

# TRANSIT COOPERATIVE RESEARCH PROGRAM

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# Research Results Digest 70

*International Transit Studies Program*  
Report on the Fall 2004 Mission

## INNOVATIONS IN BUS, RAIL, AND SPECIALIZED TRANSIT OPERATIONS IN LATIN AMERICA

This TCRP digest summarizes the mission performed October 21–November 5, 2004, under TCRP Project J-3, “International Transit Studies Program.” This digest includes transportation information on the cities and facilities visited. This digest was prepared by Margaret C. Mullins of the Eno Transportation Foundation and is based on reports filed by the mission participants.

## INTERNATIONAL TRANSIT STUDIES PROGRAM

The International Transit Studies Program (ITSP) is part of the Transit Cooperative Research Program (TCRP). ITSP is managed by the Eno Transportation Foundation under contract to the National Academies. TCRP was authorized by the Intermodal Surface Transportation Efficiency Act of 1991 and reauthorized in 1998 by the Transportation Equity Act for the 21st Century. It is governed by a memorandum of agreement signed by the National Academies, acting through its Transportation Research Board (TRB); by the Transit Development Corporation, which is the education and research arm of the American Public Transportation Association (APTA); and by the Federal Transit Administration (FTA). TCRP is managed by TRB and funded annually by a grant from FTA.

ITSP is designed to assist in the professional development of transit managers, public officials, planners, and others charged with public transportation responsibilities in the United States. The program

accomplishes this objective by providing opportunities for participants to learn from foreign experience while expanding their network of domestic and international contacts for addressing public transport problems and issues.

The program arranges for teams of public transportation professionals to visit exemplary transit operations in other countries. Each study mission focuses on a theme that encompasses issues of concern in public transportation. Cities and transit systems to be visited are selected on the basis of their ability to demonstrate new ideas or unique approaches to handling public transportation challenges reflected in the study mission’s theme. Each study team begins with a briefing before departing on an intensive, professionally stimulating 2-week mission, after which they return home with ideas for possible application in their own communities. Team members are encouraged to share their international experience and findings with peers in the public transportation community throughout the United States. Study mission experience

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also helps to better evaluate current and proposed transit improvements and can serve to identify potential public transportation research topics.

Study missions are normally conducted in the spring and fall of each year. Study teams consist of up to 14 individuals, including a senior official designated as the group's spokesperson. Transit properties are contacted directly and requested to nominate candidates for participation. Nominees are screened by a committee of transit officials and the TCRP Project J-3 Oversight Panel endorses the selection.

Study mission participants are transit management personnel with substantial knowledge and experience in transit activities. Participants must demonstrate potential for advancement to high levels of public transportation responsibilities. Other selection criteria include current responsibilities, career objectives, and the probable professional development value of the mission for the participant and sponsoring employer. Travel expenses for participants are paid through TCRP Project J-3 funding.

For further information about the study missions, contact Gwen Chisholm-Smith at TCRP (202-334-3246; gsmith@nas.edu) or Tom Downs at the Eno Transportation Foundation (202-879-4711; tdowns@enotrans.com).

## About this Digest

The following digest is an overview of the mission that investigated innovations in bus, rail, and specialized transit operations in Latin America. It is based on individual reports provided by the team members (for a roster of the team members, see Appendix A), and it reflects the views of the team members, who are responsible for the facts and accuracy of the data presented. The digest does not necessarily reflect the views of TCRP, TRB, the National Academies, APTA, FTA, or the Eno Transportation Foundation.

## INNOVATIONS IN BUS, RAIL, AND SPECIALIZED TRANSIT OPERATIONS IN LATIN AMERICA

The theme of this study mission was "Innovations in Bus, Rail, and Specialized Transit Operations in Latin America." Over a 2-week period, the study team met with senior officials and management staffs of transit agencies in São Paulo, Rio de Janeiro, and Brasília, Brazil; Santiago, Chile; and Quito, Ecuador

(for a list of host agencies, see Appendix B). All the cities visited share many interrelated themes that are placing ever-increasing demands on public transit. These issues include rapid population growth, high-density areas, an aging population, increased usage of private automobiles, and increased traffic congestion and air pollution. In addition, Brazil, Chile, and Ecuador view public transit as an important component of the national infrastructure.

The agencies are striving to address these issues and implement strategies that will reverse the decline in the transit mode share and reduce travel time by improving integration among the metro and bus systems and commuter rail networks, utilizing bus rapid transit (BRT), expanding and extending metro lines, and rationalizing bus system networks to eliminate inefficient or redundant service. Consequently, the team learned how these agencies have been successful in developing and implementing innovations in finance, operations, land use, partnerships, marketing and customer service, and accessibility. These innovations ranged from state-of-the-art technology to low-technology, common-sense approaches.

## OVERVIEW OF PUBLIC TRANSPORTATION NETWORKS

### São Paulo, Brazil

São Paulo, located in southeastern Brazil, 40 miles inland from the Atlantic Coast, is the most populous city in South America. The city of São Paulo has an estimated population of 10.6 million, while the state of São Paulo incorporates 67 municipalities with approximately 23 million residents. The metropolitan area covers 3,100 mi<sup>2</sup>, whereas the city of São Paulo is 580 mi<sup>2</sup>.

The São Paulo metropolitan area is the largest industrial and commercial center in Brazil. It is estimated that one-half of the nation's industrial output comes from the region. Within the past few decades, the growth of the city of São Paulo has slowed, while other urbanized portions of the metropolitan area—such as Santos, Campinas, Santo Andre, São Bernardo, and São Caetano—have experienced an acceleration of growth.

Within the state of São Paulo, 39.1 million person-trips are made daily. Of these, 14.6 million are pedestrian trips and 24.5 million are motorized trips. The motorized trips break down almost evenly, with 12.9 million made by private automobile or taxi

and 11.5 million made by transit. Transit accounts for 47% of all private trips taken compared with 53% for automobiles. During the course of the last 30 years, transit's share of daily trips dropped from 68%, while private automobile usage increased from 32%.

The lead agency for transportation policy development and transit operations within the state of São Paulo is the Secretaria de Transportes Metropolitana (SMT). Serving as the umbrella organization, the SMT oversees three operating agencies—Empresa Metropolitana de Transportes Urbanos (EMTU), Companhia do Metropolitano do São Paulo (Metro), and the Companhia Paulista de Trens Metropolitanos (CPTM). These agencies provide approximately 45% of public transportation services. Thirty-nine municipal bus companies provide the remaining 55% of public transport.

Each municipality within São Paulo operates its own bus service. The EMTU is responsible for the planning, inspection, and management of intercity bus operations within the state of São Paulo. In particular, it ensures compliance to routes, schedules, and maintenance standards. The system has more than 11,000 buses, all of which are owned and operated by private companies. Daily ridership is 1.5 million. EMTU performs a total of 21,000 vehicle inspections annually as well as 1,500 operational inspections. Last year, EMTU imposed 6,400 fines against private operators for violations.

EMTU manages the 68 companies that operate regular and charter bus service. The regular service is divided into common and executive. Executive buses are air-conditioned with additional amenities so the fares are more expensive. Regular service operates on 673 lines with a fleet of 5,000 buses and carries 41 million passengers per month. The charter system has a total of 6,442 buses and operates in areas that are not served by the regular service.

In 1997, EMTU established a concession agreement with Metra, a private company, to operate the BRT. The buses in operation on the dedicated bus corridor are low-floor, articulated buses as well as diesel/electric vehicles and handle 200,000 passengers per work day. By 2006, there will be eight state-of-the-art hydrogen fuel-cell vehicles in operation on this corridor.

In addition to Metra, EMTU also has concession agreements with non-centralized independent bus operators known as Operadores Regionais Coletivos Autônomos (ORCAs). ORCAs provide service to areas of low ridership. As part of the agree-

ments, EMTU determines the timetables and fares as well as the age of the vehicle, which can not exceed 5 years.

The metro comprises four lines—Lines 1, 2, 3, and 5—which total 37.2 miles with 52 stations. Line 4 is currently under construction. The metro provides about 22% of transit trips and carries about 2.4 million customers daily, with 45% of the riders transferring from buses. During peak periods, service operates at headways ranging from 101 seconds to 108 seconds with six-car trains. Peak ridership on Line 3 is 72,000 passengers per hour, per direction.

CPTM, the commuter rail train service, provides about 1.3 million passenger-trips a day, which translates into about 12% of all transit rides. It covers about 167 miles of track and operates six lines with one express line that runs parallel to Metro Line 3. Before the state of São Paulo assumed responsibility in 1994, the commuter lines were operated by private companies.

## Rio de Janeiro, Brazil

Rio de Janeiro, located in the southeastern part of Brazil on the Atlantic Ocean, is the second largest city in Brazil. Rio is located on the western side of Guanabara Bay, which separates it from the city of Niterói. The city of Rio de Janeiro has developed within a range of coastal mountains that form topographical barriers and impact the city's development pattern and transportation systems. The city is divided into three principal areas: the historic downtown, located on Guanabara Bay; the northern zone, situated to the northwest of the downtown; and the southern zone, located to the south and southwest of the beach areas. Upper and middle income residential areas are located in the southern zone, closer to the beaches, while the lower income residential areas tend to be in the northern zone, farther from the center of downtown.

The city of Rio de Janeiro has a population of 5.9 million and covers an area of 450 mi<sup>2</sup>. The larger metropolitan area has a population of 10.7 million and encompasses 20 municipalities within an area of 5,700 mi<sup>2</sup>.

Given that approximately 60% of employment is in a 6-mile radius of downtown, a high percentage of workers commute to Rio from outlying areas each day. Of the 19.7 million person-trips taken daily, 6.7 million are walking trips and 13 million are motorized trips. Bus ridership comprises the largest share

of motorized trips with almost 70%. Private automobiles and taxis account for 24% of motorized trips, while train service and the metro each account for less than 3% of trips.

Companhia de Transportes Sobre Trilhos do Estado do Rio de Janeiro (Riotrilhos) is a public company responsible for the planning, construction, finance, and maintenance of transportation projects for the state of Rio de Janeiro. Metro Rio is operated by Opportrans Concessão Metroviária S.A. (Opportrans), a private company with a 20-year concession to manage and maintain the service.

The current metro system includes 2 lines and 32 stations. Line 1, which is underground, is 8.64 miles with 17 stations and carries 336,000 customers per day. Fourteen trains provide peak-hour headways of 4.5 minutes. Line 2, which is above ground, is 13.48 miles with 15 stations carrying 112,000 customers daily. Fifteen trains are used providing 5-minute peak-hour headway. Service runs from 5:00 a.m. to 12:00 midnight, Monday through Saturday, and from 7:00 a.m. to 11:00 p.m. on Sundays and holidays.

The Superintendencia Municipal de Transportes Urbanos (SMTU) is a public company owned by the state of Rio de Janeiro that manages all regional bus service. SMTU contracts bus operations to over 60 privately held companies and independent operators. The privately operated bus system includes 1,376 routes and 15,000 buses.

The commuter rail system, operated by a private company known as Flumitrens, encompasses 173 miles, with 7 lines and 107 stations.

## Brasília, Brazil

Brasília is the capital of Brazil and is located in the central part of the country. Brasília developed as a planned city, conducive to automobiles, in the late 1950s and early 1960s. It is laid out to resemble the shape of an airplane, with commercial areas, residential apartment buildings, and foreign embassies occupying the wings and the buildings of the federal government serving as the fuselage. The economy is primarily tied to the federal government; only light manufacturing is permitted. The city of Brasília was initially designed to support a population of 500,000. Today, 2 million people live in the city and automobile ownership totals 1 million. Development, building heights, and roadway configuration are strictly controlled by government regulation.

Brasília's transit system consists of two primary elements—the metro system and privately operated bus services. The metro, which opened in September 2001, is operated by the Companhia do Metropolitan do Distrito Federal (Metro DF). Metro DF employs 586 people but is responsible for 1,771 because of outsourcing. The metro system consists of one line of 25.5 miles with 14 stations. The trains are designed to run with four cars. Two types of cars are used on the lines: car A has a capacity of 326 passengers, and car B can accommodate up to 352 passengers.

The bus system in Brasília comprises many linear routes that connect specific regions of the outer city to the central city. These routes operate like peak-hour express services that travel inbound only to the central city in the morning and outbound to outlying regions in the afternoon. Little service is provided during the off-peak hours, contributing to minimal circulation during the working hours of the city.

Ninety-seven percent of the public transportation in Brasília is provided by bus and is privately operated under concession agreements with the government. DF Trans manages bus transportation within the federal district through contracts with municipal operators obtained through a competitive bid process. These contracts allow private companies to operate a designated number of vehicles for a specified period of time. These operators run a total of 870 fixed routes using 2,300 privately owned and maintained buses. DF Trans also manages charters provided by private companies as well as shuttles to and from remote residential areas. All vehicles are required to be inspected every 3 months.

## Santiago, Chile

Santiago, the capital of Chile, has a population of approximately 5.8 million within an area of about 1,400 mi<sup>2</sup>. Santiago residents currently make approximately 10 million motorized trips per day and another 6.3 million walking trips. Transit service has historically made up a significant percentage of motorized trips, but that percentage has dropped significantly in the past decade. For example, bus ridership is down from 59.7% of motorized trips in 1991 to 38.4% in 2001.

Santiago's public transportation system currently comprises a 24.8-mile metro system and 8,400 privately operated buses. The metro system is owned by the federal government but is operated by Metro de Santiago, a private company, under a concession

agreement. The metro system currently consists of 49 stations and three metro lines (Lines 1, 2, and 5). Line 4 is currently under construction. Line 1, the most heavily traveled line, operates 40 trains per hour with a peak frequency of 92 seconds and carries 40,000 passengers per hour. Maximum line speed is approximately 45 mph and commercial speed (including station dwell) is approximately 20 mph. By 2006, the metro system will expand to 52.4 miles.

Metro de Santiago comprises two distinct management divisions. The operations division is responsible for train operations, traction power, the control center, and right-of-way maintenance. The primary objective of the operations division is system optimization. The Metro de Santiago business division is responsible for all activity starting from the station entrance to the boarding platform. These functions include ticketing, station management, marketing, advertising, and security.

## Quito, Ecuador

Quito, the capital of Ecuador, is located in the northern part of the country and has a population of 1.4 million. The city is located in a valley at the base of the Pichincha volcano and is about 2.5 miles wide, 30 miles long, and 9,300 feet above sea level. Quito is the oldest capital city in South America and has many colonial era buildings with historical and architectural value.

The population of Quito is highly reliant on public transportation because only 8% of its residents own cars. The conventional bus system encompasses 3,406 privately operated buses on 132 routes. The BRT, known as Trolebús, is operated by the Unidad Operadora del Sistema Trolebús (UOST) and runs northwest to southeast along the spine of the city. Trolebús service began in 1995 and operates from 5:00 a.m. to 12:00 midnight on weekdays and from 6:00 a.m. to 10:00 p.m. on the weekends. It transports 62 million passengers per year with a daily ridership of more than 200,000 passengers.

Trolebús uses 60-foot, low-floor, articulated, dual-powered trolley buses within dedicated lanes. The service corridor includes 39 stops/stations (enclosed shelters are located at each of the stops) and 2 terminal facilities. During peak periods, 113 buses operate on 1.5-minute headways and on 4-minute headways during off-peak times. Bus routes overlap

to assure that capacity on each segment of the corridor is appropriate to passenger demand.

The Empresa Metropolitana de Servicios y Administración del Transporte (EMSAT) is the public agency that provides oversight and management of all traffic and public transportation services, including the Trolebús, regular buses, feeder lines, school buses, and taxis. Specifically, EMSAT ensures compliance with service, permit, schedule, and maintenance standards. Like many transportation agencies in South America, EMSAT handles only the administrative and regulatory functions; operation is contracted to private companies and/or individual bus owner-operators.

## PLANNING

### Brazil

Urban planning and policy making at the local level are relatively new concepts in Brazil. With the legacy of military governments and centralized decision making, local governments have had minimal involvement in developing public policy. Although Brazil's constitution, adopted in 1988, established more independence and autonomy to municipalities, many localities did not have the expertise or the infrastructure to handle these changes. At the same time, the country began to experience a population explosion and rapid urbanization that further affected the ability of local governments to meet the infrastructure and mobility needs of its citizens.

As a result of the challenges facing local government, a national urban policy was developed to promote social inclusion and universal access to basic public services as fundamental citizen rights. The *Ministerio das Cidades* (Ministry of Cities [MoC]) was created in January 2003 to implement and manage the national urban policy and is composed of four national secretariats: *Secretaria Nacional de Habitação* (Housing), *Saneamento Ambiental* (Environmental Sanitation), *Programas Urbanos* (Urban Programs) and *Transporte e da Mobilidade Urbana* (Transportation and Urban Mobility).

To strengthen the land and urban management capabilities of local governments, the MoC required all municipalities with a population greater than 20,000 to develop master transportation plans by the year 2006. The federal government established a financial aid program to help the municipalities develop these plans.

## *São Paulo*

The SMT recently completed a comprehensive master transportation plan known as the Plano Integrado de Transportes Urbanos (PITU 2020). The principal goal of the plan is to reverse the decline in transit mode share. PITU 2020 focuses on transit infrastructure improvements as well as roadway operation and pricing policies within the state of São Paulo. The rapid increase in private automobile ownership over the last 4 decades has also resulted in significant congestion and air quality problems. To combat these problems, PITU 2020 identifies needed improvements to the metro, commuter rail system, and intercity bus service.

SMT began the planning process by conducting studies of the metropolitan area population that included an origin and destination analysis based on over 130,000 interviews with 30,000 households. Using these travel data, together with demographic information, the SMT developed multiple alternative scenarios based on differing growth assumptions, demand management strategies, and fare policies. Strategic and Regional Model (START) software was used to model policy alternatives, and EMME2 (an interactive transportation planning software program) was used to evaluate alternative development and transit scenarios. Initial results indicated that the metro network needed to be expanded in the core of São Paulo with the objective of intensifying development and ensuring infill development where needed. Along with efforts to intensify land use in the urban core, high-quality intercity linkages are planned to support the continued development of a multi-centric growth pattern, with new population growth occurring in the five other areas that are within 60 miles of the city.

Another major component of PITU 2020 includes the physical and fare integration of transit services. Currently, intermodal station facilities are being developed to support the integration of intercity bus and rail services, as well as the integration of the metro and commuter rail services. For example, the Luz station is a completely restored commuter station that integrates metro and commuter rail lines.

The existing metro system has limited capability to accommodate future ridership growth. To gain capacity, improvement plans call for upgrading light rail lines to heavy capacity lines and extending existing lines to provide travel pattern options to users and to reduce the impacts of bottlenecks. Again, the integration of transit services and the introduction of

fare integration, with pre-paid fare alternatives, are critical elements of the plan to expand the capacity of the transit system to meet future needs.

Infrastructure expansion called for in PITU 2020 includes 176 miles of metro service to be added to the existing system, including a 27-mile line to the airport, which would be developed by a private concession agreement. For the bus system, the EMTU would add 186 miles of bus corridor service, while the municipalities would put in 162 miles of segregated bus lanes. Overall, the system improvements called for in PITU 2020 would result in a 30% reduction in travel time for transit users.

Finally, PITU 2020 addresses congestion and the economic and environmental issues resulting from the projected 20% increase in time spent in automobiles during peak periods. To combat this phenomenon, PITU 2020 recommends instituting congestion pricing strategies on major roadways, establishing no-parking zones within the downtown areas, and implementing odd/even days (based on license plate numbers) when cars can travel. Ultimately, the state is advancing a comprehensive mix of initiatives designed to build in disincentives for the automobile and make public transportation a better choice.

## *Rio de Janeiro*

The state of Rio de Janeiro is focused on providing congestion relief and shorter trip times. The current heavy reliance on buses has a significant impact on both congestion and air quality. Therefore, future plans mostly involve the expansion of the metro system.

Expansion plans begin with an extension of Line 1, which currently serves the downtown area and Copacabana to Ipanema and Gávea, high-income areas in the southern zone. Other plans include developing new lines. Line 3 would link downtown Rio de Janeiro to the city of Niterói on the eastern side of Guanabara Bay. This 14.2-mile project includes a tunnel under the Bay. Line 4 (16.1 miles and 9 stations) would connect downtown to Gávea with a terminus at Alvorada. Finally, Line 6 would provide an outer loop connection from Alvorada to Ilha do Governado, running from the southwest to the northeast part of the city, with connections to Lines 2 and 4.

The introduction of these new metro lines is intended to shift significant ridership from the bus mode in an effort to reduce bus traffic and, thus, pollution. In addition, given that most of the lower income res-

idential areas are farther from employment centers located in downtown and given the topographic barriers of the city, commute times for lower income workers are often excessive. Expansion of the metro is intended to provide shorter commute times. In the case of the proposed Line 4, commutes that currently take 90 minutes would be reduced to 30 minutes.

### *Brasília*

The challenge for transit officials in Brasília is to introduce quality public transportation alternatives in a city built to optimize and encourage automobile use. Metro linkages from outlying residential areas that can compete with the private automobile in a way that fully integrates the privately operated bus services with the metro system is the ultimate goal.

An expansion plan for the metro system has been developed that includes extension of Line 1 and the implementation of a second line that would link the outlying suburban and satellite communities. Most of the metro expansion is planned as surface heavy or light rail. A total of 29 stations are planned, together with 11 integrated bus and metro terminals. For example, Ceilandia, the next metro station to open, will be located at a major bus terminal. This effort is symbolic of the planning effort to convert the commuter bus service into a metro feeder system with efficient rail transfers. In addition, to facilitate the operational and physical integration of bus and rail services, Metro DF is in the process of implementing a smart card to incorporate all public transportation services.

### **Santiago, Chile**

Through its main planning agency, the Secretaria Interministerial de Planificación de Transporte (Sectra), the government of Chile is in the middle of Transantiago, an ambitious plan to redesign Santiago's urban transportation system. A key objective of the Transantiago plan is to make transit a better choice through higher standards of investments and the comprehensive planning of an economically, socially, and environmentally sustainable system. Much like São Paulo, a fundamental attribute of the plan is the physical, operational, and fare integration of all public transportation services: feeder bus, trunkline bus, and the metro system.

The Transantiago plan focuses on reversing the decline in transit mode share by

- Prioritizing public transportation,
- Rationing the use of the private automobile, and
- Developing non-motorized transportation options.

The initial phase of the plan focuses on improving Santiago's urban transportation system. Once these improvements are in place, additional focus will be placed on congestion pricing and other steps to ration the use of private automobiles.

The Transantiago plan provides for the full integration of the bus and metro systems. As with many South American cities, bus service is privately provided by owner–operators who hold licenses or concessions for particular routes. Officials at Sectra indicated that in Santiago, this approach has led to too much service being provided for the level of demand. The excessive supply of service translates into increased congestion, air quality problems, and a higher than necessary fare to the end user, which further discourages ridership. As a result of the current inefficiencies, the Transantiago plan to reallocate current resources is expected to improve the transportation network and quality of service. Under the Transantiago plan, the metro system will expand to 52.4 miles and the total fleet of buses will be reduced from the current 8,400 to 5,021.

In addition to expanding the metro and restructuring the bus system, the Transantiago plan also provides for the physical, operational, and fare integration of bus and rail systems. Funding in the amount of \$700 million has been programmed through 2010 to add rail/bus transfer facilities as well as dedicated bus lanes. A smart card system has already been introduced on the metro and a limited number of feeder bus routes. In the future, the smart card will be expanded to all transit services, and planners expect all transactions will be performed with a smart card. With the expansion of the metro and the full integration of bus and rail systems, the Transantiago plan projects a quantum increase in ridership on the metro system from 200 million to 700 million passenger-trips per year. The implementation of the Transantiago plan is also expected to reduce emissions from mobile sources to half the current levels.

The implementing agencies for the Transantiago plan include the agency known as Transantiago and Metro de Santiago. Transantiago is currently working on rationalizing the privately operated bus service. A major objective is to organize the 3,500 current bus owner–operators into 15 or fewer companies that will

compete to operate the trunk and feeder bus network defined in the Transantiago plan. Transantiago expects to solicit proposals for the operation of 15 sectors of routes, with 10 feeder routes and 5 trunk routes in each sector. To broaden competition and ensure inclusion of qualified firms, Transantiago is seeking participation of foreign companies in the tender process.

The average age and physical condition of the buses in the current fleet is a major concern; therefore, the solicitation will include requirements on the quality of buses. For instance, all buses will be required to be low floor with automatic transmission and must meet emission standards. Service quality requirements will include cleanliness standards, operation standards (based on the Euro 3 standard), and the use of low sulfur fuels. New articulated buses will cost less to operate than the existing vehicles because articulated buses will be able to carry approximately 160 passengers versus the current 70 to 80 passenger load.

A separate solicitation process is planned for information technology (IT) and financial administration services (FAS). These concession agreements will support equipping the bus fleet with automatic vehicle location (AVL) systems and fare collection systems as well as managing the smart card system. The AVL system will be used by Transantiago to monitor the performance of the private bus companies. The IT and FAS concessions will be expected to generate revenue through market developments of the AVL and smart card systems. It is anticipated that the IT concessionaire will market AVL-based information to users and to advertisers, while the smart card will be developed as a debit card for retail and other non-transit uses.

To support the requirements of the Transantiago plan, Metro de Santiago has developed a number of capacity enhancement strategies. Through improvements to the signal system, Metro de Santiago has enhanced headway capabilities to support a 79-second headway. Signal improvements—together with operational strategies, such as interlining, turnbacks, and the use of drop-back operators—will allow Metro de Santiago to achieve a peak capacity of 55,000 passengers per hour per direction.

The introduction of smart cards to speed up fare transactions and educational campaigns to improve riding habits of existing customers are also important components of Metro de Santiago's capacity enhancement strategies.

## Quito, Ecuador

In 1990, Quito began a transportation planning process in partnership with foreign experts from Russia, Argentina, Chile, and Brazil. The resulting study and analysis determined the need for a BRT corridor that also included feeder lines to the north and south of the central city. The decision to implement BRT rather than a light rail or metro system was based on cost as well as concerns over noise and vibration impacts on the city's historical and architectural structures.

The development of the Trolebús was partially intended as a means of rationalizing the informal private bus operations. The prevalence of privately operated buses, running with limited regulation, resulted in significant congestion and air quality problems. In addition, this situation resulted in too much service being supplied for the levels of demand. Trolebús officials stated that the BRT service has reduced the number of private buses by 572, and the city has experienced a significant reduction in key pollutants.

Future plans call for converting the current Trolebús system to an elevated rail system by 2012 with construction scheduled to begin in 2008. The state and city are also working to further rationalize the privately operated bus service by reducing the number of private bus companies to either three or six companies. In addition, municipal and regional bus lines would be expected to interface with the Trolebús system at the terminal facilities resulting in an integrated network with standardized fares.

## FUNDING

Until 1993, transportation infrastructure funding was the responsibility of each state and municipality in Brazil. With the recent development of the national urban transportation policy, the federal government is now participating in the financing of transportation projects through the Banco Nacional de Desenvolvimento Econômico e Social (BNDES). In addition, the World Bank is getting more involved in financing projects. One such project is the renovation of the Luz station in São Paulo.

Privatization of the operational aspects of most public transportation services offered in Brazil has proven to be cost-effective. However, balancing the profitability of privately held companies with the national policy goals of accessibility, affordability, and interconnectivity has challenged the government.



São Paulo's capital program, outlined in PITU 2020, calls for increased investment in public transportation services with 70% allocated to rail-related investments that concentrate on linking high-population density areas. In particular, the program directs more than \$2 billion of capital investment for a variety of system improvements including rationalizing and integrating routes, services, and park-and-ride facilities; expanding the metro and commuter rail network; introducing integrated fares through smart card technology; developing hybrid electric bus technology; and establishing new bus corridors. About 41% of this investment will be funded through public/private partnerships. In addition, new concession contracts for bus service call for higher standards through capital outlays by successful bus service contractors.

Rio de Janeiro has faced some financial challenges in meeting its capital program needs. These funding problems, stemming from Rio de Janeiro's bankruptcy in 1988, have delayed full construction of the two metro lines, and, therefore, metro service operates in a limited area. However, in cooperation with the World Bank and BNDES, Riотrilhos was able to acquire \$63 million in the mid-1990s to renew construction and extend Line 1 from Arcoverde to Siqueira Campos and Line 2 to Carioca. A second private operator, Barra Consortium, has received a license agreement from Riотrilhos to build and operate Metro Line 4. This project is estimated to cost \$600 million and to serve 108,000 passengers per day when completed. The 2007 Pan American Games scheduled to be held in Rio de Janeiro is also serving as a catalyst for much of the investment.

The Trolebús in Quito was funded by a joint venture between Ecuador and Spain. Stage one of the corridor was constructed at a cost of \$72 million, with \$52 million funded by Spain and \$20 million by Ecuador. Stage two was constructed at a cost of \$65 million, with \$55 million funded by Spain and \$10 million from Ecuador.

## INNOVATIONS

### Financial

#### *National Transportation Voucher Program*

In accordance with the national urban transportation policy of ensuring access to public transportation services to its citizenry, the Brazilian federal government established an income-based transportation voucher program. Under the program, employ-

ees are only required to pay up to 6% of their total income on transportation. If the percentage of the employee's actual transportation costs is higher than 6%, then the employer pays the difference.

#### *Non-traditional Revenue Sources*

Since the year 2000, the state of Rio de Janeiro has increased its financial support for transit operations from \$3 million to \$18 million. The additional monies come from a dedicated funding source from an environmental conservation program that levies environmental fines and taxes and receives oil royalties.

Metro DF is also pushing the envelope in its efforts to secure non-traditional funding sources to defray operational costs and help fund capital programs. Outside of the normal revenue-producing concession agreements common to Brazil's transportation systems, Metro DF is actively exploring financial opportunities in the areas of right-of-way easements for fiber-optic carriers, transit-oriented development in and around Metro DF property, advertising/sponsorship opportunities on smart cards and other fare media, expanded fee-structured parking facilities, and property value appreciation fees for surrounding developments. Metro DF also plans to institute variable pricing strategies (higher fares during peak periods and lower fares during off-peak periods) into its fare structure to help balance demand with service capabilities of the system.

Metro de Santiago also has an agreement with a fiber-optic provider to lease portions of its rights-of-way to run fiber-optic cable. As part of this deal,



**Figure 1** A high-definition, flat-screen television in a Santiago metro station.

Metro de Santiago received fiber-optic cables at a reduced rate. It then pursued arrangements with an advertising company to install high-definition, flat-screen televisions in the stations. These televisions run product advertising, public service announcements, and metro-related announcements under a lease agreement. All other investment comes from the private companies who lease the space. Metro de Santiago receives 5% of all revenues from this concession.

### *Advertising*

The São Paulo Metro leases commercial space for kiosks, vending machines, and advertising inside the stations and integration terminals. Metro de Santiago covers 10% of its operating expenses through advertising revenues.

Metro DF has developed commercial space for lease in its existing stations, as well as space for billboards and advertising both in the stations and on trains. No ads are allowed for cigarettes or alcohol. Once all of the proposed stations are constructed and operational, funds generated from private sources are expected to account for 20% of the total revenue for Metro DF.

### *Profit Sharing Based on Bus/Ride Quality*

The current quality of buses in Santiago is varied; some operators use new equipment, while others use buses that are in need of repair. Because the current operators receive no assistance in vehicle purchases, the majority of buses are purchased with no extra options that contribute to customer comfort or convenience. Transantiago realizes the importance of ride quality in attracting and retaining bus passengers; therefore, it unveiled a progressive incentive plan that will be offered to the new conglomerate bus operators. Depending on the quality of the buses used, these operators will recoup different percentages of revenues. For instance, operators who purchase and provide buses equipped with low-floor accessibility, automatic voice annunciators, air conditioning, and AVL and automatic vehicle monitoring (AVM) equipment will receive 85% of all monthly collected revenues, the highest amount allowed. Transantiago will subsidize the purchase of this equipment for operators who may not be able to afford it otherwise; however, they will receive a smaller share of the revenues. This approach emphasizes the importance of the smart card because it

will be used to determine revenues paid to the operators as well as to audit fare collection.

### *Complimentary Passes*

In 2003, São Paulo Metro implemented a 90-day, non-renewable complimentary fare ticket for the unemployed to assist them in obtaining employment. To support students and teachers, Metro offers a 50% discount. The state of São Paulo reimburses Metro for providing these free and discounted fare tickets.

As in São Paulo, persons who are elderly, persons who have disabilities, and military personnel ride free on all modes of transportation in Santiago. The same is true in Brasília, where firefighters also ride free.

## **Operations**

### *Flow Guides*

An interesting low-technology but high-concept innovation employed by São Paulo Metro is the use of flow guides. The type of guides applied at stations depends on passenger volume. For instance, some stations have painted lines and arrows on the station platform, while others use metal barricades to direct the flow of passengers more efficiently into the train. In addition, most stations in São Paulo have white bars painted on the edges of the platform to indicate exactly where the train doors will stop.

Inside the train cars and buses in Brasília, decal stickers are located on the extra-wide doors indicating which door to use when exiting. For instance, right door panels have green stickers directing customers to keep to the right when exiting the car. Similarly, a decal sticker with a red arrow and slash (/) through it, is placed on the left door panel warning customers not to exit on the left side.

### *Connector Service*

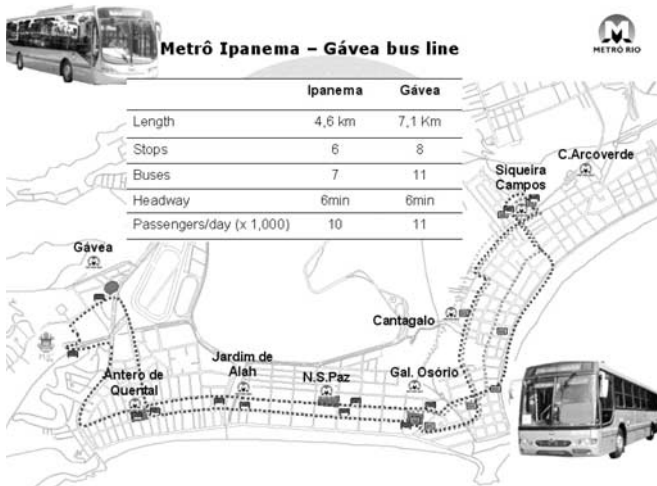
As previously mentioned, Rio de Janeiro has experienced significant funding challenges in its metro system expansion. These funding challenges have led to delays in the implementation schedule for the extension of Line 1 to Ipanema and Gávea. In August 2002, a bus connector service was implemented that provides metro users with a connection from the Siqueira Campos station to Ipanema replicating the planned extension of Line 1. The connector service uses low-floor buses that are branded to match the



**Figure 2 and 2a** Railings and painted lines to facilitate customer flow and reduce dwell time.



**Figure 3 and 3a** Signage to reduce the conflict between boarding and alighting passengers in Brasília.



**Figure 4** A map of the Metro Rio connector service.

metro system and require no additional fare payment for metro users. The service operates a 2.8-mile route on a frequent 6-minute headway with a total of 6 stops and transports about 10,000 passengers per week-day. Because of the overwhelming success of the Metro-Ipanema connector, a second connector route was implemented that links the Gávea area. This 4.4-mile route also operates on a 6-minute headway and transports over 11,000 passengers per weekday.

### Bus Rapid Transit

São Paulo’s EMTU manages 195 vehicles over 10 routes with 9 terminals and 111 bus stops and carries about 200,000 passengers daily using low-floor,



**Figure 5** Raised boarding platforms in front of the exit doors of the articulated Trolebús.



**Figure 6** A Trolebús terminal in Quito.

articulated, diesel/electric hybrid trolley buses along segregated rights-of-way. The BRT can reach average speeds of up to 16 mph, which is twice the speed of regular bus service. In addition, the buses have doors on both sides as the BRT right-of-way is on the left inner traffic lane and passengers enter/exit using a center median near each intersection. The trolley BRT service in Quito has three sets of doors to facilitate boarding and alighting at the designated stations. The Trolebús service also has raised boarding platforms to bridge gaps between the bus and high-level platforms.

### Hydrogen Fuel-Cell Technology

Despite major efforts over 3 decades to reduce pollution, the São Paulo metropolitan area continues to have major problems with air quality, which drops below acceptable standards approximately 140 days per year. Diesel engines in trucks and buses account for significant amounts of the harmful emissions. Although diesel-powered buses make up only a small part of the fleet, these vehicles make a significant contribution to toxic emissions—up to 6% of the total for nitrogen oxides. Diesel buses contribute over 50% of airborne particulate matter found in the bus corridors. The São Paulo metropolitan bus fleet is estimated to release more than 1.5 million tons of carbon dioxide per year. To combat this growing problem, Brazil is participating in a project funded by the United Nations Development Programme to test the feasibility of using hydrogen fuel-cell buses for public transportation in the São Paulo metropolitan area. This hydrogen fuel-cell program consists of four phases. Phase I was a feasibility study, which has been completed.

Phase II (from 2001 to 2006), which is the current phase of the project, totals almost \$22 million and involves operating a fleet of 8 buses for 4 years to obtain more than 600,000 vehicle-miles of experience. The bus specification is the most integral element of this phase. The prototype bus is 36 feet long, with a carrying capacity of 90 passengers and a range of almost 200 miles. The buses feature hydrogen fuel-cell engines and are designed to accommodate the added weight and carrying capacity needs. During this phase, the project uses a mobile hydrogen station that has a supply of 30 kg of hydrogen per day. For the latter phases, permanent infrastructure will be utilized. Phase III will include converting a complete bus garage to operating hydrogen fuel-cell buses, with a fleet of some 200 buses. Phase IV will involve wider deployment in the São Paulo metropolitan area as well as other regions within Brazil.

### *Integrated Fare Connections*

The Diadema station in São Paulo is a bus-only node that allows free transfers between intercity buses and the municipal bus lines. Passengers pay the fare outside of the station, then enter through turnstiles; they can then board any bus within the station. This operation eliminates fare-paying as the passenger enters the bus and speeds up boarding.

As a result of the Luz renovation project in São Paulo, free transfers are given between the metro and commuter trains on weekends and holidays.

### *Safety and Security*

In São Paulo, Rio de Janeiro, and Santiago, metro stations are wired with security cameras and have public address systems to communicate with customers. In São Paulo, metro mezzanines have offices conspicuously located so the public can see security personnel viewing security camera monitor screens at all times. Ticket agent booths are also shielded to protect ticket agents from holdups, and ticket agents have money packages with ink bombs in the booths to give in the event of a holdup. In addition, pictures of known pickpockets are framed on platform walls.

In São Paulo, stations are exceptionally well lit, particularly at platform levels, giving an even greater sense of security. Train operators are also able to view the entire platform through mirrors placed in the operator's direct line of view as the train stops to pick up passengers. São Paulo Metro also has mo-



**Figure 7 and 7a** Highly visible security kiosks in São Paulo Metro stations.

bile metal detectors, which are used at different stations during important events.

### *Dedicated, Double-Wide Bus Lanes*

In higher density areas of Santiago, two right lanes are reserved for bus traffic, except at intersections



**Figure 8** Double-wide bus lanes.

where cars can cross over to make right turns. These double-wide lanes allow buses to pass each other.

### Real-Time Monitoring of Passenger Volume

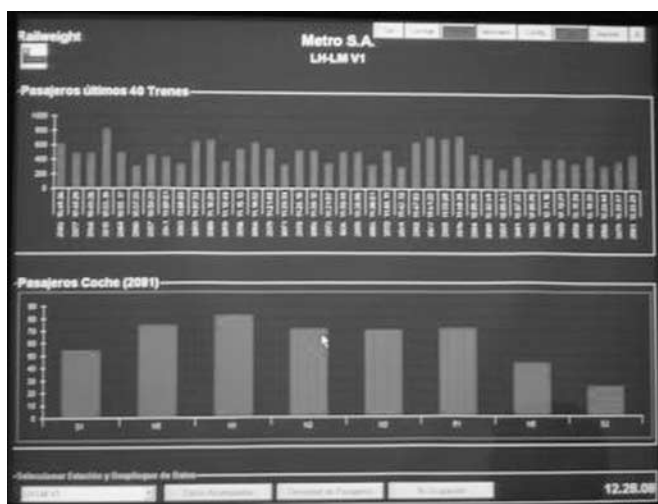
At Metro de Santiago's control center, train density is monitored in real-time through sensors in the train's pneumatic suspension that weigh each car. Passenger loads can be determined by train or even on a car-by-car basis. Information displayed in the control center is analyzed, and operational decisions are made on the spot to adjust service if weight exceeds specified levels.

### Interlining and Short-Turning Trains

In Santiago, interlining trains is common practice to help improve service capacity. For instance, the peak period for Line 2 is 15 minutes earlier than Line 1, so some trains are interlined between the two lines. In addition, Santiago also uses short-turning trains.

### Expedited Turnback Moves

To save time in Santiago, trains are turned at terminals using two operators: one in the front cab and one in the back cab of the train. This approach saves between 90 and 120 seconds.



**Figure 9** The top half of the screen details the loads of 40 trains in service, while the bottom half of the screen shows that Train 2081 carries most of its load in the middle to the rear of the train.

### Using Part-Time Operators During Peak Periods

In 1993, Metro de Santiago began hiring college students to work part time as operators. Now, 40% of the train operators are part time.

### Use of AVL and AVM

Transantiago plans to use a phased approach (between 2004 and 2006) to equip 4,700 buses with AVL and AVM technology. Transantiago also plans to establish a central information group and vehicle monitoring center to provide performance and maintenance data. This technology will allow Transantiago to maintain the quality of bus operations as well as to improve the image of the bus to levels equal to the metro system.

### Smart Cards

Metro DF's smart card includes a photograph of the patron to enhance security and also has the capability to automatically recharge its value through debiting the patron's bank account. Metro DF plans to integrate the smart card into every aspect of its operation including businesses within the stations, providing customers with the capability to purchase personal items with the smart card. Customers receive the first smart card free.

The city of Santiago is testing Multivia Cards for use on the metro and buses. Less expensive fares will be offered to passengers who use the smart card. Once the Multivia Card is integrated within the public transportation system, it will also be accepted as a discount card for movies, entertainment parks, and other social activities.

### Vehicle and Station Design

To facilitate passenger entry and exit and movement of large crowds during both peak and off-peak hours in São Paulo, train doors are located on both sides of the cars. At busy stops, center platforms are reserved for exit while wall platforms are used for boarding trains. In addition, station signage directs passengers to distribute evenly along the platforms. These innovative strategies help to decrease dwell time and increase trip speed because boarding is spread more evenly throughout the entire train.

Trains in Santiago are rubber-tired, contributing to less noise and a smoother ride. In addition, these tires are used because certain sections of the line have deep slopes. The trains are articulated and equipped



**Figure 10** Boarding only on the left side; alighting only on the right side. Note the white lines that encourage proper queuing of passengers as they wait for the train.

with automatic acceleration and braking. The trains also include next stop audio and visual displays via multicolored LED screens at the head of each car. Multi-pole stanchions mounted in the doorways also allow more space for standees to hold.

The introduction of low-floor buses has made using transit easier for passengers. To ensure the



**Figure 11** The three-pole stanchion provides more space for standees to hold.



**Figure 12** Seats mounted on the large wheel wells in low-floor buses.

number of seats on each bus is maximized, transit agencies in South America install seating on and over the wheel wells. Buses also maximize space for standees.

In addition to providing high-level boarding, high-capacity buses are often equipped with doors on both sides to further reduce dwell times or to provide operational flexibility when operating on busways or one-way streets and in terminals. This innovative high-capacity design also incorporates three axles, including two steerable axles, to reduce wheel loading and damage to pavements.

#### *Fare Collection*

Some large buses in São Paulo and Rio de Janeiro use a driver and a conductor. This two-person operation facilitates fare collection by offering passengers the opportunity to receive change; allows the driver to concentrate on driving; and helps reduce dwell time, which can become significant with large numbers of people boarding articulated or bi-articulated buses.



**Figure 13** High-capacity bus design.



**Figure 15** A conductor position and turnstiles on board an articulated bus.



**Figure 14 and 14a** A bus built with two doors on each side and three axles.

The availability of a conductor also means the driver is not interrupted by passengers seeking fare or route and schedule information, and overall customer service is enhanced. The use of turnstiles is quite common onboard buses in South America. Passengers with wheelchairs or other mobility aids must board through other doors that do not have turnstiles.

### *Travel-Demand Modeling*

ESTRAUS is a travel-demand modeling software system used extensively by the city of Santiago. The software system supports a modeling configuration that is significantly different from the modeling process generally used in the United States.

The model is configured to address the second through fourth steps (distribution, mode choice, and assignment) of the conventional process simultaneously. This modification was made based on the viewpoint that the four-step process does not properly reflect real travel behavior. People do not sequentially decide first where they're going, then how



they are going to get there, and finally what route they are going to take. In the view of the developers of ESTR AUS, all of these decisions are made simultaneously.

The software developers stated that one of the advantages to the ESTR AUS modeling process is that it is better at analyzing competing modes of travel (i.e., buses versus personal automobiles) because the software model simultaneously considers the demand and capacity for competing modes. For example, if the model shows that the number of cars exceeds available roadway capacity and there is a surplus of seats on competing bus routes, it will adjust the results to reallocate some of the trips from the personal automobile to bus. (This is a simplification of the ESTR AUS modeling process; other factors, such as socioeconomic characteristics of the trip, are also considered.)

The software runs on a Pentium personal computer platform using the Linux operating system. The ESTR AUS model is innovative and technologically very advanced, especially because it can operate from a personal computer.

## Land Use

### *Tax Initiatives*

In Brazil, to address the issue of empty buildings and unused urban land, these properties are taxed at a much higher rate to encourage land-owners to renovate the empty buildings. In Santiago, although property values increase in areas that receive improvements to the public transportation infrastructure, personal property taxes are not affected.

### *Pedestrian Underpasses*

Because the layout of Brasília facilitated a heavy reliance on the automobile, pedestrian travel was often lacking in the infrastructure. For example, the multi-lane thoroughfares along the wing-shaped residential and commercial corridor are significant barriers to pedestrian traffic. Pedestrian tunnels were constructed as part of the initial design, but these tunnels became refuges for the homeless and criminal activity.

With the development of the metro system that operates underground through the same corridor as these thoroughfares, Metro DF has improved pedestrian access. For stations along this corridor, station access points come up on either side of the multi-



**Figure 16** A pedestrian underpass in Brasília.

lane roadways. The access tunnels have been developed to include natural lighting through skylights as well as retail lease space, resulting in a pedestrian environment that is now secure and inviting.

## Partnerships

### *Special Services*

In a special operating agreement between EMTU and the São Paulo Zoo, EMTU runs a bus from a station directly to the Zoo. The bus is wrapped with Zoo advertising and related themes. Zoo employees operate a creatively decorated kiosk at the bus station where patrons pay one fee that includes the cost of the shuttle ride and entrance fee to the zoo.

EMTU also manages a special ORCA bus shuttle that operates between a metro station and CPTM



**Figure 17** Kiosk for the zoo bus shuttle.

terminal. This route provides virtual integration of three systems and is provided free of charge to passengers.

In addition, EMTU manages (1) a special charter service linking Guarulhos International Airport with Congonhas International Airport and (2) service to the Tiete Terminal for connections with intercity and interstate buses. The charter service operates 27 vehicles handling an average of 105,000 passengers per month. Service is also provided from the airports to the major hotels located downtown.

### *Joint Ventures*

São Paulo Metro partnered with the private sector to construct shopping centers directly connected to three metro stations: Shopping Metro Itaquera, Shopping Metro Tatuape, and Shopping Metro Santa Cruz. These shopping centers include department stores, supermarkets, and cinemas.

In an effort to increase demand for the São Paulo Metro on weekends, a partnership was entered into with the Museu de Arte Sacra that resulted in the designation of space for art exhibits at Luz station and a 75% discount on the museum's entrance fee for Metro riders.

Opportrans in Rio de Janeiro has formed a number of alliances to develop new projects and training programs. The agency has technical cooperation agreements with the São Paulo and Paris metro systems and a technical partnership with COPPETEC/RJ, an engineering post-graduate center linked to the Universidade Federal do Rio de Janeiro. Agreements are also in place between Opportrans and an industrial apprenticeship service and a technical school to provide programs for the retraining of metro maintenance staff. Staff also works with the Instituto Nacional de Desenvolvimento Gerencial on the review and standardization of processes as well as the provision of management training in customer relations and leadership. The agency also partners with the Fundação Gutúlio Vargas on economic research projects.

In addition, Opportrans created a commercial department to partner with private owners and entrepreneurs to establish retail businesses and kiosks in the metro stations. These concession relationships provide conveniences for transit users and a large circulation of potential customers for private businesses.

Metro de Santiago has established a non-profit cultural and arts corporation that it owns and that is chaired by the Metro de Santiago board chair. The

purpose of the corporation is to foster cultural activities at metro stations. The non-profit nature of the corporation provides tax benefits to businesses and organizations that sponsor art exhibits and other cultural activities in the stations.

### *Donations*

Items turned in to Metro DF's lost and found are kept on site for 60 days. After 60 days, unclaimed items are sent to a government agency that distributes the items to social organizations. (While having a lost and found is not innovative, using it as an opportunity to help those in need by donating useable, unclaimed articles is certainly noteworthy.)

## **Customer Service and Marketing**

### *Integration of Transit into Customers' Daily Lives*

One of the key objectives for the São Paulo Metro is to integrate transit into the daily lives of its customers. The large metro mezzanines are filled with numerous small shops including shoe stores and cell phone outlets. To encourage and facilitate more reading while riding the subway, one large station includes a public library. Station platforms also have paperback vending machines. Most notably, at a major station hub, a pharmacy outlet distributes a limited variety of prescription drugs to low-income residents.

Metro stations in São Paulo are collectively the largest informal art galleries in the metropolitan area. In 2003, about 170 exhibitions were held in stations along with a series of classical music performances. The 200 events held yearly in the metro stations offer millions of São Paulo citizens the opportunity to experience culture.

Besides art and culture, São Paulo Metro has had other innovative programs that integrate transit into the social fabric and consciousness of the São Paulo population. For example, a sports program geared towards young people was held at the Jardim station and included presentations on bodybuilding and martial arts. About 1,000 people attended. To promote health and quality of life issues, wellness functions have also been held in stations. Past events have focused on methods to quit smoking and offered diabetes and cataracts screenings.

São Paulo's EMTU also integrates transit into people's lives. The EMTU promotes art and entertainment events in bus terminals, including live music



**Figure 18** A paperback vending machine.

often performed by EMTU employees. In addition, the EMTU holds traffic safety education courses for children. In 2003, more than 7,000 children attended these classes.

### *System Marketing and Information*

“ReSPeito” (“ReSPect for You” [the “SP” stands for São Paulo]) is the message promoted throughout the metro and commuter rail stations; human faces are shown rather than vehicles. Print communication is very consistent in promoting the themes of citizenship, employee service, and professional pride.



**Figure 19** A pharmacy located at a metro station hub in São Paulo.

These marketing approaches successfully enhance the image of being customer focused.

One of the most impressive aspects of the Metro de Santiago is its approach to advertising. The marketing business plan focuses on three basic components: customer satisfaction, customer loyalty, and the metro image. The marketing department believes the most effective way to change behavior is by creating humorous light-toned messages. For example, the humorous, but poignant, “No Corras” (“Don’t



**Figure 20** “Respect for You” message on a train in São Paulo.



**Figure 21** A life-sized human cut-out advertising the “Don’t Run” campaign.

Run”) campaign features life-sized human cutouts with various bandages or arm/leg casts displayed on the metro mezzanine level to warn customers not to run.

Metro de Santiago has developed very creative and innovative public service announcements and print campaigns. When needing to educate the public about a new route and an unfamiliar idea, Metro de Santiago produced a TV spot of two children holding their breaths while taking a metro train through a newly constructed sub-aqueous tunnel. To address growing problems associated with graffiti and window etching, Metro de Santiago used the theme “O Metro Cuida de Você, Por Favor Cuyide do Metro” (“Metro takes care of you, please take care of Metro”). Anti-etching signage with an 800 number was publicized throughout the metro system so customers could report acts of window etching. The campaign resulted in a one-third decrease in window etchings. Finally, in an effort to discourage passengers from sitting on the floors of the train when seats were not available, Metro de Santiago placed footprints and signage on the floor itself say-

ing that sitting on the floor occupied the space of several persons and jeopardized personal safety.

Prior to the construction of new metro rail lines and stations in Santiago, an information kiosk and construction office is built and located at the future site. This office announces the presence of the future Metro line in the neighborhood and acclimates neighbors and others to the advent of the new rail extension and/or station. It also fields questions and complaints related to the construction of the new metro rail line and station.

Before the advent of the Trolebús system, buses in the city of Quito operated more as a demand-response service. Passengers boarding buses would often inform the driver where they wanted to be dropped off, and in most cases, the driver would comply. To change this way of thinking, the UOST initiated a marketing campaign to educate the public about the corridor and the Trolebús’s limited stops at designated stations.

#### *Dedicated Customer Service Offices*

In São Paulo, an ombudsman office reports directly to the SMT. This office handles complaints, suggestions, and compliments. Each metro line in Santiago has a separate customer service office. These offices provide a wide range of services that include handling travel information questions, complaints, or commendations as well as serving as the point of contact for customer claims relating to accidents or injuries.

Metro DF in Brasília solicits customer input with suggestion boxes located throughout the stations and also mails surveys, on a regular basis, to customers to learn about user habits, expectations, and opinions. In addition, an Office of Management of Community Operations receives complaints and makes information available on routes and timetables.

#### *Customer-Friendly Design*

Throughout São Paulo, the bus and rail services are made as convenient as possible for the public to use. Pictographs, rather than text, are used whenever suitable to ensure that directions and instructions can be understood by everyone, including tourists who do not speak the local language and people who are illiterate.

In São Paulo, the design of some bus shelters is angled toward the oncoming bus. This design enables



**Figure 22** A suggestion box in Brasília metro station.

passengers to see oncoming buses and is particularly useful at stops served by multiple routes. The design also enables drivers to easily see if there are passengers waiting. The design is also popular with advertisers as it enables a larger advertising panel to be visible to passing motorists and bus passengers.

### *Branding*

To help the public understand the different types of bus service operating in São Paulo, the buses are branded. Each bus has the route schematic painted on both sides showing all the stops.

## **ACCESSIBILITY**

Brazil's most recent census, completed in 2000, showed that 14.5% of the population has some type of disability. The 26.5 million people represented by that percentage do not include the entire population



**Figure 23** Angled shelters to improve customer and driver visibility.

with mobility restrictions. For instance, Brazil has a large population of people over 50 years old who have significant mobility impairments due to polio; however, they are not considered disabled.

Brazil's elderly population is growing at two-and-a-half times that of the younger generations. Currently, 8.5% of the population is elderly. By 2025, 15% of the population will be over 60 years of age, according to current estimates.

Passengers with disabilities account for 8% to 10% of the total São Paulo Metro ridership with approximately 180,000 such passengers using the metro system per year. Brasília's population includes 14% persons with disabilities and 9% persons who are elderly.



**Figure 24** The route schematic branded on a bus.

## Brasil Acessível

As part of Brazil's overall urban development policy, and in an effort to acknowledge the existence of a mobility crisis in public transit, the Secretaria de Transporte e da Mobilidade Urbana (SeMob) created Brasil Acessível (Accessible Brazil), a program designed to specifically address access issues. Brasil Acessível outlines a three-stage approach for municipalities to follow. The first stage entails training personnel, diagnosing local problems, and examining legislative issues. The second phase requires the municipalities to draft mobility plans encompassing necessary changes specific to their localities. The final stage involves the development of projects and the implementation of the mobility plans specific to each municipality. In addition, the SeMob plans to assist local governments in providing training, drafting directives, conducting research, implementing a national database, creating new sources of funding, and disseminating best practices.

## Centro de Video Independente

In addition to the federal government, a national, private, non-profit organization, Centro de Video Independente (CVI), works diligently to improve the lives of persons with disabilities. There are 22 offices of CVI located throughout Brazil with the goal of achieving accessibility in urban transit as well as buildings and other infrastructure. The CVI began its efforts in 1992, when the city of Rio de Janeiro began developing the Copacabana oceanfront area. Original plans did not include ramps or sidewalk cuts for persons with disabilities. As a result, the CVI volunteered to provide complimentary blueprints for the project. Since this was the first major undertaking relating to universal access design, experts from around the world were brought in to observe the development of the project. As a result of these efforts, a new program, Cidade do Rio, was designed to improve universal accessibility, with the main objective of removing all obstacles and barriers. As a first step, tactile signage has been installed on sidewalks to improve access for persons with disabilities.

By 1995, little had been done to make the bus system accessible so the CVI filed a lawsuit against the bus companies using a 1978 congressional amendment that required all new buses be handicapped accessible by 1987. Although this legislation existed, there was minimal compliance since no penalties ex-

isted for non-compliance. CVI won the court case. By 2002, however, only 14 out of 9,500 buses were handicapped accessible.

## Individual Programs

As a result of a presidential commission that partners CVI-Rio and the Institutos Para Cegos (Institute for the Blind), Riotrilhos has begun an aggressive program to improve accessibility for persons with disabilities.

Brasília has formed a successful strategic alliance with Brasil Acessível. In a recent national survey, Brasília was rated first for providing accessibility to its metro passengers. The accessibility issues addressed in the survey included handicapped-accessible mobility areas, visual cues, adaptable accessibility for the hearing impaired, and traditional accessibility features such as elevators and ramps.

As part of the Transantiago plan to modernize the city's public transportation system, future projects include the addition of articulated buses with low floors. All the new buses will have designated areas for wheelchairs. In a departure from the current policy, this equipment will be paid for by the federal government to guarantee compliance.

## Innovations

### *Pre-stop*

To accommodate passengers who need more time to board, there is a pre-stop at the Diadema sta-



**Figure 25** The pre-stop at the Diadema station in São Paulo.

tion in São Paulo. The buses pull up to a designated area where passengers alight. Passengers with disabilities, who are elderly, and/or who are pregnant are then allowed to board the bus. The bus then pulls ahead to a second designated location where the other passengers board.

### *Free/Discounted Fares*

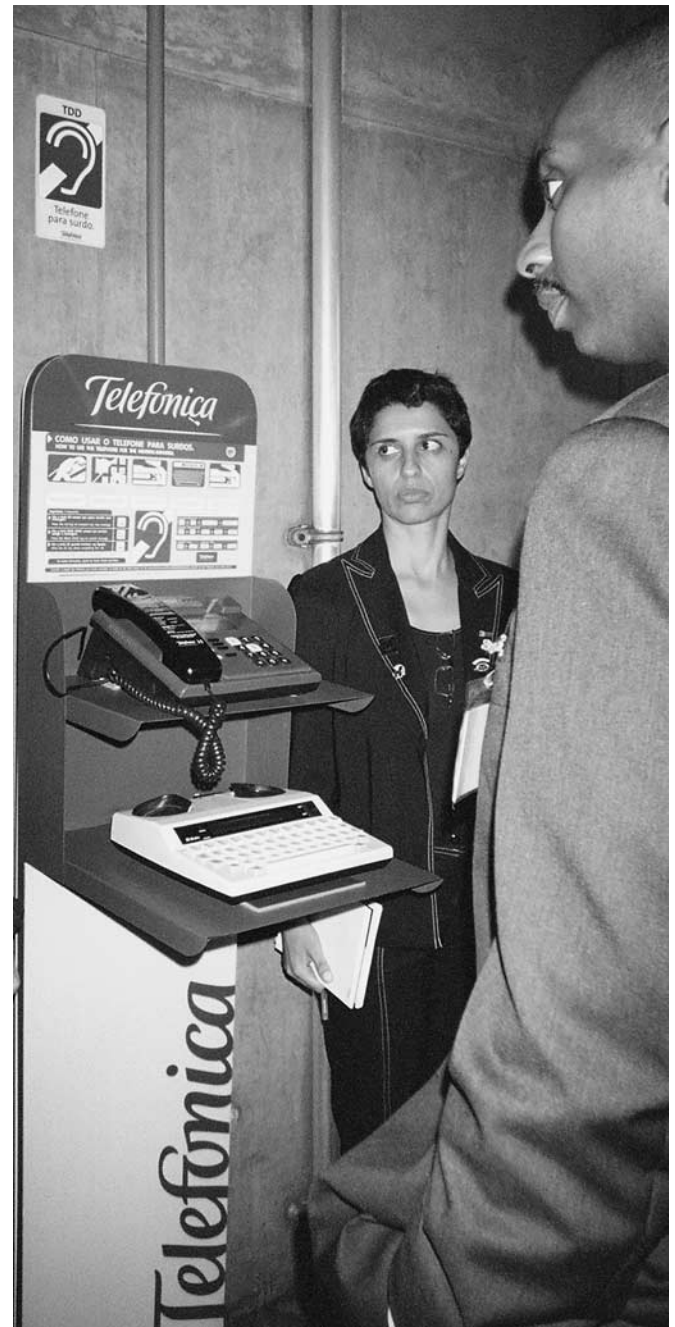
In 1993, São Paulo Metro began to issue free tickets to the disabled who meet the criteria defined in guidelines established by the state Secretaria da Saude (Health) and Secretaria dos Transportes (Transportation) and based on the International Code of Diseases. This program was modeled after the free access program for senior citizens (age 65 and older) implemented by Metro in 1987. As in Brazil, to make sure that transportation is affordable, all senior citizens and persons with disabilities are offered free transit services on buses and metro in Santiago. The federal government reimburses all operators for providing free rides. In Quito, discounted fares are given to senior citizens and persons with disabilities.

### *Station Improvements*

São Paulo Metro has installed a special ticket distribution counter for persons with disabilities at the Tatuape station as well as telecommunication devices for the deaf (TDDs) at the Santa Cruz and Villa Mariana stations. Modifications have also been made to some public restrooms. Tactile flooring and signage has been improved, and elevators have been installed in many of the stations.

Metro Rio is in the process of retrofitting existing stations. Planned improvements as well as those currently in progress include external accessible routes with ramps and double handrails leading to the stations, visual and tactile signage at the top and bottom of stairs, accessible information desks, service doors at turnstile lines, foldable platforms and special equipment for curved stations to bridge the gap between the platform and the train, intercoms with security lenses at the top and bottom of stairways, vertical lifts, escalators with platforms for wheelchairs, and stairway lifts with foldable chairs.

Metro de Santiago is beginning the process of renovating the stations to make them accessible. On Line 5, the last two stations were designed to accommodate passengers with disabilities. Plans are in development to retrofit Lines 1 and 2 to improve accessibility by the end of 2005.



**Figure 26** A TDD located at a station in São Paulo.

In Quito, all bus stations have ramps and banister rails that allow passengers with disabilities unrestrained access to the Trolebús system.

### *Training*

São Paulo Metro conducts internal layout recognition training sessions at stations throughout the metro system for the visually impaired. Refresher courses on how to transport wheelchairs on escalators

have been provided to almost 2,000 employees. Special training on how to assist people with mobility impairments and other accessibility issues is provided to Metro DF employees who have direct contact with customers. This training also includes teaching the employees sign language. Currently 150 to 200 employees have completed the training.

### Escorts

Throughout Brazil, station attendants help people with disabilities navigate systems that are otherwise not fully accessible. In the São Paulo metro system, attendants greet people with disabilities and assist them in the stations. After helping them board the trains, the attendants call ahead to the destination station with detailed information about where to meet the alighting passenger. This low-technology solution ensures that passengers with disabilities reach their destinations safely.

Metro de Santiago provides attendants to assist passengers on Line 5. The attendants assigned to this line are part time or outsourced.

### Designated/Reserved Seating Areas

In all the systems visited, designated areas for wheelchairs are located inside the front cars of the metro trains, and passengers with disabilities use the second door to enter and exit, allowing them to avoid the crowds. In Rio de Janeiro, priority seating is given to senior citizens and passengers with disabilities who wait on train platforms where the first car stops. All Trolebuses have special designated areas that are reserved for wheelchairs, and priority seating is provided for others with mobility concerns such as ambulatory passengers with disabilities, passengers who are elderly, and passengers who are pregnant.

### Vehicle Design

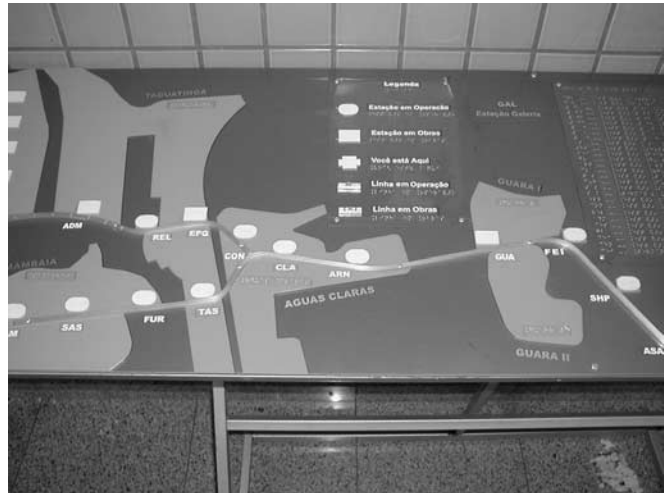
Large, wide doors on all metro rail cars in São Paulo, Brasília, and Santiago make entry and exit easier for senior citizens and passengers with disabilities. In Quito, the Trolebuses are equipped with ramps that deploy onto raised curbs allowing wheelchairs easy access to the bus. Future plans for trains in Rio de Janeiro include warning bells and flashing lights to indicate the doors are closing.

### Tactile Maps

In Brasília, the metro system has a Braille tactile map that depicts not only existing stops and lines,



**Figure 27** A wheelchair ramp in operation on a Trolebús in Quito.



**Figure 28** A Braille tactile map in Brasília.



**Figure 29** Braille etchings on handrails to help the visually impaired navigate the stairs in Santiago.



but also planned additions to the system using different textures. The existing lines are represented by metal strips, while planned lines are indicated by metal strips that are scored at regular intervals. In Santiago, Braille etchings on handrails help the visually impaired navigate the stairs.

## APPENDIX A—STUDY MISSION TEAM MEMBERS\*

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\* Titles and affiliations are at the time of the mission.

## APPENDIX B—STUDY MISSION HOST AGENCIES/COMPANIES

### São Paulo, Brazil

Empresa Metropolitana de Transportes Urbanos (EMTU)

Companhia do Metropolitano do São Paulo (Metro)

Companhia Paulista de Trens Metropolitanos (CPTM)

Secretaria de Transportes Metropolitanos (SMT)

### Rio de Janeiro, Brazil

Companhia de Transportes Sobre Trilhos do Estado do Rio de Janeiro (Riotrilhos)

Opportrans Concessão Metroviária S.A. (Opportrans)

### Brasília, Brazil

Ministerio das Cidades (MoC)

Companhia do Metropolitano do Distrito Federal (Metro DF)

DF Trans

### Santiago, Chile

Secretaria Interministerial de Planificación de Transporte (Sectra)

Transantiago

Metro de Santiago

### Quito, Ecuador

Unidad Operadora del Sistema Trolebús (UOST)

## APPENDIX C—LIST OF ABBREVIATIONS

AVL	Automatic Vehicle Location
AVM	Automatic Vehicle Monitoring
BNDES	Banco Nacional de Desenvolvimento Econômico e Social
BRT	Bus Rapid Transit
CPTM	Companhia Paulista de Trens Metropolitanos
CVI	Centro de Video Independente
EMME2	An interactive transportation planning package
EMSAT	Empresa Metropolitana de Servicios y Administracion del Transporte
EMTU	Empresa Metropolitano de Transportes Urbanos
FAS	Financial Administration Services
IT	Information Technology

LED	Light Emitting Diode	SeMob	Secretaria de Transporte e da Mobilidade Urbana
MoC	Ministerio das Cidades		
Opportrans	Opportrans Concessão Metroviária, S.A.	SMT	Secretaria de Transportes Metropolitana
ORCA	Operadores Regionais Coletivos Autonomos	SMTU	Superintendencia Municipal de Transportes Urbanos
PITU 2020	Plano Integrado de Transportes Urbanos	START	Strategic and Regional Model
Riotrilhos	Companhia de Transportes Sobre Trilhos do Estado do Rio de Janeiro	TDD	Telecommunication Device for the Deaf
		UOST	Unidad Operadora del Sistema Trolebús



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