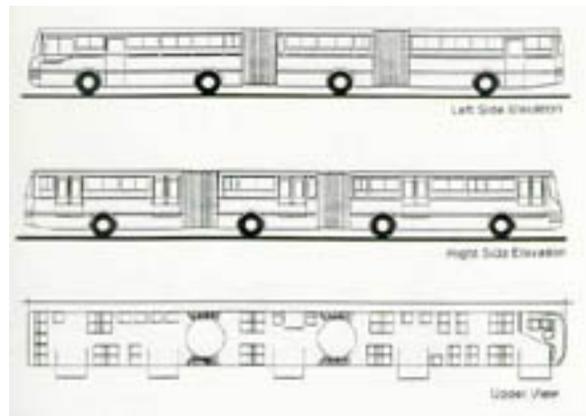

Bus Rapid Transit in Curitiba, Brazil

An Information Summary

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• December 11, 2004



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INTRODUCTION

The transit system in Curitiba, Brazil, has attracted worldwide attention for remarkable accomplishments with limited resources. In the U.S., Curitiba has become the veritable poster child for “bus rapid transit.” However, the most recent news is less than favorable: traffic is declining, a “vicious cycle” of fare increases has set in, a monorail project has been canceled owing to lack of financing, and the city has announced that it will study replacement of buses with “electric tramcars” – that is, surface light rail transit (LRT) – on the two busiest busways. Curitiba’s mayor announced in 2003 that the *Metrô Leve* (“Light Metro”) project would proceed. The purpose of this paper is to summarize available information and provide references and links.

This paper was not written as a critique. However, the author does state what he believes to be true when appropriate. A good place to start: it is clear that definitive information on virtually all aspects of transit planning, operations and management has been published. Few if any significant details of operations or finances are kept secret, as evidenced by citations found in the references below. The principal impediment to the flow of information appears to be the language barrier: Recent events (in the Middle East) have highlighted the disadvantages that Americans face with regard to information not available in English. It seems fair to say that few Americans, other than those of Portuguese or Brazilian ancestry, have a working knowledge of Portuguese (or are aware that Brazilian Portuguese differs considerably from that of Portugal). Much information of interest on public transportation in Curitiba is available only in Portuguese, in reports and documents that are probably circulated only in Brazil, and then, perhaps only in Curitiba.

The author hopes that others with information and statistics on Curitiba's transit system will share their findings as the author has done here.

I. CONTEXT: THE COUNTRY & CITY

Curitiba is a clean, attractive city that enjoys significantly higher per-capita income than the national average. However, important national indicators contrast sharply with those associated with the U.S. and Canada.

Table 1.	GDP Per Capita (1999) US Dollars	Passenger Autos per Thousand People	Central Government Expenditure Per Capita (1993) US Dollars
Brazil	\$6,300	81	\$949
Canada	\$21,700	429	\$4,568
United States	\$30,200	476	\$5,744

Sources: *New York Times World Atlas - 2000. The Illustrated Book of World Rankings*; Armonk, NY: Sharp Reference, 1997. *Statistical Abstract of the World*, Detroit: Gale Research, 1996.

Figure 1.

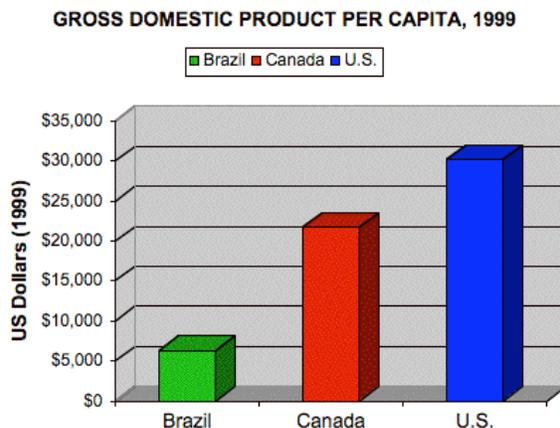
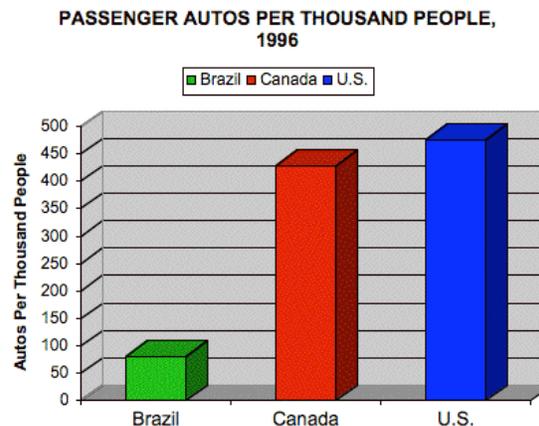


Figure 2.



In terms of "purchasing power parity," U.S. income per capita was 5.6 times that of Brazil at 2000 (CIA World Fact Book; see:

<http://www.cia.gov/cia/publications/factbook>.

GDP per capita was 40 percent greater in Mexico than in Brazil at 2000. Personal income is distributed very unevenly in Brazil; about 25 percent of the population must survive on U.S.\$1

per day or less. Few if any "industrialized" countries have a less-equitable distribution of personal income. According to the U.S. State Department, the "top" 10 percent earns 48 percent of the national income. An estimated 17 percent of the workforce nationwide earns less than the legal minimum of \$105 per month (less than \$1,300 per year). In Curitiba, bus operators earns \$630 per month (\$7,560 per year).

http://gulliver.trb.org/publications/tcrp/tcrp_rrd_33.pdf (large file, 3.8 MB).

There is no worker's compensation and no risk management. Brazil also has a high illiteracy rate, estimated at 17 percent.

Seventy-five percent of all Brazilian households earned \$375 or less per month. In Curitiba, 79 percent of households earned between \$75 and \$750 per month; only five percent earned less than \$75 per month compared to 18 percent for the country overall. Curitiba's household income distribution was similar to that of São Paulo, Brazil's largest city (Rabinovich and Hoehn).

According to the official website of the city government, Curitiba's annual "Gross Internal Product" is US \$12.1 billion a year, and the annual income per capita is U.S.\$8,000, significantly higher than the \$5,000 national average for Brazil.

<http://www.curitiba.pr.gov.br/pmc/ingles/Cidade/Perfil/index.html>

The 1996 Gross Internal Product for the metropolitan region at U.S.\$17.69 billion.

http://www.curitiba.pr.gov.br/pmc/ingles/Desenvolvimento/domestic_product.html.

Brazil, a very large country with a low population density, is almost tailor-made for road transport. More buses are built in Brazil than in any other country. Wages are low and the country produces much of the petroleum it consumes. Although it strives for self-sufficiency in petroleum, Brazil must import more than 40 percent of its oil, mostly from Argentina and Venezuela. This is down from 75 percent during the early 1970s.

<http://www.fe.doe.gov/international/brazover.html>

<http://216.239.57.104/search?q=cache:CpGcplEH0gwJ:www.planetark.com/dailynewsstory.cfm/newsid/16520/story.htm+&hl=en&ie=UTF-8> (Google cache).

As one of the handful of nations that produces a large agricultural surplus, Brazil is able to "trade" cheap labor for oil on a large scale. Few if any other countries can do this. Ethanol produced from sugar cane provides a remarkable share of the country's motor fuel. The sugar cane industry produces 3.4 to 3.7 billion gallons of ethanol for automobiles per year. Under a

government program began partly in response to the 1973 energy crisis, and partly to promote self-sufficiency, all gasoline sold in Brazil is blended with ethanol. The percentage of ethanol is mandated by law (about 20 percent), and subsidies are provided so that pump prices remain competitive. In other countries, fertilizer production, ethanol extraction and ethanol purification consume significant quantities of energy. This is not the case in Brazil, where much of the work is performed by hand.

<http://www.eia.doe.gov/emeu/cabs/brazenv.html#ethanol>.

At one time, most new cars sold in Brazil burned pure (hydrous) ethanol (*álcool*). However, shortages and soaring prices caused the market for new ethanol-fueled cars to collapse at the end of the 1980s. The sugar-cane industry is lobbying for a new alcohol-fuel program.

<http://www.climateark.org/articles/1999/alcocaro.htm>.
<http://216.239.57.104/search?q=cache:CpGcplEH0gwJ:www.planetark.com/dailynewsstory.cfm/newsid/16520/story.htm+&hl=en&ie=UTF-8> (Google cache).

Curitiba placed 30 biodiesel-fueled buses in service in December 2000, following a testing program with two prototypes. These burn a mixture of diesel fuel containing 11.2 percent anhydrous ethanol and 2.6 percent of an additive derived from soy oil. Although the biodiesel vehicles emit 43 percent fewer particulates than buses using conventional diesel fuel, carbon dioxide emission is reduced by only 0.7 percent and the biodiesel fuel damages electronic fuel-injection systems. Nonetheless, the city hopes to convert all of its buses to biodiesel.

<http://www.tierramerica.org/2001/0304/article.shtml>.

Brazil had just 14 million passenger cars in 1999, compared to 130 million in the U.S. The number of passenger cars in Brazil was just a bit more than in Canada -- which had less than 20 percent of Brazil's population. About four million cars, slightly less than 30 percent of the total fleet, burned pure ethanol.

<http://www.consumerenergycenter.org/transportation/afv/ethanol.html>.

Curitiba's city government has a well-deserved attention for managing urban problems with creative strategies making the best use of limited resources. Among the city's most striking successes are those related to coordination of public transportation and land use. Curitiba has accomplished this to a degree to which most U.S. and Canadian cities can only dream. To some extent, then, the commentary below is unduly dismal.

"Curitiba is a system which provides a third-world solution to a third world problem . . . not to entice passengers out of their cars but rather to provide basic public transport for an impoverished population" (unsigned editorial, *Transit Australia*, February 1999).

However, the fact remains that Curitiba's public transport services are relatively labor-intensive, fuel-intensive and slow. Such a system would not fare well if it had to compete against the transport choices available to consumers in high-wage countries.

2. THE CITY – ADDITIONAL DETAILS

Curitiba's population grew from 140,000 in 1940 to 500,000 in 1965, when a new master plan concentrating growth in five radial corridors (*eixos*, or "axes"), including busways (*canaletas*), was adopted. High-rise buildings were limited to a four-block strip on either side of the busway axes. The *sistema trinário* ("trinary" or "trinitarian" system) axes were built on rights-of-way set aside under a 1943 plan to create Paris-style boulevards (Cervero). See also:

<http://www.curitiba.pr.gov.br/pmc/ingles/Cidade/Historia/planoagache.html>

By 1980, the city had 1.29 million people and the *Região Metropolitana* ("metropolitan region") had nearly two million (Herbst). The current (2002) population is 1.5 million.

<http://www.curitiba.pr.gov.br/pmc/ingles/Cidade/Perfil/index.html>

According to the city's official website, the metropolitan region includes 25 municipalities having a total population of 2.42 million.

<http://www.curitiba.pr.gov.br/pmc/ingles/Cidade/Regiao/index.html>

<http://www.curitiba.pr.gov.br/pmc/ingles/Desenvolvimento/population.html>

Therefore, 38 percent of the metropolitan-area population is housed outside of Curitiba, a slight increase from the 1992 figure, 35 percent (implied by Smith and Hensher).

Population-density statistics for the "metro" area, reported by Smith and Hensher, are contradictory. The 1991 metro-area population is stated at 1.98 million, and the population density is stated at 567 per sq km. This implies a land area of 3,492 km² – but this is much smaller than the 8,763 km² stated for the "metro area." If the smaller figure refers to the "built-up area" – which available information does not confirm or disprove – and the size of the built-up area has not changed, then today's metro-area population density would be 693 per km² (1,800 per

mi²). This statistic suggests that greater Curitiba has a large quantity of undeveloped land outside of the city boundary.

The notorious shantytowns (called *favelas*, *mocambos*, or *alagados*, depending on the region) which stand at the edge of large Brazilian cities (and are said to completely surround the capital, Brasilia) are also found at the periphery of Curitiba:

"[Curitiba] has its share of squatter settlements, where fewer than half the population is literate" (Meadows).

In Brazil, the "well-off" (high-income residents) have historically sought to live as close to the city center as possible, in order to be near the cathedral and other amenities. Employment and retailing have not been dispersed to suburban locations as in the U.S. The high-rise housing along the "trinary" axes is occupied by middle- and upper-income residents. As typical in Brazil, lower-income workers live primarily in outlying areas and account for a large share of transit passengers. To serve this market, Curitiba added Direct (popularly known as *Ligeirinho*, = "Speedy" or "Speedybus") services on one-way streets parallel to the busways, which were too slow and served a more affluent population.

A number of factors, including highly-integrated land-use and transit planning, gave rise to an urban form very different from U.S. and Canadian cities (Parsons Brinckerhoff). Curitiba's transit services were developed concurrently.

Employment was concentrated in two centers: retailing in the historic downtown, and industrial development in the *Cidade Industrial de Curitiba* ("Curitiba Industrial City," or CIC) about three km (two miles) away (Smith and Hensher).

Curitiba's land-use controls encourage development of the highest population densities along the structural axes. Between 1970 and 1978, Curitiba's overall population increased by 73 percent, but along the five axes, it increased by 120 percent. "By 1992, almost 40 percent of Curitiba's population resided within 3 blocks of the major transit arteries."

<http://www.fta.dot.gov/brt/issues/pt3.html>

Sources disagree about the city's land area and population density, but most differences are minor. The International Council for Local Environmental Initiative states the "city" area at 432 km². (It also states the "municipal budget," presumably the annual budget, at \$500 million.) The "city" population density, based on the most recent population figure, is 3,500 per km² (9,000 per sq. mi.).

<http://www3.iclei.org/localstrategies/summary/curitiba2.html>

The city had 1,276,000 people at 1985, when it included 434 km² (167 sq. mi.) of land. The structural axes, 1.6 percent of the city's land, housed 5.7 percent of the population (about 20,000 people), and this population had increased by 98 percent between 1980 and 1985. The structural axes and the surrounding residential areas occupied less than seven percent of the land but housed almost 20 percent of the population, implying a population density of 9,400 per km² (24,000 per sq. mi.). Overall, about 75 percent of Curitiba's population lived on 41 percent of its land (Rabinovich and Hoehn).

Various

Table 2.	Kilometers/Hour	Miles/Hour
São Paulo	24.1	14.9
Rio de Janeiro	30.0	18.6
Mexico City	22.5	13.9
Caracas	18.0	11.2
New York	38.5	23.9
Madrid	35.1	21.8

sources report that Curitiba has a high level of auto ownership for Brazil: "One car for every 3 people."

<http://www.dismantle.org/curitiba.htm>

"Over 500,000 private cars in Curitiba, one for every 3 people"

<http://www.sage-rsa.org.uk/sage>

This implies 333 cars per 1,000 residents, far lower than Los Angeles (U.S.), which has more than 500 cars per 1,000 residents.

Smith and Hensher state that the urban area had 562,000 registered "motor vehicles," or more than one car per household. This implies that four percent of all autos registered in Brazil are in Curitiba, which had less than one percent of the country's population (at 1990). "More than one car per household" implies that the average Curitiba household has little more than two people, which seems low.

Gasoline use is reported to be 30 percent less per capita than eight comparable Brazilian cities.

<http://www.dismantle.org/curitiba.htm>

"Twenty-eight percent of express bus users previously traveled in their cars, which translates into savings of up to 25 percent of fuel consumption city wide.

<http://www.rec.org/REC/Programs/SustainableCities/Transportation.html>

A 1991 estimate credited transit with a reduction of 27 million auto trips, saving 27 million litres of fuel. This implies an average of one litre per auto trip, which also seems low. In the U.S., urban auto trips are longer, on average, than urban transit trips. This may, or may not, be true of Curitiba; sources consulted by the author provided no information.

A 2003 news release by the Curitiba municipal government refers to a study, "The Millenium Cities Database for Sustainable Transport," by the International Union of Public Transport (UITP), Brussels. It states that Curitiba's transit system has a positive impact on traffic congestion. Average road traffic speeds were stated at 40 km/h (25 mph) in Curitiba, compared to:

Private transport costs are lower in Curitiba than elsewhere. The aggregate cost of private transport in Curitiba is stated at 10.8 percent of regional economic output ("Crude Internal Product"), compared to 17.1 percent for São Paulo. Aggregate public transport costs for Curitiba were stated (according to UITP) at 1.45 percent of crude internal product.

(Prefeitura Municipal de Curitiba, RIT transportou 84 mil pessoas a mais no Dia sem Carro, September 29, 2003.)

<http://www.curitiba.pr.gov.br/Noticia.aspx?not=2177>

3. CURITIBA TRANSIT SYSTEM DETAILS

Transportation and land-use planning in Curitiba is closely coordinated. The regional planning organization is the *Instituto de Pesquisa e Planejamento Urbano de Curitiba* (IPPUC, = Curitiba Institute of Research and Urban Planning), founded in 1965.

Curitiba's transit system is managed by the *Urbanização de Curitiba* (URBS, = "Urbanization of Curitiba"), owned privately but managed publicly. URBS administers publicly-owned transport infrastructure, contracts with private companies that operate the buses and monitors their performance. URBS establishes schedules and service standards, sets fares, collects revenues and distributes payments to the private companies (Rabinovich and Hoehn).

At 1995, the ten operating companies and their fleet sizes were:

Table 3. Curitiba Operating Companies

Operating Company	Buses Operated
Auga Verde	119
Carmo	209
Cidade Sorriso	205
Cristo Rei	138
Curitiba	96
Gloria	203
Luz	126
Marechal	117
Merces	61
TOTAL	1,274

Routes operated by some companies were concentrated in specific areas of the city, but some routes were shared by more than one company (Rabinovich and Hoehn).

The fleet size at 2004 was reported at 1,800 vehicles (PMC 2004.) This evidently refers to the (annual average) maximum number of vehicles in service. A 2003 report states that RIT possesses a fleet of 2,200 buses (*Prefeitura Municipal de Curitiba, RIT transportou 84 mil pessoas a mais no Dia sem Carro*, September 29, 2003).

<http://www.curitiba.pr.gov.br/Noticia.aspx?not=2177>

The most important component of the transit system is known collectively as the *Rede Integrada de Transporte* (RIT, "Integrated Transport Network"). This was established in 1980. Some bus services are not considered part of the RIT; that is, they are not "integrated" with other services.

Curitiba's five major transit corridors, or *Eixos* ("Axes") are:

Boqueirão (southeast), to Boqueirão.

Norte [North], to Santa Cândida.

Sul [South], to Pinheirinho.

Leste [East], crossing the city boundary to Pinhais, with a branch to Centenario.

Oeste [West], to Campo Comprido.

http://www.curitiba.pr.gov.br/pmc/a_cidade/Solucoes/Transporte/rit.html

These total 72 km (45 mi). A small map showing these corridors is available online at

http://www.solutions-site.org/cat7_sol110.htm

The reported route length at 2004 was the same as stated above (PMC 2004).

Municipal planners began studying creation of exclusive alignments (*canaletas*) for public transit services – worked by *bondes*, or electric tramcars – from 1964 (PMC 2004). At the time, Brazil had no "modern" urban tramways or LRT lines, but planners were well aware of developments in Europe.

(Readers interested in the subject of Latin American urban transport in general, and Brazilian tramway history in particular, are referred to the superb *Electric Transport In Latin America* website by Allen Morrison:

<http://www.tramz.com>

(Morrison's 1989 book, *The Tramways of Brazil – A 130-Year Survey*, is available online but without the maps and photographs that appeared in the print version.

<http://www.tramz.com/br/tto/01.html>

Curitiba's town tramway, which at 1945 had 38 km (24 mi) of meter-gauge track worked by 38 cars, was closed in 1952.)

<http://www.tramz.com/br/tto/6PR.html> .)

Planners eventually realized that Curitiba did not have the resources to develop a high-capacity LRT or metro network. A "more serious" study, outlining *ônibus* (buses) rather than *bondes* in the planned *canaletas*, began in 1968. Implementation began under the leadership of Jaime Lerner, who was appointed Mayor of Curitiba in 1971 (PMC 2004).

The first busway corridor, the North-South axis, was completed in 1974 and extends 20.0 km (12.4 miles; Smith and Hensher). The Boqueirão corridor was completed in 1977.

The dedicated busways are now worked by 25-meter (82-foot), three-section, four-axle *ônibus biarticulados* ("bi-articulated" or "double-articulated" buses). These vehicles, built for high-platform loading, are colloquially known as *biarticulados*. The first group of 33 entered service in 1992 on the Boqueirão route (Rabinovich and Hoehn describe Boqueirão as a "high demand, lower income district"). The North-South axis received 66 *biarticulados* in 1995. Twenty *biarticulados* began working the *Circular Sul*, a circular route linking Boqueirão with the industrial zone, in 1999. In 2000, 53 *biarticulados* were placed on the upgraded East-West axis.

At 2004, the number of *biarticulados* was stated at 164 (PMC 2004).

At 1997, Curitiba had several categories of bus service:

<http://www.busesintl.com/news/dec97newsletter.html>

--*Convencional* ("Conventional). There are two groups of Conventional lines. One group, including six routes, connects downtown Curitiba to districts and terminals located away from the axes. There are also 86 "traditional" conventional bus routes that are not part of the RIT.

--*Alimentador* ("Feeder") routes, which link residential areas to various terminals. At 1995, there were 111 feeder routes (Rabinovich and Hoehn).

At 1997, Conventional and Feeder routes were worked by 660 buses and carried 675,000 passengers per day.

--"Executive," a niche service with two lines worked by seven minibuses, carrying 4,200 passengers per day.

--*Interbairros* ("Interdistrict"), seven express peripheral routes worked by 127 buses.

The first *Interbairros* services were started in 1979. At 2004, the number of *Linhas Interbarrios* was stated at five (PMC 2004).

--*Directo* ("Direct," also known as *Ligeirinho*, = "Speedy" or "Speedybus"), developed from 1989. These operate on one-way streets parallel to the busway axes and on other high-demand routes, stopping only at terminals or tube stations where floor-level platforms are provided, 13 lines worked by 180 buses.

(A news release dated 2004 states that the first Speedybus services were started in 1991. PMC 2004.)

--*Expresso* ("Express"), the core of Curitiba's transit system, including 13 routes at 1995 (Rabinovich and Hoehn). There were two distinct groups of Express lines until 2000:

1.) *Expresso Articulado* services, worked by 95 double-articulated buses (biarticulados). These served the South, Boqueirão and North corridors. These services carry more than 320,000 passengers daily.

2.) The east-west corridor (with branches) was worked by 43 single-articulated buses, which carry nearly 100,000 passengers per day. These services did not have high platforms. This corridor was upgraded subsequently as the *Eixo Leste – Oeste* with 72 tube stations and 53 bi-articulated buses.

http://www.curitiba.pr.gov.br/pmc/a_cidade/Solucoes/Transporte/lesteoeste/index.html

Other bus services:

City center routes, working a two-way, reduced-fare circular line in downtown Curitiba. Since the lines were intended for short-distance travel, they were worked by minibuses having no seats.

Neighborhood routes, minibus routes serving two "close-in" neighborhoods (Portão and Xaxim) that have sufficient local traffic to justify such service.

Night routes, which operate every hour between 1 and 5 a.m. The 17 Express, Feeder, and Conventional night routes are designed to be no more than one km apart.

Special-education routes, serving physically or mentally disabled students. Operation of the 27 routes is subsidized by the RIT, but assistants are paid by parents.

"Pro-park" routes, three Sunday-only services which connect downtown Curitiba to major parks (Rabinovich and Hoehn).

At 2004, the total number of RIT routes was stated at 385, and the total number of daily services (vehicle-trips) was stated at 21,000 (PMC 2004).

Figure 3. Typical Tube Station



There are currently 21 terminals (*Terminais*), where passengers may transfer between routes, and 351 of the distinctive "tube" stations (*Estações-Tubo*) that provide high-platform boarding. Passengers pay their fares to a conductor, stationed near the entrance, and pass through the turnstile. Tube stations also have small lifts to provide easy access for handicapped passengers, and those with baby strollers or large parcels.

<http://www.curitiba.pr.gov.br/pmc/ingles/Solucoes/Transporte/index.html>

<http://www.scroll.demon.co.uk/brazil/curi70.htm>

(The same number of *terminais urbanos* and *estações tubo* as above was reported at 2004. PMC 2004.)

"Transfers are accomplished at terminals where the different services intersect. Transfers occur within the prepaid portions of the terminals so transfer tickets are not needed. In these areas are located public telephones, post offices, newspaper stands, and small retail facilities to serve customers changing buses."

<http://www.fta.dot.gov/brt/issues/pt3.html>

The different categories are designed to complement one another, but the overall network resembles the classic "trunk-feeder" pattern and is not set up to maximize the number of "one-seat" trips. The RIT, once confined mostly to the city proper (Smith and Hensher) now serves eight surrounding municipalities, and carries 250,000 passengers each day who either live or work outside of Curitiba.

<http://www.curitiba.pr.gov.br/pmc/ingles/Solucoes/Transporte/index.html>.

At 2004, 13 of the 25 municipalities surrounding Curitiba were served by the RIT. Of these, ten were described as "fully integrated" and three as "partially intergrated" into the RIT (PMC 2004).

4. CURITIBA TRANSIT OPERATION & RIDERSHIP

Curitiba has a very high transit riding habit compared to U.S. cities. In 1991, the system carried about 230 revenue passengers per capita, and about 330 boardings (trip segments) per capita (URBS estimated that the number of boardings, or trip segments, was about 1.4 times the numbers of fares paid). This was the highest riding habit in Brazil: Belo Horizonte was second-highest with 208 revenue passengers per capita (1990). Transit services in São Paulo, Brazil's largest city, carried 158 revenue passengers per capita (1991).

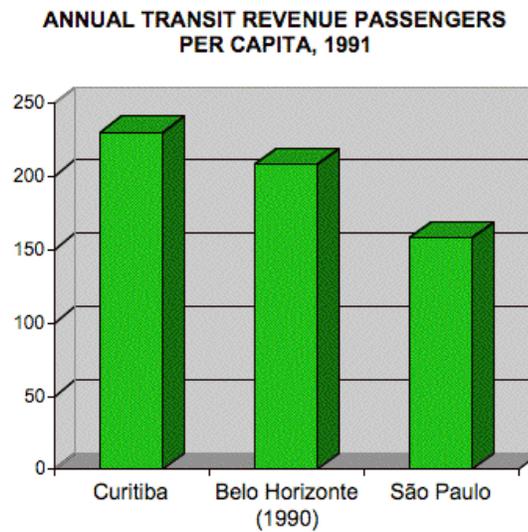
Between 1970 and 1990, Curitiba's population grew at an average annual rate of 4.9 percent. The number of transit revenue passengers grew at approximately half this rate, 2.4 percent, between 1974 and 1992. During this period, RIT ridership grew at an average annual rate of 14 per cent, while the network of conventional routes shrank and lost traffic. After 1980, RIT ridership growth reflected increases in feeder, Interdistrict, and *Directo* ("Speedybus") traffic. Expansion of feeder lines to provide convenient access to the express network contributed to the near-doubling of RIT ridership between 1980 and 1989.

Speedybus services, introduced in 1991, provided time savings of up to 40 percent and created new travel opportunities (PMC 2004).

However, according to a recent report, ridership throughout the metropolitan region fell by four percent between 2000 and 2002, and the downward trend continues, according to the most recent performance data (*Gazeta do Povo, Prefeitura estuda implantar bonde elétrico nas canaletas*, August 7, 2002). At 2004, RIT carried 94 percent of transit "demand" within Curitiba and 73 percent within the urbanized area.

In 1991, Curitiba had about 1,200 km (750 mi) of transit routes (this evidently refers to "directional" route length). The annual service level worked out to 74,000 vehicle-km per km of route, or 56 vehicle-km per capita.

Figure 4.



Transit's modal share is high in Curitiba, but sources do not agree on details: "By 1989, Curitiba's bus system accounted for 70 percent of total workday trips in the city" (Birk and Zegras). But the same source also states, "1.3 million passengers is 55 percent of the total transport demand in the city." Another source states that 70 percent of Curitiba commuters use transit.

<http://www.fta.dot.gov/brt/issues/pt3.html>

These reports imply that Curitiba transit services carry 70 percent of commute trips and 55 of all trips. Another source states that transit handles a 75 percent share of commute trips

<http://www.busesintl.com/news/dec97newsletter.html>

Average speeds on Curitiba's busways are low. Brazilian cities have found that the maximum volume that can be carried at an average speed greater than 19 km/h (12 mph) is 11,000 passengers per hour per direction (phd), as in Curitiba (Hensher). If the busway operator attempts to carry higher volumes, then the operating speed drops toward the level of the surrounding traffic flow (in the "regular" lanes flanking the busway). São Paulo and Curitiba planed to carry 22,000 phd at speeds exceeding 26 km/h (16 mph), but had not yet demonstrated that this is practical.

The effect described above is familiar to anyone who drives on the freeway. As the number of vehicles on the roadway increases past a certain point, speed starts to drop until traffic comes to a stop. In addition, Curitiba has no traffic-signal priority for transit buses (White); other sources state the opposite.

An American transit planner/marketer with more than 30 years of experience questions whether the hourly passenger "volumes" reported for Curitiba busways, and others in Brazil, are in fact "flows" or "flow rates."

"Volume" refers to a count of the number of passengers transported past a fixed point during a one-hour interval. A "flow rate" is based on a count during some other interval, scaled up to an hourly rate. Thus, "10,000 phd" might be based on 10,000 persons during a 60-minute interval – or 833 persons during the busiest five-minute interval, scaled up to a "per hour" rate. The author believes this is the case with reference to Ottawa, where the maximum hourly passenger "volume" carried along "Transitways" (busways) ranges from 3,400 to 4,700 phd, or 45-70 percent below the published "maximum" figure. Additional information is available at:

www.carquinezassociates.com/ptlibrary/modalcapacity5.htm

As outlined below, the reported maximum hourly "volumes" for Curitiba imply 250-300 passengers per vehicle – on average – during the busiest hour. These figures appear implausibly high; this in turn suggests – but does not establish – that actual maximum "volumes" in Curitiba are significantly lower than implied by the reported statistics.

Average transit operating speed in Curitiba fell by ten percent between 1992 and 2002, according to a local news report (*Gazeta do Povo, Prefeitura estuda implantar bonde elétrico nas canaletas*, August 7, 2002).

At 2003, the average speed of RIT bus services was stated at 22.4 km/h (13.9 mph). This was compared to:

The average speed for *Directo* (Speedybus) services was stated at 32 km/h (20 mph; *Prefeitura Municipal de Curitiba, RIT transportou 84 mil pessoas a mais no Dia sem Carro*, September 29, 2003.)

<http://www.curitiba.pr.gov.br/Noticia.aspx?not=2177>

Table 4.	Kilometers/Hour	Miles/Hour
Rio de Janeiro	14.3	8.9
São Paulo	15.4	9.6
Mexico City	16.9	10.5
Madrid	18.5	11.5
Los Angeles	20.2	12.5

Curitiba transit ridership is concentrated overwhelmingly in the five transit corridors: 80 percent of transit passengers use Express or *Directo* (Speedybus) services; only 20 percent use conventional feeder services.

<http://www.fta.dot.gov/brt/issues/pt3.html>

In 1992, services within Curitiba averaged 1,028,000 revenue passengers per workday. RIT services averaged 630,000 revenue passengers per workday and conventional services averaged 398,000 per workday (Rabinovich and Hoehn).

URBS estimated that the number of boardings was equal to 1.4 times the number of fares paid, implying 1,440,000 boardings per workday.

(Another source states: "About 1,100 buses make 12,500 trips per day, serving 1.3 million passengers.")

<http://www.dismantle.org/curitiba.htm>

At 2002, according to the city of Curitiba official website: transit services were worked by 1,902 buses which operate 14,000 daily trips totaling 320,000 km (196,000 mi) per day, and carry 1.9 million passengers per day <http://www.curitiba.pr.gov.br/pmc/ingles/Solucoes/Transporte/index.html> [this link is no longer active].

On a *Dia sem Carro* ("Day Without Cars") held on September 22, 2003, RIT services carried 1,172,000 paying (revenue) passengers, up by 84,000 from the reported annual average (1,088,022). RIT operated an additional 135 vehicles (an increase of seven percent) and 800 vehicle-trips (an increase of 3.4 percent) to carry the additional traffic. Car use was reduced by an estimated 100,000 vehicles (*Prefeitura Municipal de Curitiba, RIT transportou 84 mil pessoas a mais no Dia sem Carro*, September 29, 2003.)

<http://www.curitiba.pr.gov.br/Noticia.aspx?not=2177>

At 2004, the number of vehicle-km per workday was stated at 468,500 (= 290,500 vehicle-mi). RIT services carried 1 million paying (revenue) passengers and 2 million total passengers (boardings) per workday (PMC 2004). This implies that the number of boardings was estimated at roughly 2.0 times the number of fares paid. This in turn implies an increase in the average number of transfers per revenue passenger.

A more explicit report, dated 2003, states the average number of paying (revenue) passengers per workday at 1,130,000. The number of "exempt" or non-paying passengers (i.e. those permitted to travel free of charge) was stated at 135,000. The total number of passengers per workday was stated at 2,140,000. This implies a transfer rate of 41 percent (*Prefeitura Municipal de Curitiba, RIT transportou 84 mil pessoas a mais no Dia sem Carro*, September 29, 2003.)

<http://www.curitiba.pr.gov.br/Noticia.aspx?not=2177>

At May 1993, services within Curitiba averaged 829 revenue passengers per bus per workday; the reported figure for RIT services was 839. ("May 1993" figures are from Rabinovich and Hoehn.) This implies:

--1,240 vehicles in maximum service (annual average) systemwide.

--750 vehicles in maximum service (annual average) for RIT services.

--490 vehicles in maximum service (annual average) for "conventional" services.

At May 1993, services within Curitiba averaged 301,600 vehicle-km (187,000 veh-mi) per workday, and RIT services averaged 207,000 vehicle-km (128,000 veh-mi) per workday. This implies:

--3.4 revenue passengers per vehicle-km (5.5 per veh-mi).

--4.8 boardings per vehicle-km (7.7 per veh-mi).

--240 km (150 mi) per bus per workday systemwide.

--280 km (170 mi) per bus per workday for RIT services.

According to Rabinovich and Hoehn, the transit system employed 5,000 people (the author assumes this figure is current to 1993). This implies:

--4.0 employees per vehicle operated in workday peak-period service.

--60 workday veh-km (37 workday veh-mi) per employee.

Cervero reports that all express buses (except those working the "direct-line" routes with the "tube stations" – i.e. *Directo* or Speedybus) have two-man crews. This may be true of all Curitiba buses except those using the tube stations.

At May 1993, Express and Speedybus services accounted for 48 percent of weekday RIT vehicle-km, and 33 percent of all transit service (vehicle-km) within Curitiba.

At May 1993, express services averaged 58,000 km (36,000 mi) per workday, and averaged 1,823 revenue passengers and 2,039 boardings per bus per workday. Express services averaged 285,114 revenue passengers and 454,054 boardings per workday at 1993 (Smith and Hensher). This implies:

--156 express buses in maximum service (annual average).

--4.9 express revenue passengers per vehicle-km (7.9 per veh-mile).

--7.8 express boardings per vehicle-km (12.6 per veh-mile).

--370 km (230 mi) per express bus per workday.

At May 1993, Speedybuses averaged 41,000 km (25,000 mi) per workday, and averaged 532 revenue passengers and 1,563 boardings per bus per workday. Speedybus services averaged 71,201 revenue passengers and 209,331 boardings per workday at 1993 (Smith and Hensher). This implies:

--134 Speedybuses in maximum service (annual average).

--1.7 Speedybus revenue passengers per km (2.8 per mi).

--5.1 Speedybus boardings per km (8.2 per mi).

--310 km (190 mi) per Speedybus per vehicle.

At 1993, the average speed for express services was 22 km/h (14 mph), and that for Speedybus services was 34 km/h (21 mph; Smith and Hensher).

The author estimates the average express ride length, given that the busway corridors extend 5-7 miles from the city center, in the range of 3-4 miles.

At 1993, the South axis carried a total of 222,000 passengers per workday, 160,000 by Express and 62,000 by *Directo* (Speedybus) services (Smith and Hensher). Implied Express (busway) traffic density, based on a 10-km (6-mi) route length and a 5-km (3-mi) average ride length, was 80,000 passenger-km per km of route per workday (rounded to one significant digit). Implied Speedybus traffic density, based on a 10-km (6-mi) route length and an 8-km (5-mi) average ride length, was 50,000 pass-km per route-km per workday (one significant digit). Implied overall traffic density was 70,000 pass-km per route-km per workday (weighted average, one significant digit).

At 1993, the North axis carried 85,000 passengers per workday; this figure is for Express (busway) and parallel "Speedybus" services combined (Smith and Hensher). Implied overall traffic density, based on a 10-km (6-mi) route length and a 6-km (4-mi) average ride length, is 60,000 pass-km per route-km per workday (one significant digit).

(The average ride length estimates above represent "maximum plausible" values. Therefore, the traffic density estimates also represent "maximum plausible" values. The author notes that 80,000 pass-km per km of route = 80,000 pass-mi per mi of route.)

Service levels in the busway corridors were as follows at 2002:

--BOQUEIRÃO:

Boqueirão, 212 trips/workday trips, 5' midday service freq, max 18 veh/hr.

Circulo Sul, 128 trips/workday, 10' midday service freq, max 11 veh/hr. (This service uses part of the Boqueirão busway.)

--NORTE – SUL (North-South):

Santa Cândida (north), 286 trips/workday, 3-4' midday service freq, max 22 veh/hr.

Pinheirinho (south), 195 trips/workday, 6-7' midday service freq, max 17 veh/hr.

--LESTE – OESTE (east-west):

Pinhais (east), 133 trips/workday, 10' midday service freq, max 13/hr.

Centenario (east branch) – Campo Comprido (west):

192 trips/workday, 5-7' midday service freq, max 13 veh/hr.

5. CURITIBA PERFORMANCE STATISTICS (1993)

ALL SERVICES (SYSTEMWIDE):

- 1,440,000 weekday boardings.
- 302,000 vehicle-km (187,000 vehicle-mi) per workday.
- 1,240 vehicles in maximum service.
- 150 mi per bus per workday.
- 5,000 total staff members.
- 4 employees per vehicle in maximum service
- 60 workday veh-km (37 workday veh-mi) per employee.
- 20,000 annual veh-km (10,000 annual veh-mi) per employee.
- 0.06 employees per 1,000 veh-km (0.1 employees per 1,000 veh-mi). Estimate.
- 700 annual veh-hr per employee (1.0 employees per 1,000 veh-hr). Estimate.
- 3.4 revenue passengers per vehicle-km (5.5 revenue passengers per vehicle-mi).
- 4.8 boardings per vehicle-km (7.7 boardings per vehicle-mi).
- 20 pass-km per veh-km (= 20 pass-mi per veh-mi); annual average. Estimate.
- 300 workday boardings per employee.
- 90,000 annual boardings per employee (0.01 jobs per 1,000 boardings). Estimate.
- 500,000 annual pass-km (300,000 annual pass-mi) per employee. 0.002 employees per 1,000 pass-km (0.003 employees per 1,000 pass-mi). Estimate.

Estimates above based on assumptions of: 300 workday equivalents per year, 24 vehicle-km (15 vehicle-miles) per vehicle-hour, and average ride length per boarding of 5 km (3 mi) systemwide. Estimates rounded to one significant digit.

[The author subsequently located a source, cited above, that states the "average speed" of RIT bus services at 22.4 km/h, = 13.9 mph, at 2003.]

The Federal Transit Administration has posted comparable figures posted for systems operating "250 or more" buses, derived from 1989 data, on its website.

<http://www.fta.dot.gov/library/reference/CUTS/frchap3.htm> (Table 3-5).

The author's estimates for Curitiba were added, and errors in the FTA table ("Per 1,000 Rev. Veh. Hours," "Per 1,000 Rev. Veh. Miles" and "Per 1,000 Passenger Miles") corrected.

Table 5. BUS LABOR INPUTS PER UNIT OF SERVICE BY SYSTEM SIZE

Employees (Full Time Equivalents) 250 or more buses (34)

	US Average	US Low	US High	Curitiba
Per 1,000 Revenue Vehicle Hours	0.910	0.580	1.570	1.00
Per 1,000 Revenue Vehicle Miles	0.069	0.038	0.139	0.10
Per 1,000 Passenger Miles	0.011	0.011	0.180	0.03
Per Peak Vehicle	3.190	2.29	4.78	4.00

The author reconfigured data from the table above to show productivity in terms of units per employee in three of the charts below (annual vehicle revenue hours, annual vehicle revenue miles and annual passenger-miles).

Curitiba's transit system does not achieve significantly greater labor productivity than large U.S. bus systems. It is significantly more labor-intensive than "average" for large U.S. bus systems in terms of employees per revenue vehicle-hour – no surprise, given the use of

Figure 5.

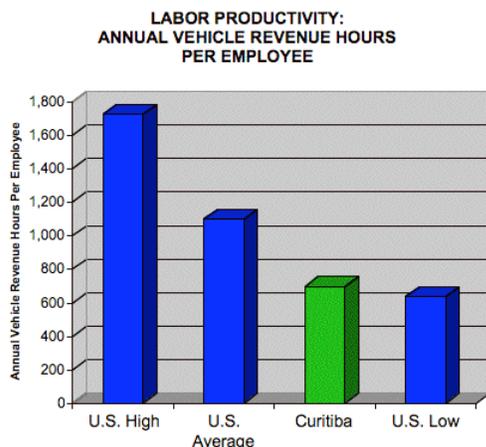


Figure 6.

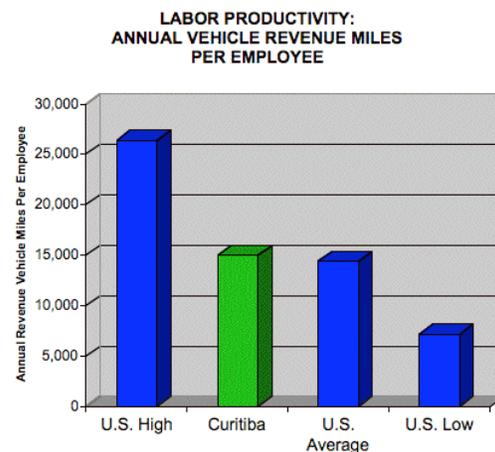


Figure 7.

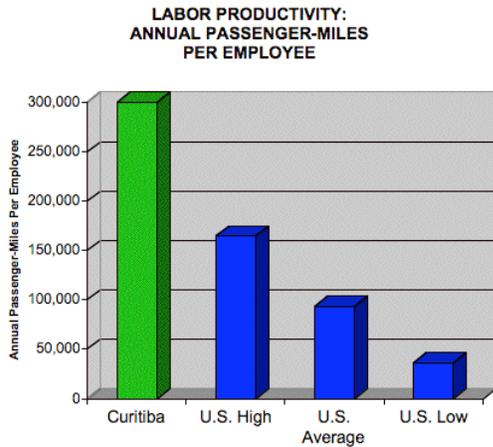
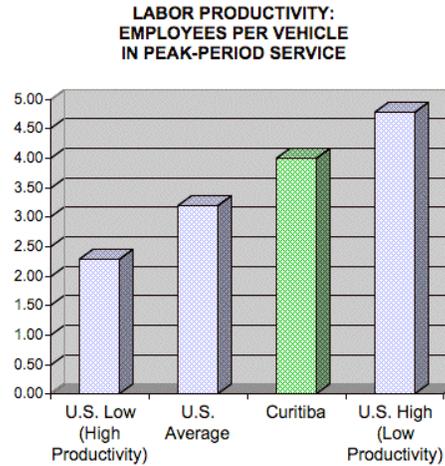


Figure 8.



two-person crews. It achieves equivalent productivity in terms of employees per revenue vehicle-mile. This certainly reflects the "BRT" measures that permit a higher average speed than the system could otherwise achieve.

The fact that Curitiba achieves many more passenger-miles per employee than large U.S. bus systems reflects site-specific conditions – not the configuration of the transit system per se. These include the city's unique land-use patterns -- and, in particular, the willingness of *Curitibanos* to tolerate much higher levels of crowding than consumers than would be acceptable in most U.S. or Canadian transit markets.

EXPRESS (BUSWAY) SERVICES:

- 454,000 workday boardings.
- 58,000 vehicle-km (36,000 vehicle-mi) per workday.
- 156 vehicles in maximum service.
- 600 operating staff (includes conductors and supervisors); estimate.
- 50 pass-km per veh-km (= 50 pass-mi per veh-mi). Estimate, based on based on 6-km (4 mi) average ride length.

A Curitiba-style busway, built in most U.S. or Canadian transit markets, would have to operate twice as much service (veh-mi) per unit of consumption (boardings, or pass-mi), and 3-4 times as much during peak periods, as the Curitiba busways actually provide. As noted above, con-

sumers in most U.S. and Canadian transit markets would not tolerate the high levels of crowding reported aboard Curitiba buses.

The bi-articulated buses (built in Curitiba by Volvo do Brasil) are 25 meters (82 feet) long and seat 57 passengers.

http://www.lightrainow.org/facts/fa_00013.htm

As noted before, the "rated capacity" of 270 pass/veh works out to 10.8 passengers per meter of vehicle length, far above anything observable on busway or HOV services in the U.S. (average, busiest hour, busier direction). However, loads of 200-270 passengers per bus may, according to firsthand accounts, be observed in Curitiba.

It is important to note that bi-articulated buses of the type operated in Curitiba do not conform to the vehicle code in at least one U.S. state -- California -- and therefore could not be operated on public streets.

The reported Curitiba "service standard" of 6 pass / sq meter, assuming a vehicle width of 2 meters, works out to 12 passengers per meter of vehicle length.

http://gulliver.trb.org/publications/tcrp/tcrp_rrd_33.pdf

DIRECTO (SPEEDYBUS) SERVICES:

--209,000 weekday boardings.

--40,000 veh-km (25,000 vehicle-mi) per workday.

--134 vehicles in maximum service.

--500 operating staff; estimate.

--40 pass-km per veh-km (= 40 pass-mi per veh-mi). Estimate, based on 8-km (5-mi) average ride length.

[As noted above, the reported average speed for Speedybus services was 32 km/h = 20 mph at 2003.]

Many but not all Speedybus services operate in the busway corridors.

Several Brazilian operators achieve remarkable hourly passenger volumes on busways -- 20,000 phd on two-lane busways in Porto Alegre and São Paulo, and 30,000 phd on three-lane busways (São Paulo). Two-lane busways require a minimum street width of 23 meters (75

feet). Three-lane busways require even greater width, but permit buses to pass one another (Gardner et al.). However, these services are slow, labor-intensive, and have levels of peak-period crowding far greater than U.S. consumers would tolerate.

(Of the two Brazilian subway systems, only the Metro do São Paulo has more than one line. This network carries the world's third-highest urban rail traffic density, second only to Hong Kong and Moscow.)

On the Boqueirão axis, Smith and Hensher report that 33 bi-articulated buses replaced 66 conventional buses, leading to a 12.5 percent reduction in cost per passenger. This implies that the bi-articulated buses cost 75 percent more to operate than conventional buses. The reported maximum passenger volume "approaches" 10,000 phd. The route length is 11 km (7 mi), and the reported operating speed is 23 km/h (14 mph). The implied average load is 300 pass/veh – which exceeds the rated capacity of these vehicles.

Smith and Hensher describe the plan for conversion of the North-South axis to bi-articulated buses (completed in 1995). The length is stated as 19 kilometers (12 miles); the operating speed at slightly less than 19 km/h (12 mph), and the peak vehicle requirement would be reduced from 91 to 44 (presumably all bi-articulated). The anticipated reduction in cost per passenger, 6.8 percent, implies that each bi-articulated bus cost nearly twice as much to operate as the vehicle it would replace. The reported maximum hourly volume was 11,000 phd. The minimum implied average load – which would require continuous operation, without layovers or recovery time – is 250 passengers per vehicle.

The author reiterates that, except in the most crowded and congested urban centers, U.S. or Canadian consumers would not tolerate such high levels of peak-period crowding aboard transit vehicles.

Labor productivity is an important issue associated with Curitiba's transit system, and this has not received adequate attention. A transit system in a high-wage country, carrying the same level of traffic, would almost certainly include a rail trunk line or network. It would therefore achieve significantly greater labor productivity overall, and therefore cost significantly less to operate, than a system based on the "Curitiba Solution." Such savings would provide a considerable return on the additional capital investment, and would reduce the long-term total cost of providing transit service.

6. CURITIBA TRANSIT REVENUES & EXPENSES

Curitiba transit passengers pay a flat fare, with unlimited transfers between buses. Various sources report different figures for this fare. At an "interactive conference" in 2000, the president of URBS stated that the fare was U.S.\$0.50.

http://www.future-urban-transport.com/FUT_2000/doc/Summary_FUT.pdf

At 2004, the flat fare was stated at R\$ 1.90 (PMC 2004). This was slightly less than US\$ 0.70 (based on 2.8 Brazilian reals per U.S. dollar).

The reported (current) 1.1 million revenue passengers per workday implies about \$550,000 per workday in revenue. This, divided by the reported (current) fleet size of 2,160, implies that each bus takes in about \$250 per day. APTA reports that each driver earns \$630 per month.

http://gulliver.trb.org/publications/tcrp/tcrp_rrd_33.pdf

Rabinovich and Hoehn state that the average operator workweek is 36 hours (144 hours per month). This implies that each bus takes in nearly 10 times more in annual revenue than each driver receives in annual pay. Given the disparity in wage rates between Brazil and the United States, Curitiba's operating costs provide little basis for comparison with U.S. transit operations, let alone for predictions of operating Curitiba-style transit systems in the U.S.

Fares are collected by URBS, which then pays the ten operating companies on a per-vehicle-mile basis. As Rabinovich and Hoehn make clear, URBS recovers all operating costs, all costs accruing to URBS, depreciation, and capital subsidy used to pay for new buses, from fares.

"The bus companies are paid by the distances they travel rather than by the passengers they carry, allowing a balanced distribution of bus routes and eliminating the former destructive competition that clogged the main roads and left other parts of the city unserved"

<http://www.fta.dot.gov/brt/issues/pt3.html>

URBS sets fares based on various elements of operating and administrative expense – which, as evidenced by the detailed summary presented by Rabinovich and Hoehn, are not proprietary or "secret." For example, the fuel economy of the bi-articulated buses was estimated (at 1992) at 0.7464 km per liter, about 3 miles per gallon.

Total administrative costs average 13 percent of operating cost. The operating companies are paid a three percent return on administrative costs for equipment and facilities (accounting for 0.39 percent of revenues).

In addition to operating (and administrative) expenses, the ten companies are reimbursed for capital expenditures at a rate of 1 percent per month (accounting for about 11 percent of the revenue). With a secure 12 percent annual rate of return, the companies have strong incentive to invest in new vehicles. During the mid-1990s, Curitiba's bus fleet had an average age of 3.5 years. At the end of the scheduled life, a bus has a book value equal to 10 percent of the purchase price, adjusted for inflation. The city then receives 90 percent of this residual value (this implies that the city pays one percent of the original purchase price and assumes ownership). Old buses are often "recycled" for non-transit uses by the city (as mobile classrooms and soup kitchens, and for "pro-park" services).

Smith and Hensher state that "profit margins are set at 10 percent of turnover;" this suggests a total weekday operating cost of about \$500,000 per workday (\$0.50 per boarding, or \$0.06 per pass-km = \$0.10 per pass-mi – rounded to one significant digit). The capital subsidy and administrative-cost subsidy percentages above suggest that "direct" operating costs are about \$400,000 per workday (\$0.40 per boarding, or or \$0.05 per pass-km = \$0.08 per pass-mi – one significant digit).

As for publicly-owned infrastructure, this was funded in part "through a 15-year long-term loan from a national Brazilian policy-based financial institution." However, no other source consulted by the author addresses this matter.

<http://www.dbj.go.jp/english/IC/active/hot/curitiba/01.html>

7. CURITIBA TRANSIT: UNCERTAIN PROSPECTS

An important detail lacking from many descriptions of Curitiba's transit system: the city would have built a rail system long ago if it could have obtained the capital. Had funding been available, the city would have developed rail lines at the same time it built the structural axes. Since 1979, Curitiba has made four attempts to secure financing for rail (or, most recently, monorail) development. All were unsuccessful.

Many sources emphasize that the existing network was developed at a fraction of the capital cost that system including rail trunk lines would have required.

"Even if there still exists a small difference in speed between a bus-based Mass Transit System, this difference pales when the question of costs is raised. Compared with the internationally accepted value of \$100 million per km for the cost of a subway, a Biarticulated mass transport route using existing road space costs \$1.3 million per km, 50 times less than a subway. The cost of a Speedybus route – about \$0.2 million per km – is 500 times less" (Sustainability Action Group Exchange, search site for "Curitiba: Integrated Transportation Network")

<http://www.sage-rsa.org.uk/sage/>

An older comparison states that "a subway would have cost \$60-\$70 million per km, but the 'over-ground' bus system (for which the city already had the land) cost only \$200,000 per km."

It is unfortunate that mitigating issues – including relative operating cost - have been ignored. Understanding labor-productivity issues is essential if realistic operating cost estimates under U.S. or Canadian economic conditions are desired.

As Curitiba planners certainly know well, rail transit provides significant economies of scale so that unit cost of service consumed (boardings or pass-miles) falls as consumption rises (up to a point). But the "Curitiba Solution" provides no economies of scale, and has significant "diseconomies of service quality" (e.g. travel time) that may not be accounted for in planning models.

In the U.S., new LRT systems typically provide an "internal rate of return" of 3-4 percent, owing to increased productivity. In other words, a transit system including an LRT trunk component costs less to operate than that including a non-rail alternative carrying the same traffic. The annual operating-cost savings may amount to 3-4 percent of LRT construction cost. If so, then LRT pays for itself within 25-33 years, and thereafter returns an internal "surplus" for the remainder of the project life.

It is possible to argue that, notwithstanding potential benefits, rail development would have absorbed a great deal of capital that was used for other important social needs. A Marxist critique of the Mexico City metro makes essentially this point (Cervero). However, had the money used to build the metro been used for other purposes, the city would have spent more per year to support transit operations (much more, given that the Mexico City metro ranks 12th among the world's urban rail systems in terms of traffic density). The cumulative total of "excess" (or "unnecessary") outlays for transit operations would eventually grow to exceed the cost of building the Metro. Meanwhile, the city would have obtained none of the other benefits provided by its current rail system.

In 1998, the Curitiba city government announced that a 15-km (9-mi) underground metro would be built beneath the two busiest busways (*Gazeta do Povo*, *Obras do metrô começam no ano 2000*, September 3, 1998). The announcement stated that the express bus lines have reached saturation. The "federation" (the Brazilian federal government) was to pay about US\$500 million of the cost, the "first 40 percent." Other funding was to come from the state of Parana, the city of Curitiba, and private initiatives. In Brazil, projects of this sort often do not proceed as announced, and the *Metrô do Curitiba* was no exception. The project cost, US\$ 1.25 billion or about \$90 million per km (\$140 million per mi), may have exceeded available resources

A monorail was proposed as an alternative – although not in the same corridor – and negotiations for financing began in 1999. Early in 2002, Curitiba Mayor Cássio Taniguchi announced a project for a 13.5-km (8.4-mi) monorail line, with construction to start by 2003.

Details, at least in English, were fragmentary:

". . . there are plans to divert a highway running north-south through Curitiba to the suburbs, and convert the original highway route into a new monorail-based transport system. The total cost of diversion of the highway and construction of the monorail is around US\$400 million, well beyond the financial capabilities of the municipal government. The plan is thus planned to be co-financed by the national government (60%), municipal Curitiba government (20%) and private sector (20%)" <http://www.dbj.go.jp/english/cooperat/hot/curitiba/04.html> [this link, to a Development Bank of Japan page describing the project, is no longer active].

The BR-116 highway extends in fact from southwest to northeast, skirting central Curitiba to the east. The project includes development of the highway corridor into another "Trinary" axis, with new housing and other development.

The initial monorail line was planned to extend from Centro station, at Praça Eufrásio Correia near the old railway station in central Curitiba. The planned route was to extend southeast to "Cidade Industrial de Curitiba Sul" station, at the southern portion of the industrial zone, with seven intermediate stations. Planned end-to-end running time was 15 minutes, suggesting a commercial speed of almost 55 km/h (34 mph). The planned maximum permitted speed was 50 mph. The line was to be patterned after the Osaka Monorail, with four-car trains having a capacity of 420 passengers each. Again, this figure implies far higher levels of peak-period crowding than consumers in most U.S. or Canadian transit markets would tolerate.

Planned second-stage expansion included a 6-km (4-mi) line from the city center northeast to Atuba, and 6.9 km (4.3 mi) of branches. Among the destinations to be served by branches were the educational institutions *Centro Politécnico* and *Pontifícia Universidade Católica do Paraná*. The completed 27-km (17-mi) Metrô Elevado was projected to carry 183,000 passengers per day.

The initial line was estimated to cost U.S.\$ 343.3 million, less than \$23 million per km (\$41 million per mi). This was less than 30 percent of the cost of the planned subway. The financing plan outlined at first included a 60 per cent share paid by the Brazilian federation, with 20 percent paid by the city and 20 percent by private investors. The most recent reports stated that 80 percent would be financed by a long-term low-interest loan from the Japan Bank for International Cooperation to the Brazilian federal government, with the remainder paid by the city http://www.curitiba.pr.gov.br/pmc/a_cidade/Solucoes/Transporte/metro.html. [this link, to a Curitiba city government page describing the project, is no longer active].

The monorail was to be operated by a private enterprise, and the Brazilian federation was to provide financing for "equipment" purchase. The city was to contribute land along the highway corridor, valued at U.S.\$ 36 million (Gazeta do Povo, *Financiamento não sai e metrô de Curitiba volta à estaca zero*, August 4, 2002).

Early in August, Mayor Taniguchi announced that the project had been "suspended" owing to withdrawal, in May, of the JBIC financing offer. Taniguchi said that federation authorities took three years to approve terms of the contract, and during this time, the JBIC fund that would have provided the loan became depleted. JBIC offered less generous terms, no better than what could be obtained through the World Bank or the Inter-American Development Bank. The state of the Brazilian economy was an apparent additional issue (Gazeta do Povo, *Financiamento não sai e metrô de Curitiba volta à estaca zero*, August 4, 2002). The city had issued a contract, using U.S.\$5.8 million in federation funds, for design work and environmental-impact

studies (*Gazeta do Povo, Oposição quer mais explicações sobre metrô*, August 5, 2002). This expenditure became a political issue.

The monorail plan had attracted criticism. In April 2002, a transport engineer and former president of Metrô do Rio de Janeiro criticized the "before the fact" selection of monorail technology. He argued that "The selection of technology must be the final decision, following demand analysis and calculation of costs and benefits of various options." He also argued that guarantees of the planned development along the corridor would be necessary in order to justify construction of the monorail (*Gazeta do Povo, Alternativa vem sendo discutida há 18 anos*, August 4, 2002). The idea of building the monorail in a "new" corridor, rather than invest in improving facilities serving already-developed corridors, also attracted criticism.

Taniguchi soon announced that the Curitiba Institute of Research and Urban Planning (*Instituto de Pesquisa e Planejamento Urbano de Curitiba*, or IPPUC) would recommend an alternative to monorail in the BR-116 corridor, and that this alternative might be bi-articulated buses.

"When we implemented the North-South axis, during the 1970s, the preference was also for a metro, but the resources were not available and so we implemented the express bus system. The same can happen now with the BR-116 corridor," said Taniguchi (*Gazeta do Povo, No lugar do metrô, BR-116 poderá ter ônibus expressos*, August 6, 2002).

The city announced at the end of August 2002 that new bi-articulated buses, built for a maximum capacity of 300 passengers each, will be used on three new routes serving the BR-116 corridor (*Prefeitura define com a Volvo novos ônibus para a BR 116*).

<http://www.curitiba.pr.gov.br/pmc/agencia/index.asp?ncod=3712>

Soon after the collapse of the monorail project, the city announced that IPPUC would study replacement of bi-articulated buses on the North-South axis with *bondes elétricos* – electric tramcars. This would lead to reduced pollution and increased comfort to passengers, stimulating demand for public transit, which is currently decreasing.

"We have to improve the quality of public transport to make it competitive with automobiles and attract new passengers," said Luiz Hayakawa, president of IPPUC.

Hayakawa explained that this, and not traffic saturation of the corridor, would be the primary justification for investment. Increased capacity would be another advantage: one articulated tram could replace one bi-articulated or three conventional buses. (*Gazeta do Povo, Prefeitura estuda implantar bonde elétrico nas canaletas*, August 7, 2002).

Despite its remarkable accomplishments over the past quarter-century, it is clear that Curitiba's public transportation must pursue a new direction in order to reverse the current downward trend. The city government is well aware of this need, and wants to include surface LRT as part of its program to improve service quality and compete more effectively with private autos. It would appear that Curitiba will begin LRT development as soon as funding can be secured.

8. UPDATE – DECEMBER 2004

Curitiba Mayor Cássio Taniguchi announced on July 15, 2003, that a 19.5-km (12.1-mi) *Metrô Leve* ("Light Metro") LRT line would be built along the *Eixo Norte-Sul*, replacing bi-articulated buses. A World Bank loan of US\$ 174 million would pay 60 percent of the estimated US\$291 million construction cost. The Brazilian federal Ministry of Transport would pay US\$48 million and the Curitiba municipal government would pay US\$ 28 million. The remaining \$48 million, for vehicle purchase, would be provided by private investors who would also operate the system (Bondenews, *Curitiba poderá ter metrô leve nas canaletas de ônibus*, July 17, 2003.)

http://www.bonde.com.br/bondenews/bondenewsd.php?retranca_id=24¬icia_id=664&data_AAAAMMDD=20030717

Curitiba celebrated the 30th anniversary of the opening of its first busway services on September 20, 2004. Among those participating were Mayor Cássio Taniguchi and Jaime Lerner, who was Mayor in 1974. He, Taniguchi and other planners made a test trip over the line on the night before opening.

"When we made that trip before dawn, we knew that we were innovating," Lerner said.

The busway plan evolved, Lerner recalled, "with the contributions from various persons at IP-PUC."

"We did not have the resources for a metro and so implementation, without question, would have been long delayed," he added.

Planners concluded that the speed and comfort necessary for successful mass transit could be provided on surface-level alignments.

"It did not have to be a subterranean solution, nor an expensive one," Lerner said.

The first lines were built to serve the structure of urban growth envisioned in the city's master plan.

"This was a structure of life and work together. This structure included planning for land use, transport, economic activities and housing together. And the provision of transport that would be needed were we would have greater density," Lerner said.

Taniguchi, who participated in early planning, said, "Many people did not understand the importance of what we were doing in the city at that time."

"We received all sorts of criticism. The difficulties were many," Taniguchi said.

Taniguchi noted that, since opening, the system has been upgraded and new services implemented. "We are constantly innovating, with creativity," he said.

"The system is not exhausted," Taniguchi said. "We have developed new projects incrementally, new changes to make it better. This has occurred in the past and occurs through the present."

Surface-level public transit, Taniguchi explained, has the ability to stimulate development.

"From surface transport, citizens see everything that goes on along their street. They discover the city, identify opportunities, form an identity with the municipality. If traveling underground, you lose such contact," Taniguchi said.

At the end of 2004, the newly-elected Mayor of Curitiba, José Alberto ("Beto") Richa, announced his support the Metrô Leve project. Richa also stated his intention to implement the project, described as "already approved," during the "coming year." The incoming administration also intends to conduct a public debate on the future of transit in Curitiba (*Gazeta do Povo*, *Prefeito deixa legado de projetos para o transporte coletivo*, November 14, 2004).

9. AUTHOR'S COMMENTS

As stated above, this paper was written to summarize available information on public transit in Curitiba, and to provide references and links. It was not written as a critique; in particular, it was not written to critique the decisions made by Curitiba planners.

However, the author has stated what he believes to be true when appropriate. A good place to conclude:

Descriptions and evaluations of Curitiba's transit system seldom address the issue of relative labor expense. This is true in particular of certain narratives that are best described as "hagiography."

The greater "expense" of rail transit development, referred to above, is "capital expense." Curitiba planners certainly knew well that labor expense, in terms of annual person-hours per passenger-km, would be greater. In other words, construction of LRT or metro lines along the structural axes would have required more capital, but less annual labor input per passenger-km.

Over a 30-year period, the cumulative labor input for a Curitiba transit network including rail trunk lines would have been less than the current network has consumed. The monetized cost of this "excess" labor consumption, within the context of the Brazilian economy, was less than it would have been elsewhere: for example, within the context of the U.S. economy.

The "trade-off" between capital investment and annual labor input – in other words, lower annual labor costs in exchange for a higher level of capital investment – is an important concept in economics. Substitution of capital for labor is a long-established practice in "developed" economies. This is obviously not practical if the necessary capital cannot be obtained, but the issue does not go away.

Rather than "do nothing," Curitiba pursued an innovative strategy that maximized the use of available resources. The net social benefit certainly offset any excess labor cost that might have been incurred within the context of the Brazilian economy. In other words, Curitiba's leaders did the best they could with what they had, and Curitiba's citizens reaped the benefits.

However, it is unwise to the point of foolishness to ignore the labor-cost implications of the "Curitiba Model" in the context of high-wage "developed" economies.

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