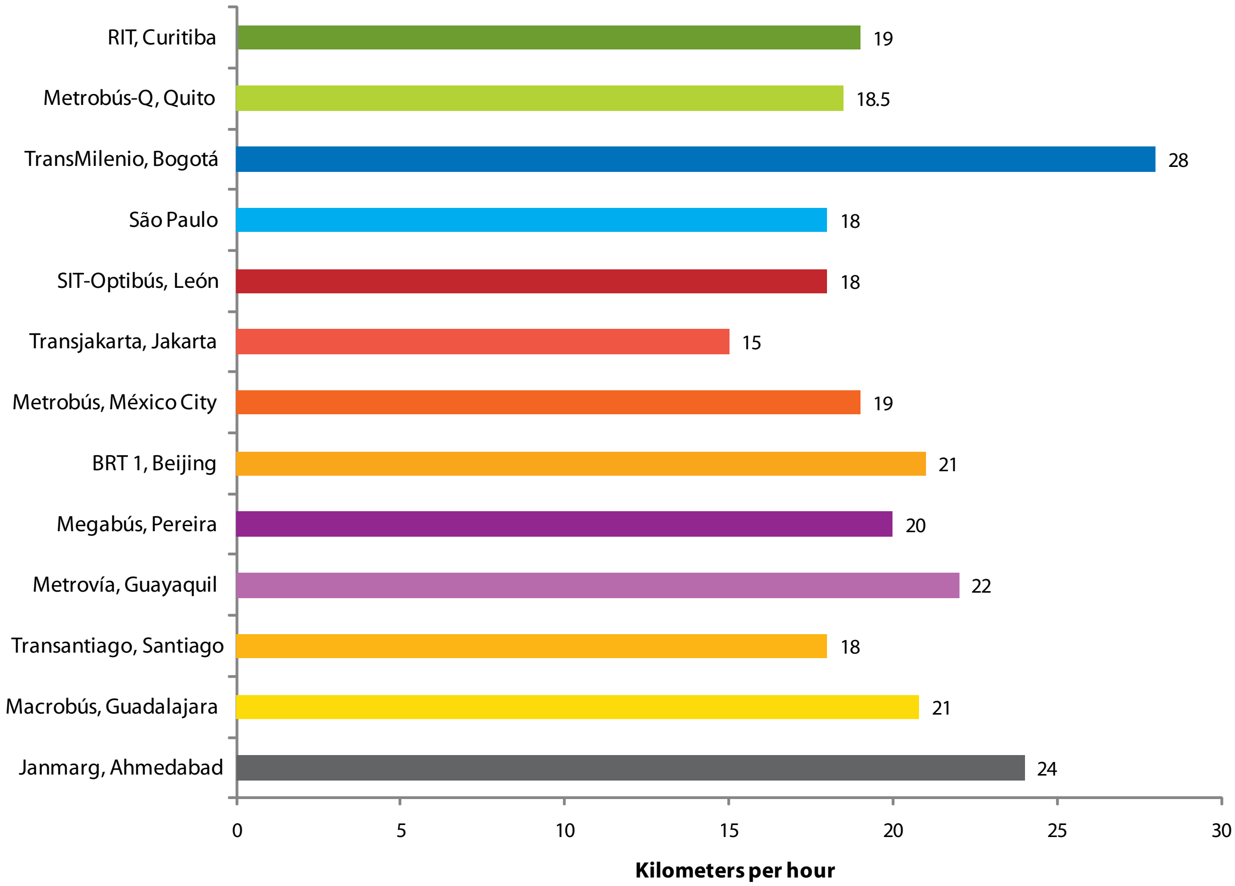
Notes: São Paulo and Quito data from 2006. Data unavailable for Santiago.

Highest operational productivity[5] was achieved in Guayaquil where Metrovía reported 13 passenger boardings per bus-km (figure 4). The lowest levels of productivity were reported in Jakarta, Beijing and Bogotá (around five passenger boardings per bus-km). Even these relatively low levels of operational productivity are still five times greater than those observed in traditional systems operating in mixed traffic.

In terms of capital productivity (average number of daily passengers per bus), Guadalajara's Macrobús reported 3,100 passengers per bus per weekday and Guayaquil's Metrovía nearly 3,000 (figure 5). Lowest capital productivity was reported in León with 396 passengers per bus per weekday[6].

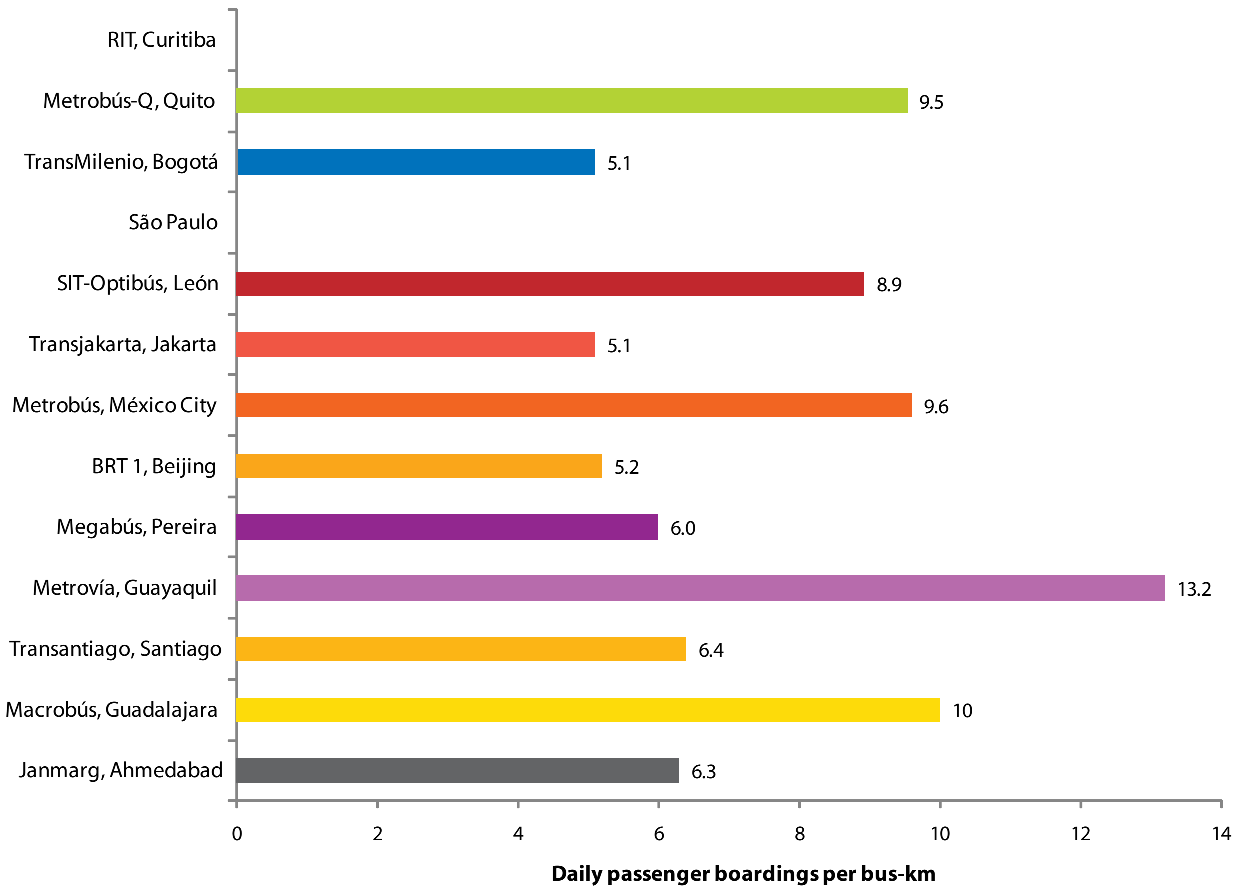
[5] Operational productivity is defined as passenger boardings per day (output) per daily bus kilometers (input). There are external factors affecting operational productivity such as corridor density, trip length, and availability and characteristics of transport alternatives. Conversely, there are also internal factors such as the way routes are programmed (radial/diametric, short/long, local/express), minimum headways, and occupancy levels, among others.
[6] This figure combines segregated and mixed traffic operations.

Figure 3 Commercial Speeds (2009)



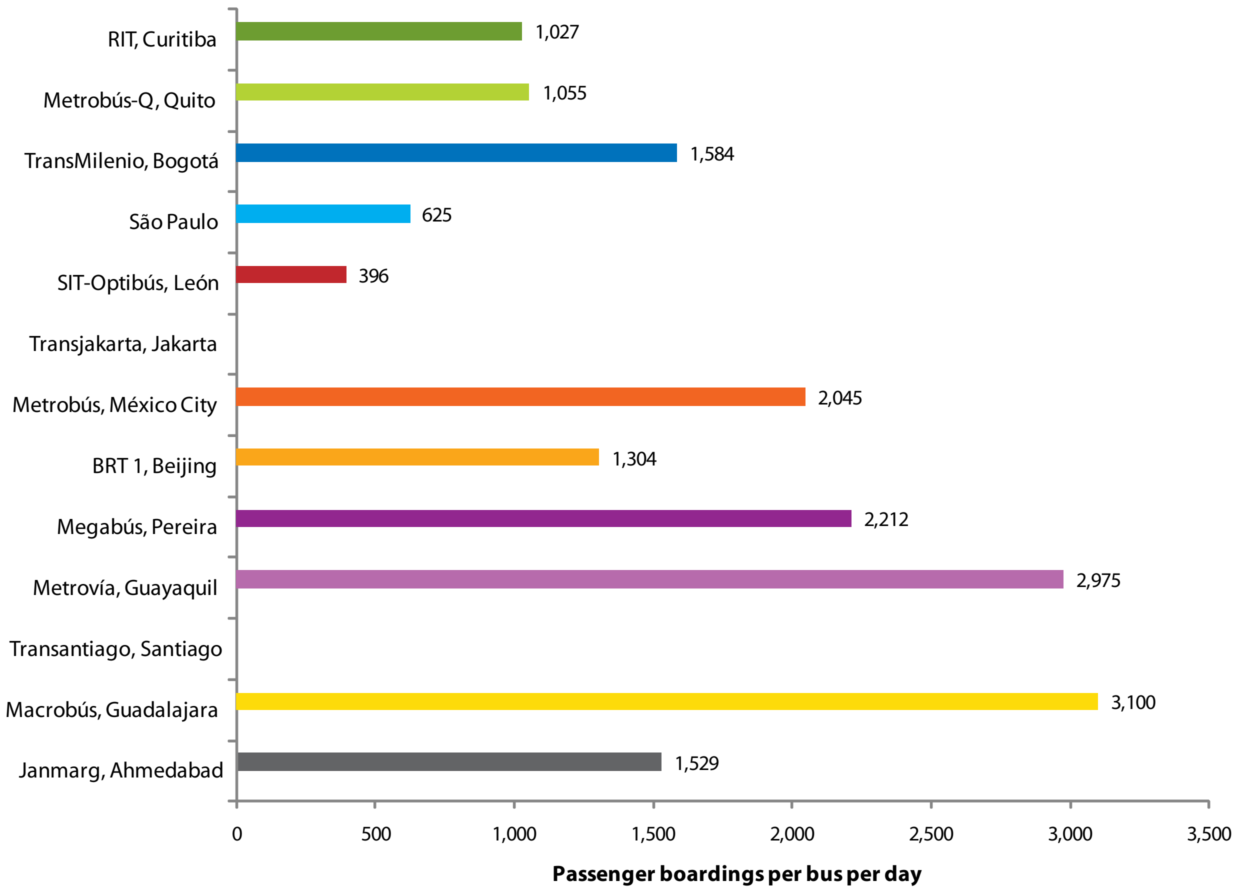
Notes: Santiago, São Paulo and Curitiba data from 2006.

Figure 4 Operational Productivity—Passenger Boardings per Bus-km (2009)



Notes: Santiago, Beijing, Jakarta and Quito data from 2006. Data unavailable for Curitiba and São Paulo.

Figure 5 Capital Productivity—Average Daily Passengers per Bus (2009)

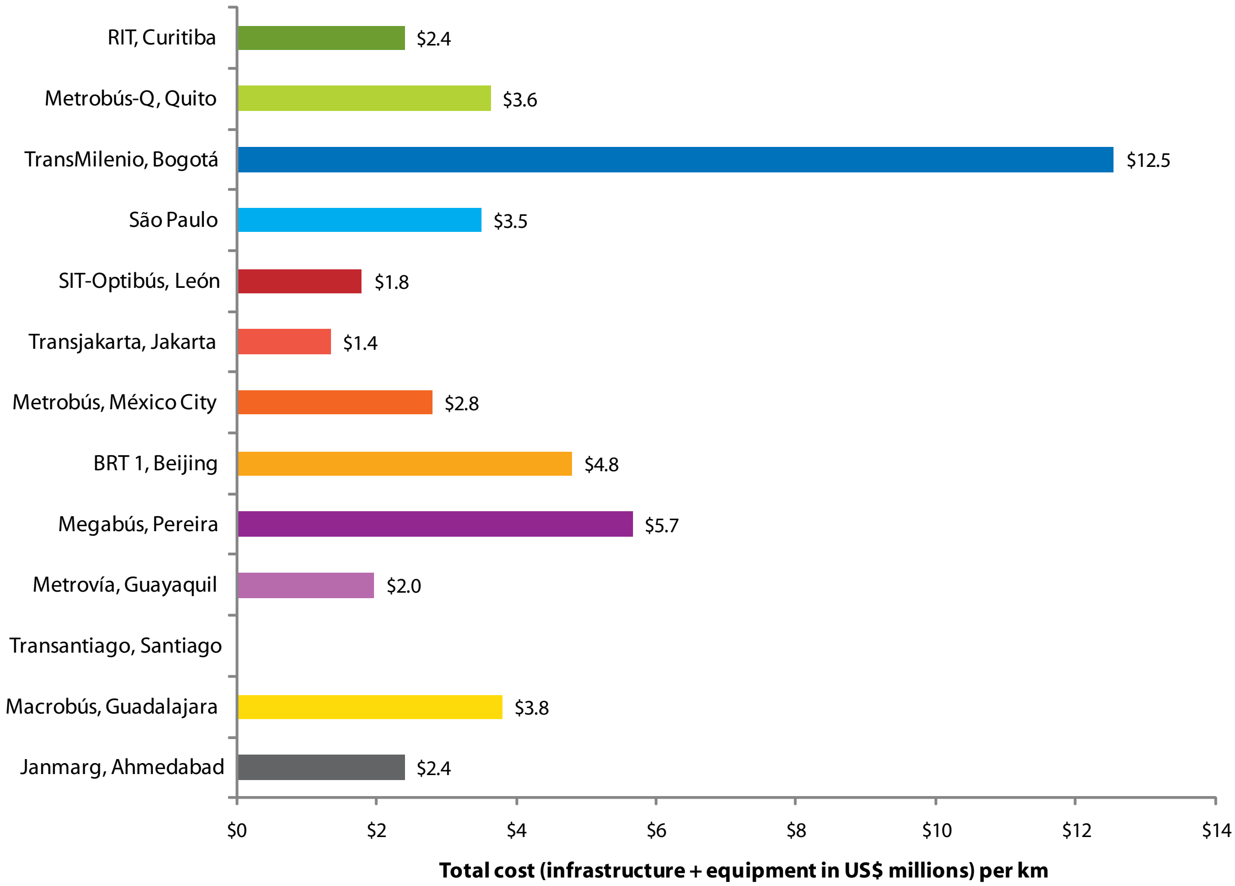


Notes: São Paulo and Quito data from 2006. Data unavailable for Jakarta and Santiago.

Total capital costs of bus system improvements varied from US$1.4 million per kilometer (Jakarta) to US$12.5 million per kilometer (Bogotá) as shown in figure 6. New transit systems requiring only minor physical improvements to the roadway cost in the range of US$1.4–3.50 million per kilometer to implement. Major reconstruction of corridor roadways, two bus lanes per direction, or new trolleybus systems required more capital investment: US$3.8–12.5 million per kilometer. In each city, the infrastructure to support system operations was built by local agencies with local and external (state or national government) funds. León and México City also attracted private capital through concession contracts for the construction or improvement of stations and bus stops. Quito (Trolebús and Ecovía), Jakarta and Beijing purchased their buses with public funds and the México City municipality directly acquired 20% of the bus fleet[7]. Quito and México City also procured fare collection equipment with public funds. Other systems have equipment provided by the private sector, which is paid back with user fares.

[7] There are two operators in México City's Metrobús: a private operator CISA and a public operator RTP; the buses acquired by RTP are funded by the municipality.

Figure 6 Capital Costs per Kilometer (2009)

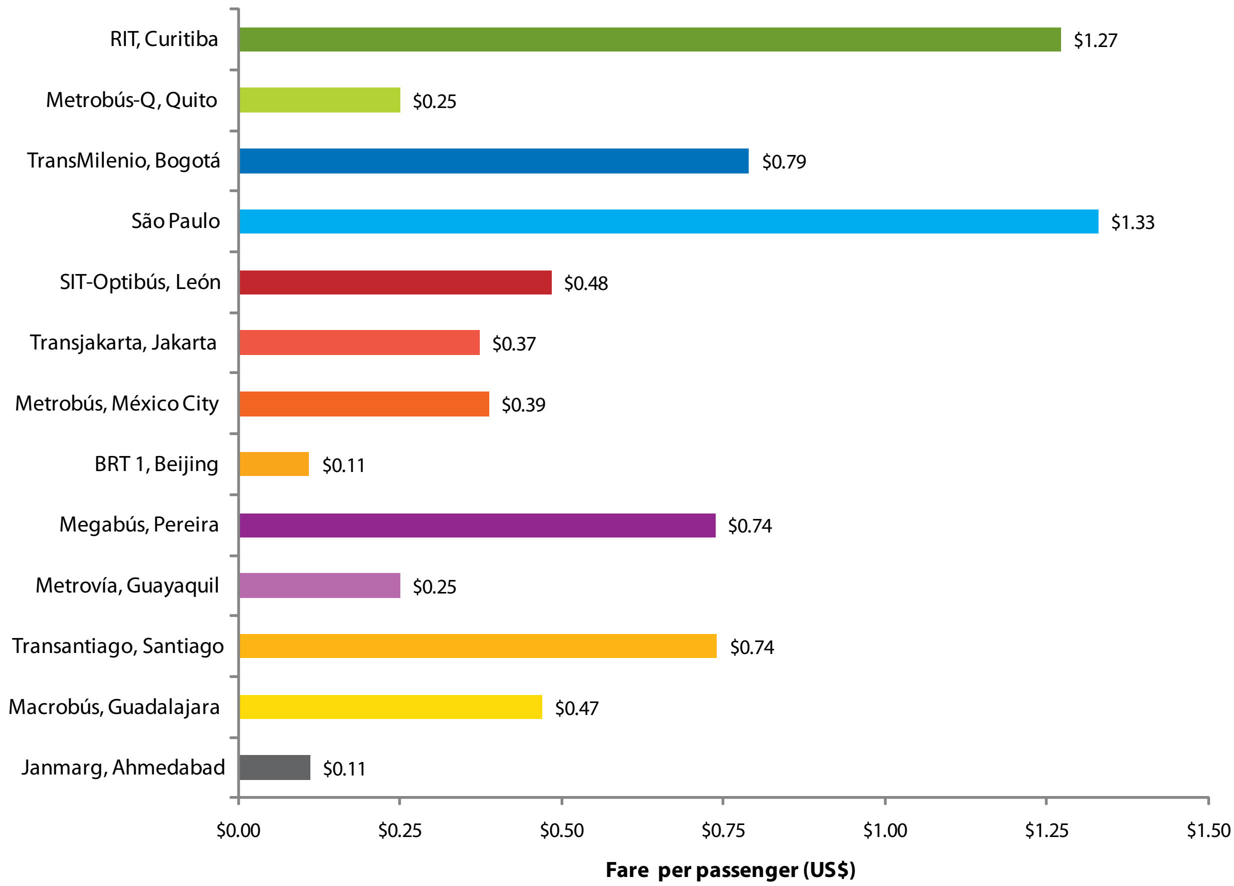


Notes: Includes only transit infrastructure and equipment costs. Data from different years adjusted. Data unavailable for Santiago. São Paulo and Quito data from 2006. Guayaquil reports capital costs of $0.986 million/km for the 63 lane-km, which equates to $1.97m/km for the 31.5 system kilometers.

Fares in most systems were below US$0.80 per trip as of 2009, with the exception of Curitiba and São Paulo whose fares are US$1.27 and 1.33 respectively (figure 7). Most systems with fares below US$0.40 (Beijing, Ahmedabad, Jakarta, Quito, México City) either received subsidies or were financially strained. However, Guayaquil has been able to operate the Metrovía system with US$0.25 fares without subsidies, due to its very high productivity (13.2 passenger boardings per bus-km, and 2,975 passenger boardings per bus per day). Supervision and planning agencies are typically funded from the general municipal budget and not from transit user fares.

Total capital costs of bus system improvements were less than US$12.5million/km

Figure 7 **User Fares (2009)**



Notes: Quito data from 2006.

SYNTHESIS OF FINDINGS: LESSONS LEARNED

Planning Issues

GOOD PLANNING IS GENERALLY RECOGNIZED AS A KEY SUCCESS FACTOR FOR TRANSPORTATION PROJECTS (MEYER 2010)**.** Nevertheless, providing adequate funding for the planning phase was not a high priority for most of our featured cities. This failure to invest in planning resulted in significant adverse consequences. In many cases, lack of adequate planning resulted in project delays.

It is important to note that none of the selected cities started their transportation systems from scratch. Some preliminary transportation planning usually preceded the decision to go forward with the new BRT system or citywide service reorganization. For example, in the case of Bogotá, busways had been in place since 1989, without full BRT components, and conceptual proposals for busway expansion had been proposed. However, no advanced feasibility studies had been completed at the time the city decided to initiate the TransMilenio project.

On the other hand, advancing planning activities depended on the ideas and expectations of key decision makers. In cases where the mayor or other political leaders had a clear vision for the project (e.g. Curitiba, Bogotá, Guayaquil, Jakarta), development cycles were short. When commitment at the highest level was not clear (e.g. León, Santiago[8]), project implementation took several years. Thus, political commitment played a key role in the overall speed and of project planning and implementation.

As metropolitan funding for project planning was scarce, most cities needed to rely on grants, budget allocations from their national governments and loans. The process of applying for such funds, as well as approval of project activities by sponsoring institutions, took several months. As a result, valuable time was lost at the beginning of the planning process.

Once high-level commitments were made, planning lead times were shortened to make project implementation possible within a short window of opportunity, such as before the end of the term limit of supportive elected officials. Generally, when cities used experienced teams and contracted capable consultants, project design happened faster. However, planning became difficult in cases when local staff, consultants and/or international support organizations (providing technical or financial assistance) were unfamiliar with BRT applications. Such situations resulted in protracted discussions of technical issues such as the design of busways (median/curbside), types of platform (high/low), corridor capacity, propulsion technology (compressed natural gas, diesel), and type of payment (on-board/prepayment). It is also important to note that most of the effort at this stage was assigned to resolving transport planning and engineering issues, with less effort dedicated to key institutional, legal and financial issues.

Another aspect that affected project planning was the definition of transit fares by the relevant public regulatory authority. In general, decision makers in our featured cities were tempted to set fares as low as possible for all users, to maximize political buy-in. This left little financial breathing room for planners to incorporate optimal technical and institutional components of a BRT system, such as new, larger buses, advanced fare collection and control systems, and new operators organized as formal companies.

Cities took different approaches to settling final fare levels. In projects with competitive bidding for bus operating concessions (e.g. Bogotá, Pereira and

[8] Despite the fact that Transantiago was a commitment of Ricardo Lagos as a presidential candidate, the project did not have full support of other top government officials and many key decisions were delayed or changed through the planning and implementation process. For instance, the leadership of the project planning and implementation team changed 4 times in 6 years.

Santiago) final fares were determined as a result of the bidding process itself. Initial user fares were calculated based on prospective operators' bids and the contracts built in adjustment formulas to account for changes in the cost of fuel, labor and other supplies over time. In other systems, fares were defined by the political authorities and did not necessarily reflect actual system costs. This produced various predictable adverse consequences: Quito´s system was not able to generate enough surpluses to repay the operators of trolley buses[9] and Ecovía buses, while the México City, Jakarta and Beijing systems operated under financial stress until fare increases were approved.

One consistent and effective feature of the case studies was that the planning and implementation teams were set up outside existing public institutional frameworks, in order to overcome the burden of business-as-usual in existing agencies. Most cities created ad-hoc "task forces" that were later transformed into new institutions.

Decision-Making Processes

Two types of decision-making processes were observed with respect to the origin of the initiatives: top-down and bottom-up. Top-down decision making originates in the upper echelons of the political hierarchy such as elected officials and cabinet-level authorities. Bottom-up decision making is precisely the opposite. It originates with proposals from staff at the planning or implementation agencies or from comprehensive long-term planning processes. Top-down approaches were implemented in Curitiba, Bogotá, Quito, Guayaquil, São Paulo, Jakarta, Beijing, Ahmedabad and Guadalajara and bottom-up approaches in León, México City, Pereira and Santiago. Top-down processes took less time and reduced initial conflicts between agencies. Nevertheless, some interagency conflicts generally emerged later in the process during the operational phase. For instance, in the case of Bogotá, the leadership of the Mayor made interagency cooperation straightforward in TransMilenio's Phase I, but lack of the same leadership in successive administrations made interagency cooperation difficult in Phases II and III. This resulted in delayed implementation and increased costs.

The experience across our featured cities suggests that adequate governance and regulatory structures are as important as resolving all the technical details when aiming to create effective bus-based transport systems. All the city transport improvement schemes we reviewed required either regulatory change, the transfer of public transportation authority between different levels of government, or the creation of new institutions to develop the projects. For example, São Paulo passed a new city transportation law that made possible the changes required for an integrated public transit system, including integrated fares. In Quito and León, the transport regulatory authority was transferred from the national and state level respectively, to the local level. Bogotá, México City and Guayaquil created new institutions for transport system development and oversight.

Typically there were no general public transportation regulatory and oversight institutions, such as regulatory commissions or superintendence agencies, in charge of defining and overseeing user fares and quality of service. Consequently, the new governance structures that cities put in place for project planning were mostly contract based. This meant that the distribution of responsibilities, risks and revenues was defined in contractual instruments between local agencies and operators.

Providing adequate levels of funding for infrastructure was challenging, despite the fact that most projects had low capital costs compared with rail transit options. New funding mechanisms, such as taxes, privatizations, and the use of extraordinary budget surplus, as well as intergovernmental grants were often required to trigger project implementation[10].

Implementation Approach

The preferred approach among reviewed cities was to manage operations through public private partnerships, where the private operators provided the equipment and services and the public sector built and maintained the infrastructure. Since all cities but Beijing and to a certain degree México City had private operators

[9] Government loans provided for trolley bus acquisition were pardoned.
[10] For instance, México City used extraordinary funds in the city budget to fund Metrobús infrastructure; Bogotá combined new tax revenues from a gasoline surcharge, funds from the privatization of the local power company, and transfers from the National Government to fund TransMilenio infrastructure.

already in place, there was an effort to make them part of the new operation. In general, the approach taken by authorities was to encourage small enterprises and owners to transform themselves into formal companies. This was done either through a limited bidding process or direct negotiation. In Bogotá and Santiago, politically powerful transport authorities were able to open up project operations to general bidding. This resulted in protests by existing bus operators but made it possible to take advantage of competitive bidding. Other city authorities negotiated terms and conditions directly with the existing operators. This resulted in easier implementation (no stand-offs), but with the trade-off of higher costs and softer contractual conditions, as observed, for example, in México City and Quito's Central Norte corridor.

The projects feature a diversity of scope and level of integration[11], even in their understanding of BRT concepts. There are single-corridor projects without fare integration with feeders or other transport modes (México City, Beijing); projects with sequential implementation of non-integrated corridors (Quito, Jakarta); some that gradually implement physically integrated corridors (Bogotá, Guayaquil); and others that deployed extended route reorganizations (São Paulo, Santiago, León). Judging from the outcomes observed across the cities, sequential implementation with clear integration of bus and other public transport services is preferable to developing isolated corridors. Large-scale route reorganizations (Santiago; São Paulo) seem to be the best conceptual approach, as this enables optimum use of all system components. However, this approach can provoke significant opposition from incumbent operators and carries the risk of institutional or financial overreaching, as was the case in Santiago.

Implementation Hurdles

Most of the transport systems reviewed were rushed and started operations without all the planned elements in place (table 3). This was generally caused by the need to inaugurate projects before the elected officials backing them came to the end of their elected term. This was the case, for example, in México City, Bogotá, León and Guayaquil. Cities where launches were rushed generally suffered from problematic initial operations, which improved within the first few months.

Problems were generally encountered in the following areas. Infrastructure and fare collection systems were delayed due to implementation obstacles or contractual problems, such as delays in approvals by various authorities. Another common problem was limited time between bus delivery and the start of operations, resulting in incomplete drivers' training, as was the case in León and México City. Delays were often the result of over-optimistic timetables for the delivery of different components.

In cities with new BRT projects, user education was neglected prior to system implementation causing many issues during the first weeks of operation, particularly in México City and León. In cities launching extensive bus service changes, including the TransMilenio Phase II expansion in 2006 and the Transantiago launch, insufficient public information and education led to chaotic conditions, and, in some cases, public protests requiring law enforcement.

In Quito and Bogotá and during an early phase in Santiago[12], transport operators also protested, largely due to a lack of communication and engagement by city authorities. Involving existing operators through direct negotiations (México City, León, Jakarta), or limiting external actors from the bidding processes (Bogotá, Pereira, Guayaquil, São Paulo) helped to ease or avoid protests and discontent. Santiago chose to have an open bidding process so that transport users would reap the benefits of competition for-the-market, but this approach also generated some implementation barriers. In particular, it necessitated the slow and costly removal of the obsolete bus fleet from the hands of traditional operators who were not the new concessionaires.

[11] Integration can be defined at three levels; physical, operational and fare integration. Physical integration refers to infrastructure that allows passengers to transfer between bus routes and other modes of transport; operational integration involves coordination of schedules; fare integration involves payment of a single fare or reduced fares for combined services.
[12] A pilot implementation of feeder buses for the Metro System in Santiago in 2002 resulted in very extensive protests by existing operators; the government used the existing laws to prosecute the operators' leaders.

Table 3 Condition of System Elements When Projects Were Commissioned

CITY, SYSTEM	INFRASTRUCTURE	BUSES	FARE COLLECTION	CONTROL	USER EDUCATION	OBSERVATIONS
Curitiba, RIT	Gradually improved over several years	Operators reluctant to buy new buses—initially bought by the municipality	Coin based for three decades—electronic ticketing in 2006	Manual not dynamic control on platforms—based on schedules prepared by the municipal urban development agency (URBS)	Gradual implementation made it part of the city's life and development	Negotiated agreements between traditional operators and the municipality
Quito, Trolebus	Pavements were not rehabilitated and deteriorated rapidly	Insufficient for initial demand—required special programming	Coin based—fare cards abandoned	Manual on platforms and selected points	Scarce	Large protests by existing operators
Quito, Ecovía	Ready long before buses were available	Delayed due to lack of finance—bought by the municipality	Coin based without problems	Manual on platforms and selected points	Scarce—but users knew Trolebus	Difficult to get existing operators on board
Quito, Central Norte	Very incomplete—no terminal, low-quality stations	Insufficient—traditional buses not completely retired	No fare collection system—large evasion opportunities	Manual on platforms and selected points	Non-existent—significant discontent	No single image—low-quality temporary structures
Bogotá, TransMilenio Phase I	Incomplete—gradually introduced	Insufficient due to financial difficulties of operators	Electronic system not ready—gradually introduced—unreliable	Started with manual control—systems gradually introduced	Abundant—system was well received	Protests by existing operators—early pavement deterioration
Bogotá, TransMilenio Phase II	Incomplete—gradually introduced	Gradually introduced as infrastructure was completed	Not prepared for expansion—ran out of fare cards	Vehicles not equipped with automatic vehicle locators (AVL), manually controlled	Scarce—large changes in route structure	Changes in route structure caused problems, user protests
São Paulo	Passa-Rapido corridors gradually introduced	Gradually replaced over a three-year time span	Problems with distribution of the farecards—too many transactions to process	No centralized control—AVL and telematics used in terminals for user information, not operational actions	Large promotion of the changes and the use of the farecards—difficulties in reaching users	Operations did not improve dramatically—only Passa-Rapdio corridors with median lanes
León, SIT Optibús	Incomplete stations and access to one terminal	Delivered shortly prior to implementation—no trained drivers	Implemented long before high-capacity corridors—successful	Manual on platforms and selected points	Abundant—initial quality fell short of expectations	Lengthy feeder bus trips—some traditional routes reintroduced
Jakarta, Transjakarta	Small stations and inefficient terminal	Initial fleet not sufficient; 12m-buses too small with only one door	Delayed implementation, technical problems	No communication with the buses	Scarce, there is not a focus on the user	Performance below expectations

Table 3 (continued)

CITY, SYSTEM	INFRASTRUCTURE	BUSES	FARE COLLECTION	CONTROL	USER EDUCATION	OBSERVATIONS
México City, Metrobús Insurgentes	Incomplete stations	Delivered few days prior to implementation—no trained drivers	Started with paper tickets—gradually replaced by electronic farecards	AVL introduced three months late	Scarce – widespread confusion during the initial days of operation	Expected speeds not achieved—problems at intersections and with driver training
Beijing, BRT 1	Small and uncomfortable stations	Initial fleet too small, low-floor buses lose capacity to wheel wells and steps, poor internal circulation	Implemented months after initial operation	Good control but still deficient operation	Scarce, there is not a focus on the user	Very low fares (no subsidies allowed), peak period crowding due to reduced bus capacity
Pereira, Megabús	Incomplete corridors—provisional terminals	Feeder bus fleet insufficient due to route extensions	Insufficient number of fare cards—manual control	Not ready for initial operation, gradually introduced	Large campaign, but scarce focus on system operation—initial confusion	Delays in infrastructure due to lengthy decision process for the relocation of utilities
Guayaquil, Metrovía	Most elements in place for corridor 1	Insufficient fleet—use of small buses for trunk operations	Started manually—gradual implementation of farecards	Not ready for initial operation, gradually introduced	Scarce, difficulties in the initial days of operation	Did not achieved the expected speeds
Santiago, Transantiago	Long delays in busway construction and planned bus shelters were not completed on time—insufficient infrastructure	Only a fraction of the contracted fleet was available—operational difficulties made it necessary to increase bus and metro fleet	The fare collection system was not fully operational—resulted in a full week of free-of-charge services	Buses were not fully equipped and centralized oversight was not operational	Extensive campaign was not enough for particular needs of most users	Very large-scale implementation had several problems—transition phase using new buses on the old route system proved chaotic
Guadalajara, Macrobús	Second access to stations was not available. Sidewalks were still being upgraded.	Insufficient driver training prior to implementation (buses were delivered days before commissioning)	Electronic fare collection using smart cards was not fully operational; was gradually introduced during first four months	Control center (buses and traffic) was completed four months after initial operation began	Extensive effort but many users were not well informed, particularly about the use of smart cards	Initial commercial speed was very low due to lack of driver training. A fraction of feeder bus users was dissatisfied due to long transfer times.
Ahmedabad, Janmarg	Some roadway and station elements were still being completed during trial operations period. One section was temporary—the pavements and stations were to be replaced after the monsoon season.	Bus fleet was underestimated (actual passenger demand exceeded forecasts)	Started manually—electronic fare collection using smart cards was not fully operational after five months	Centralized control was not fully operational after five months—traffic lights were turned off at critical intersections	Extensive effort to educate users and provide adequate information	Gradual implementation as system elements became available

Sources: Interviews with stakeholders, information provided by managing agencies and news reviews

Problems During Operation

The reviewed systems greatly improved travel conditions and generally received good ratings from users.[13] However, some common problems during operation highlight the need for several ongoing improvements. First, buses are commonly overcrowded during peak travel times. Second, pavement condition has often been an issue, due either to the use of existing roadway without improvements, inadequate pavement structural design, or faulty construction. Bus lane segregation devices in some cities (e.g. León and México City) deteriorated very quickly and required early replacement.

Third, advanced fare collection systems proved particularly difficult to implement. These systems are intended to reduce fare evasion, to allow for faster passenger loading and to generate data for operational planning. However, implementation schedules in many case study cities were too short to adapt software applications to local conditions, resulting in insufficient testing and quality assurance. Furthermore, in most cases, fare collection systems were not integrated with other components of the public transport system (Bogotá, México City, Beijing) or even other BRT corridors (as in Quito, and in Jakarta during the initial four years).

Table 4 summarizes the main concerns encountered, by city, during the early operational phase.

Structural Problems

Fortunately, none of the cities' transport systems faced such serious problems as to merit a complete overhaul of the newly implemented structure. Most importantly, nearly all the systems are providing higher-quality and higher-performance services than the traditional systems they replaced. Nevertheless, our case study review highlighted aspects that may challenge system sustainability and affect the quality of service delivered.

Table 5 summarizes structural problems experienced in each city. The most critical common challenge was maintaining the systems' operational quality at an affordable fare. Financial sustainability was threatened in several systems because fares were defined by political authorities without a sound and comprehensive calculation of cost and revenues. To keep fares low and the systems accessible to users of all incomes, some cities subsidized system components on top of the ubiquitous capital subsidy for infrastructure. For instance: Quito (Trolebús, Ecovía) and Jakarta bought the vehicles for their systems with public budgets and will not necessarily recover these costs from user fares; México City bought the buses of the public operator RTP with funds from the general municipal budget[14]; São Paulo used direct budget allocations for special users; and Santiago covered the new transport system's financial losses with the public budget[15]. The case of Beijing differs from the above, as subsidies are not allowed. As a result, low fares are generating financial difficulties for the operator.

Another common problem was limited maintenance funds. Municipal public transport systems compete with general funding for road maintenance and rarely receive timely attention. Opportunities for route expansion are limited by resistance to change from existing operators. In Bogotá, existing operators that were resistant to change have organized themselves to put pressure on the local government to slow funding of system expansions, and the city government has delayed the plans for further expansion beyond Phase III[16]. In México City, negotiation with operators in each corridor expansion has become extremely complex, as they have raised their financial expectations.

Renegotiation of agreements between authorities and private operators further threatened the financial sustainability of many systems. Even though contract renegotiation is welcome when external conditions affect the financial equilibrium both for government

[13] The only system in the review with poor ratings from the users is Transantiago. Nevertheless, ratings have improved steadily in the first year of operation, and with the changes introduced in service and supervision, user ratings are expected to continue improving in 2008.
[14] Furthermore, the cost of operation of RTP was not covered by the farebox revenue of the Metrobús corridor during the first year, generating a "subsidy by default".
[15] In 2009 the Chilean Congress passed a law making subsidies for public transport permanent.
[16] The city is currently planning for a Metro line, and has not included additional expansions of TransMilenio in the approved plans.

and private operators, most negotiations seem to favor private interests. Renegotiation is most common in directly assigned contracts (such as in México City, León, Quito's Central Norte, and Jakarta), but also happens in contracts resulting from open bidding processes, such as in Bogotá, in order to adjust conditions as systems evolve. Conversely, in the case of Santiago, contract renegotiation in favor of the public interest was done to save the Transantiago system from collapse in 2007[17].

From a technical point of view, there are different needs and concerns specific to each system, as indicated in table 5. Most of the technical problems require both a political decision and for funding constraints to be resolved. There are major challenges of this kind in Santiago, Quito, Bogotá and Jakarta in particular.

In Santiago, after a chaotic transit system launch featuring user protests, the government took action to introduce enclosed interchange facilities and exclusive bus lanes, to expand the bus fleet, and to provide stronger control mechanisms. Improvements during the first three years of operation were significant, and by the end of 2009 Transantiago was perceived as providing a higher-quality service than previous operations. The outlook in Santiago is positive, with structural changes completed citywide and a clear improvement plan in place, including the implementation of high-capacity infrastructure in the trunk corridors.

In the case of Quito, the Central Norte Corridor infrastructure has not yet been completed, and the capacity of the Trolleybus has been exceeded, sparking interest in a Light Rail Transit (LRT) alternative. Moreover, there is a lack of physical and fare integration among the three BRT corridors. The LRT debate has resulted in slow action on short-term improvements and system integration of the BRT.

In Bogotá's TransMilenio, service quality perception has declined recently compared to the initial years of operation, despite constant route upgrades and bus fleet expansions. There are proposals underway to integrate fares between TransMilenio and traditional services citywide, to build an integrated Metro system, and to explore a light rail alternative. These discussions have slowed action for short-term improvements in the existing TransMilenio system, such as new connections among corridors, construction of intermediate return points, introduction of bi-articulated buses and reduction of competition from traditional bus services on parallel routes.

Advanced fare collection systems proved particularly difficult to implement

In Jakarta, both facilities and buses need expanding and upgrading. Given that the system's corridors are handled by different operators using dissimilar fare collection technologies, Jakarta has been unable to reach fare integration and passengers are required to pay twice to complete their journeys.

[17] Private operators were required to expand the bus fleet and assume higher risks than initially established, in order to be able to improve service quality and keep the system in operation. The government increased the oversight mechanisms and committed to create a permanent subsidy.

Table 4 Main Operational Concerns

CITY, SYSTEM	MAIN OPERATIONAL CONCERNS
Curitiba, RIT	- Operating close to capacity in some sections and stations of the busway (structural corridor) - Large number of transfers required - Insufficient service during peak hours and excessive service off-peak - Inflexible operations—no clear balance between supply and demand
Quito, Metrobús-Q	- On-board vehicle and station crowding during peak periods (Trolebús and Ecovía) - Long waiting and travel times in feeder buses (Central Norte) - Non-integrated corridors - Buses were subsidized—no funding for vehicle replacement (Trolebús) - Demand below expectations may cause financial problems to private operators (Central Norte) - Protracted and unsuccessful contract negotiations with historic private operators (Ecovía) - Feeder buses remain under traditional operation (Central Norte) - No clear system vision (proposed replacement by LRT) (Trolebús)
Bogotá, TransMilenio	- On-board vehicle and station crowding during peak periods; delays in accessing feeder buses - Rest of the city has very poor transport service - Funding for system expansion is lacking
São Paulo	- Long dwell times and "bunching" of buses in critical sections - Invasion of bus lanes, especially those located on the curb-side - Low travel speeds outside the Passa-Rapido corridors
León, Optibús	- Some feeder routes with reverse commuting (from city to suburbs) result in long travel times - Invasion of the bus lanes by general traffic (sometimes encouraged by the traffic authorities) - On-board vehicle crowding during peak periods
Jakarta, Transjakarta	- On-board vehicle crowding during peak periods - Service among corridors is not integrated, passengers are required to make transfers and pay additional fares - Currently subsidized - Difficult negotiations with the private operators
México City, Metrobús Insurgentes	- On-board vehicle and station crowding during peak periods - Isolated corridor - Financially stressed—needed fare increase - Permanent negotiation of conditions with private operators
Beijing, BRT 1	- On-board vehicle crowding during peak periods - Isolated corridor - Needs subsidy—bus operator faces possible bankruptcy - Mixed traffic operations reduce reliability - Requires new stations
Pereira, Megabús	- Insufficient capacity in temporary terminal facilities—resolved with the opening of the Cuba terminal in August 2008 - Poor reorganization of the remaining bus routes - Flexibility of buses not fully used in operations
Guayaquil, Metrovía	- On-board vehicle crowding during peak periods - High temperatures and humidity—buses not equipped with air conditioning - User fare defined by a national political authority—US$0.25 per trip with a reduced fare for students and people with disabilities—and not on the basis of costs and revenue
Santiago, Transantigo	- Insufficient infrastructure to support operations (lack of integration points, segregated bus lanes) - Expected commercial speeds not achieved; hence, an increase in bus fleet is required - Lack of adequate oversight of required minimum levels of service led to the non-compliance of some contractors - The system is operating with an initially unexpected permanent subsidy requiring national congressional approval
Guadalajara, Macrobús	- High temperature inside the buses - Low commercial speeds (gradually improved as operators received necessary training) - Penetration of electronic fare collection was small, the majority of users pay with coins at the turnstiles
Ahmedabad, Janmarg	- Highly uncertain passenger demand, since BRT is in a rapidly developing area - Demand exceeded expectation and initial fleet was insufficient - Lack of centralized control and dependable traffic control system resulted in unreliable operations (large variance in service frequency)

Sources: Interviews with stakeholders and information provided by managing agencies

Table 5 Structural Problems of Selected Systems

CITY, SYSTEM	FINANCIAL SUSTAINABILITY	TECHNICAL DESIGN
Quito, Metrobús-Q	Not clear: fares are politically defined; depends on the ability of public administrators to subsidize buses; no earmarked funds for maintenance; ambiguous contract conditions for private sector operations (Ecovía); actual user demand is probably below expectations (Corredor Central Norte).	Trolebús corridor currently operating beyond capacity—needs overhaul and expansion (of station length, operation of bus platoons); LRT is being proposed as one solution. Corridor Central Norte operating with temporary facilities (terminals) and incomplete implementation of route reorganization.
Bogotá, TransMilenio Phases I and II	Clear: fares established in contracts; however, expansion limited by pressure from existing operators and lack of funds; also no earmarked funds for maintenance (existing funds dedicated to system expansion).	Decline in level of service requires construction of special infrastructure, revision of routes, and fleet expansion (which will be limited due to impact on user fares).TransMilenio also lacks integrated fares with other bus services.
São Paulo	Not clear: growing pressure for free or reduced-fare services provided from the public budget; high existing fares inconsistent with service provision for the poor.	On-board ticket validation generates long dwell times at stations; some stations are also too short; requires faster replacement of curb lanes with median lanes.
León, SIT Optibús	Clear: fares negotiated with all operators; however, no earmarked funds for maintenance.	Bus lanes easily invaded—geometric improvements required.
Jakarta, Transjakarta	Not clear: fare defined as social policy and currently subsidized.	Limited capacity: can be addressed with larger buses (i.e. 18m with four doors), larger stations and shorter traffic signal cycle times.
México City, Metrobús Insurgentes	Not clear: fares politically defined; permanent negotiation with private operators; fares currently subsidized; no earmarked funds for maintenance.	Limited capacity—system could be easily extended by expanding stations and bus convoys; intersections easily blocked—requires geometric improvements.
Beijing, BRT 1	Not clear: fares set below system costs; operator may face bankruptcy.	Limited capacity: can be easily expanded with a larger fleet and operational improvements; could modify stations and fleet to accommodate high-platform/high-floor buses.
Pereira, Megabús	Not clear: fares established in contracts but traditional services are not integrated and the system faces competition; no earmarked funds for maintenance.	Requires completion of Dosquebradas Terminal and better connection to Cuba Terminal; excessive transfers, probably mitigated with hybrid operation where feeder buses are able to continue in the trunk corridor.
Guayaquil, Metrovía	Not clear: fares defined by a national authority (US$ 0.25) with reduced fares for special groups.	Limited capacity in first corridor; second corridor designed for higher capacity with passing lanes at stations.
Santiago, Transantiago	Clear: fares established in contracts, with funding for system operations provided by law; additional investments financed with government funds.	Trunk-feeder scheme increased transfers and route design resulted in longer walking times; requires infrastructure to enhance bus operations and integration.
Guadalajara, Macrobús	Not clear: financial equilibrium was very tight during the first year, fare increase is not based on inputs.	Challenging busway geometry in some sections. Buses are not air conditioned.
Ahmedabad, Janmarg	Not clear: the public-private partnership agreement has clear financial clauses; nevertheless the system is gradually replacing the state-owned provider which receives public funds for operations.	Initial operation is (mainly) within exclusive busways (mainly) without integration with BRT feeders or the conventional transport system. This is expected to be solved in further phases as the system grows.

Sources: Interviews with stakeholders and information provided by managing agencies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CONCLUSIONS AND RECOM-MENDATIONS

MOST OF THE BUS IMPROVEMENTS IN LATIN AMERICAN AND ASIAN CITIES REVIEWED IN THIS PAPER HAVE HAD POSITIVE OUTCOMES. They have improved the travel conditions for users and raised the quality and performance of public transport, particularly in relation to faster, more efficient services. There have also been associated environmental and social benefits. As efficiency has improved, systems have reduced energy consumption and polluting emissions. Public infrastructure redevelopment and urban revitalization are evident in Curitiba, São Paulo (Passa-Rapido), Bogotá, Quito (Trolebús), Pereira and Guayaquil where appalling urban environment conditions along the bus corridors have been dramatically improved. Air quality improvements are also evident in Santiago.

Despite these benefits, the projects were also characterized by several planning, implementation and operational challenges. Most of these issues were not directly associated with the bus systems themselves, but with prevailing planning and implementation practices and external constraints in financial and institutional matters. The specific issues pertaining to each system are identified in our in-depth city case studies (available online at EMBARQ's website (www.embarq.org) and in the summary tables presented above.

Key lessons learned support the following general recommendations for city transport planners and political authorities[18]:

Planning Phase

- Institute a comprehensive planning process which combines financial, legal, institutional and environmental concerns with engineering/technical efforts.
- Improve the quality of information used to make decisions on key building blocks of a new or improved transport system, such as: route selection, basic infrastructure concepts (median lanes, types of stations, terminals), vehicle technologies, and types of operation (open vs. closed systems).
- Reliable data (i.e. trip origins and destinations, travel by income and gender) are required for adequate understanding of the demand patterns, socioeconomic conditions and baseline characteristics of existing public transit operations.
- Dedicate enough resources (time and money) for adequate project preparation, but avoid endless alternatives analysis.
- Use best practices from other cities as a reference, but adapt infrastructure, operations, and institutional frameworks to local conditions.
- Seek to create special-purpose full-time teams for system planning and implementation, independent from day-to-day responsibilities.

Decision-Making Process

- Get approval from high-level decision makers early on in the process as top-down approaches are faster and resolve interagency conflict. At the same time, maintain community involvement through education and participatory processes.
- Maintain and nurture high-level approval and buy-in during the implementation and operation of the system.
- Pay careful attention to regulatory/institutional issues, adapting the existing regulatory framework if required. Proceed with special care where the bus improvement is to be integrated with an existing metro system, and convince the rail operator that the BRT is complementary, not a competing element in transport supply.

[18] The expanded case studies address some of the recommendations in more detail and are tailored to the context of each city.

- Create a special-purpose agency to plan, oversee and control system development, and provide adequate coordination mechanisms.
- Be creative in funding project development, using new taxes, loans and non-traditional sources such as privatizations, special purpose bonds, real estate development, etc.
- Involve existing operators to mitigate conflicts, but use bidding processes to reduce user costs through increased competition for-the-market.

Design Phase

- Only attempt citywide reorganization of transit services where the institutional capacity for regulations and enforcement is strong and there is broad public support.
- Define clear development objectives, estimate passenger demand and develop a service plan as the basis for physical and operational design.
- Implement gradually, adapting the project on the basis of initial "demonstration" experience.
- Make an effort to use existing right-of-way to reduce land acquisition and involuntary displacement.
- Use sound engineering design to produce adequate infrastructure; pay special attention to pavement design and construction to avoid rapid deterioration.
- Prefer median lanes and level access platforms with many bus boarding doors to increase speed and reliability.
- Use strong lane dividers to segregate traffic. Focus on physical integration during planning and design phases (e.g. match vehicle floor and station platform heights).
- Design vehicles (e.g., their size, internal configuration, number of doors and configuration) and other physical features for market and service plan.
- Wherever possible, minimize the negative effects on mixed-traffic flow as increased traffic congestion can create vociferous criticism and jeopardize support for the bus improvement.

Implementation Phase

- Generate and manage a realistic schedule to avoid rushed implementation. System commissioning dates usually do not allow much opportunity for extension due to term lengths of elected officials.
- Have contingency plans ready if system components are not complete.
- Dedicate funds to plan and implement user education programs.
- Involve the community in implementation through adequate information and various participation/ engagement programs

Operational Phase

- Match service operations to supply and demand, using the intrinsic flexibility of buses. For example, allow departures from the fixed route, introduce mid-way returns, and operate express services. Note that feeder-trunk operations might not be applicable to all local conditions.
- Restructure or transform existing bus operations so that they complement rather than compete with the new system.
- Account for required infrastructure maintenance such as pavement, stations, and terminals.
- Allow time to adapt and implement advanced fare collection systems.
- Use advanced transit management systems if operations are complex, and apply them as tools to control reliability, not just as a means of acquiring operational data.
- Pay attention to the system's image, through good public information provision, user surveys, and careful maintenance of fixed infrastructure and vehicles.

Structural Issues

- Define fares using technical (automatic) methods, in order to avoid financial difficulties and political interference.
- Adhere to operating contracts and avoid continuous renegotiation. Permanent renegotiation has often tipped in favor of operators.
- Integrate the system development with other transport initiatives such as construction of non-motorized facilities and implementation of rail transit projects.
- Apply transit-oriented development concepts to enhance positive impacts and reinforce project sustainability. Consider a general land-use reform, permitting higher densities along the mass transit corridor.
- Have a clear vision for system expansion.

FURTHER STUDIES

There are several aspects of planning, implementing and operating urban bus improvements in which this review can be complemented, expanded and updated. In particular there are six topics of study that deserve further discussion: co-benefits of transport, operational performance, governance issues, implementation approaches, financial structures, and the factors which favor BRT or urban rail systems.

While the reviewed cities reported improvements in travel time, travel cost, greenhouse gas and air pollutant emissions, safety, and public health, further analysis of these impacts would improve the understanding of **co-benefits of transport**. EMBARQ is conducting research on road safety and BRT, and through the BRT-ALC Centre of Excellence is assessing the transport and environmental impacts of worldwide BRT systems.

Operational performance is discussed in this study, but further analysis could explore the underlying differences between bus systems. A detailed review of how the design and operation of BRT and citywide bus systems relate to operational efficiencies would be helpful. With the BRT-ALC Centre of Excellence, EMBARQ is analyzing the physical, financial, institutional, and other factors affecting BRT performance.

Governance issues for urban transportation are mentioned in the study but require more extensive analysis. A systematic review drawing from the governance literature could better define challenges and elaborate on institutional barriers and solutions. Also helpful would be an explicit analysis of the structure, authority, and funding of planning agencies and how issues of accountability have been handled. The development of regulatory and oversight agencies may be another area of study. Finally, the issues of public disclosure and participation in project planning, implementation, and evaluation need further review.

Implementation approaches can be gradual processes (corridor by corridor) or citywide transformations. The results of the reviewed systems suggest that gradual approaches can have very interesting initial impacts but lead to difficulties in terms of integration and expansion. Citywide transformations, on the other hand, face significant initial challenges, as observed in Santiago, but may provide a solid and sustainable base for transit provision in the medium and long term. Further investigation of the advantages, disadvantages, and required processes in each case would be fruitful.

Regarding **financial structures**, most systems in Latin America have been promoted as covering capital equipment and operational costs with revenue from user fares, without the need for general budget allocations. However, this approach can affect both user convenience and the system's image, as service quality suffers because of the desire to maintain a financial equilibrium. Improvements in efficiency have not proved large enough to cover the additional costs of formalization of unregulated services and fares in new systems have a tendency to be higher than in existing systems. This suggests a need to better understand the dilemma between quality of service and cost. An acceptable bus occupancy level for developing cities has yet to be defined, with the current standards repeatedly reported as unacceptable in user surveys. Also requiring exploration is the economic justification of subsidies from the general budget vis-à-vis the positive externalities of public transportation for society at large—reduced congestion, noise, local air pollutants, greenhouse gases and accidents, and denser urban development. Other sources of funding, such as value capture mechanisms from real estate developments and transfers from less efficient modes through congestion and parking charging schemes also need to be explored.

Rail systems (light rail or metro) are often considered a superior alternative to BRT. However, for both modes, there is a knowledge gap about operating and maintenance costs, as well as environmental, social, and urban development impacts. Studies comparing the life-cycle costs and benefits of rail and BRT would help clarify which mode can most effectively reduce congestion, air pollution, and energy use. With too much decision making based on ideological arguments or commercial interests, objective analyses and case studies can identify situations where a certain mode of transport is clearly superior.

Ongoing updates of the data and information about the evolution of the reviewed systems, as well as case studies on new systems, will also enhance the pool of lessons learnt from bus systems improvements.

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