

The Curitiba Bus (R)evolution: Integrated Transport Systems as Mass Transport.

A.E.R. Cannell

Transcraft Consultants, Curitiba. Brazil

SUMMARY

The city of Curitiba has developed over the years a school of urban planning which has had enormous influence on city and transport planning in Brazil. Central to this planning process in the concept of "global vision" of the city, an effort to perceive the structure of a developing city as a whole, rather than isolated segments or functions.

In a situations of rapid growth and scarce capital resources creative, low-cost solutions had to be found. In terms of public transport, this has led to a series of innovations using bus technology which has revolutionized Mass Transport in Latin America.

The first and principal concept was the creation of the Integrated Transport System, using high capacity, high frequency trunk routes, feeder routes and interdistrict routes, all of which pass through integration terminals allowing passengers to change from one route to another for the same flat fare.

The introduction of articulated buses on the trunk routes then showed that busways could carry Mass Transport passenger flows without urban severance or environmental degradation.

The next step was the introduction of pre-paid, at-floor level access to the "speedy" buses, which have a limited number of "tube station" stops.

The latest development has been the Metrobus - or Bi-Articulated Vehicle - a unit that can carry 275 passengers and which now operates with at-floor, pre-paid access via the "tube" stations. For a fraction of the cost of a conventional Transit scheme, the city now has a quality Mass Transport System, operated on a profit making basis by the private sector.

THE CURITIBA MODEL

1. Curitiba, the Capital of the State of Paraná, is a city of some 2 million set in the high plains of the south of Brazil. Despite the rapid population growth of the 70's and 80's (of the order of 5%/yr.), the city has managed to maintain a high standard of living for its inhabitants, within the general context of the nation. This has been achieved by adopting practical, innovative and low-cost solutions to the city's problems, within a "global vision" concept of the city that covers land use, the road network, public transport, the preservation of green areas and the cultural and economic background of the city.

2. In 1965 a Master Plan was established that adopted a Linear Growth Model for the city along pre-determined Structural Axes. These Axes are formed by three roads: a central, exclusive Mass Transport busway with 2 lateral service lanes and 2 one-way streets for through traffic, distant one block from the busway. Within a one-way circular Ring Road which defined the city centre, several of the principal streets were transformed into pedestrian areas, and, at the same time, the historic sector was defined and preserved by the creation of incentives that permit old buildings to gain new uses and the developers to gain "Air Rights" to compensate their investment. New street furniture was designed for the city centre and a great number of new parks and recreational areas were incorporated, giving the city a total of 54 square metres of public green space per inhabitant.

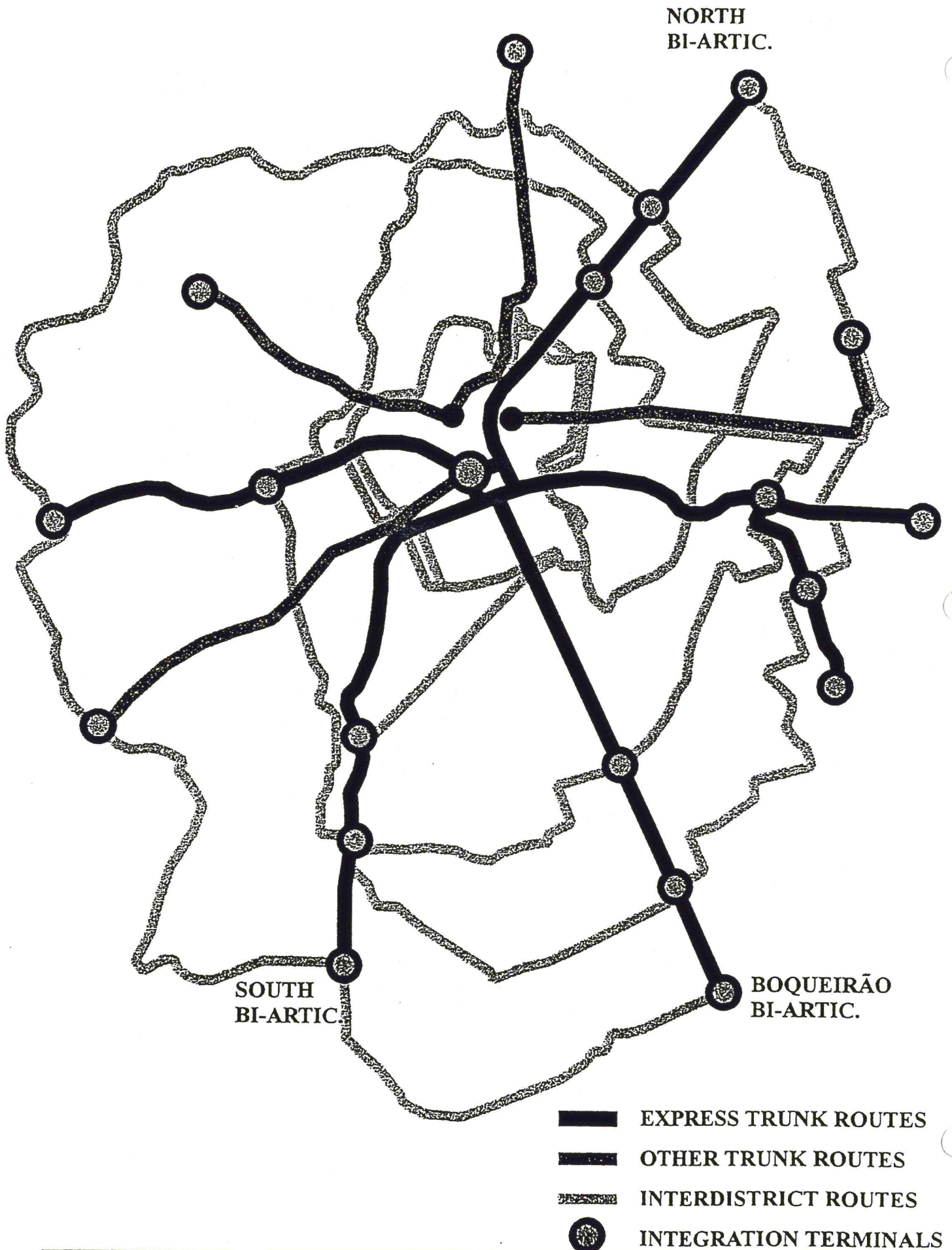
3. The traditional service and extraction economy was transformed by the creation of the Industrial City of Curitiba. Fully integrated into the urban fabric, this district has a complete infra-structure with housing, leisure and transport and is responsible, directly or indirectly, for more than 200.000 jobs, without causing any problems of pollution.

THE INTEGRATED TRANSPORT SYSTEM

4. In 1974 the planning policy which established the preference of public transport over the private car was also transformed into concrete action, initiating the Curitiba Bus Revolution, which has been ongoing ever since. Initially, 8 conventional bus routes were converted into 2 Express bus routes. These operated on 20 km of the exclusive busways, together with 45 km of feeder routes, transporting 50.000 passengers /day. The system was increased over the years with the inclusion of new trunk and feeder routes and, in 1979, the first Interdistrict route was created, linking various districts of the city without the need to pass through the city centre.

5. By 1980 the Integrated System had been consolidated with the addition of three trunk routes as well as new Interdistrict routes allowing the passenger to travel on any part of the network for a flat fee of about 45 US cents. The gradual upgrading of route capacity using articulated buses also showed that high bus capacity does not always lead to an environmental disaster and that the "cutting effect" of busways can be managed.

FIG. 1 CURITIBA INTEGRATED TRANSPORT SYSTEM



6. The system uses Transfer Terminals that permit integration between routes for the same fare. This "social fare" implies a cross-subsidy between the shorter trips and the longer trips from the poorer outskirts and is viewed as a question of **citizenship**, making the city accessible to all. The Integrated System covers today about 75% of the municipality and is composed of 5 transport axes with 60 km of exclusive busway, 280 km of feeder routes, 190 km of Interdistrict routes and 300 km of the "speedy" buses. These "speedy" units were first introduced in march 1991 and marked the introduction of the concept of at-floor, pre-paid boarding by means of the steel and glass "tube" stations. In 1994 the transport system of Curitiba carried some 1.6 million passengers per work day. The bus fleet of 1300 is totally operated by the private sector with no direct subsidy.(fig. 1).

OTHER INTEGRATED SYSTEMS

7. Integrated Transport Systems tend to be popular with passengers for several reasons: the passenger can travel on two or more buses for the same fare, the average travel time is reduced as trunk frequencies are of the order of 2 - 3 minutes and feeder buses are more frequent and reliable. Waiting time is concentrated in the terminals, which are more comfortable and safer than overcrowded city centre bus stops. The city and the traffic benefit from the systems as the total number of buses circulating - and stopping - downtown is greatly reduced, as are the kilometres of bus stops and pavement queues. Passengers simply take the first bus on their busway.

8. The private bus companies lose, of course, the revenue that came from the passengers using two or more buses for one trip, however, this is compensated by the reduction in overall mileage and the lower costs per pass.km. Most of the Brazilian bus fleet is bought with National Development Bank (BNDES) funding, which operates with lower interest rates than normal bank loans. Since 1990 this Bank has offered additional financing for the units to be used in Integrated Systems. This fact, allied to the popularity of the Curitiba system, led to a "revolution" in Brazilian urban transport and some 20 similar systems have been built in the past few years that now serve millions of passengers per day.

9. Even São Paulo, a mega city of almost more than 11 million people - and another 5 million in the surrounding conurbated Metropolitan Area, is introducing an Integrated System of 16 exclusive busways with the objective of restructuring the whole of the city's transport around the high-capacity bus mode and thus ease traffic congestion and overcrowding on the existing metro lines.

10. Table 1 gives an indication of the present number of cities that operate - or have planned - an Integrated System. This list is not exclusive and other systems may exist or be in the pipeline. The population figures are also estimates - a rough idea of passenger flows can be obtained by considering a bus "mobility index" of 0.5 trips per inhabitant per day, though the situation is more complex as conventional routes normally exist together with the Integrated System.

TABLE 1. SOME CITIES SERVED BY INTEGRATED TRANSPORT SYSTEMS

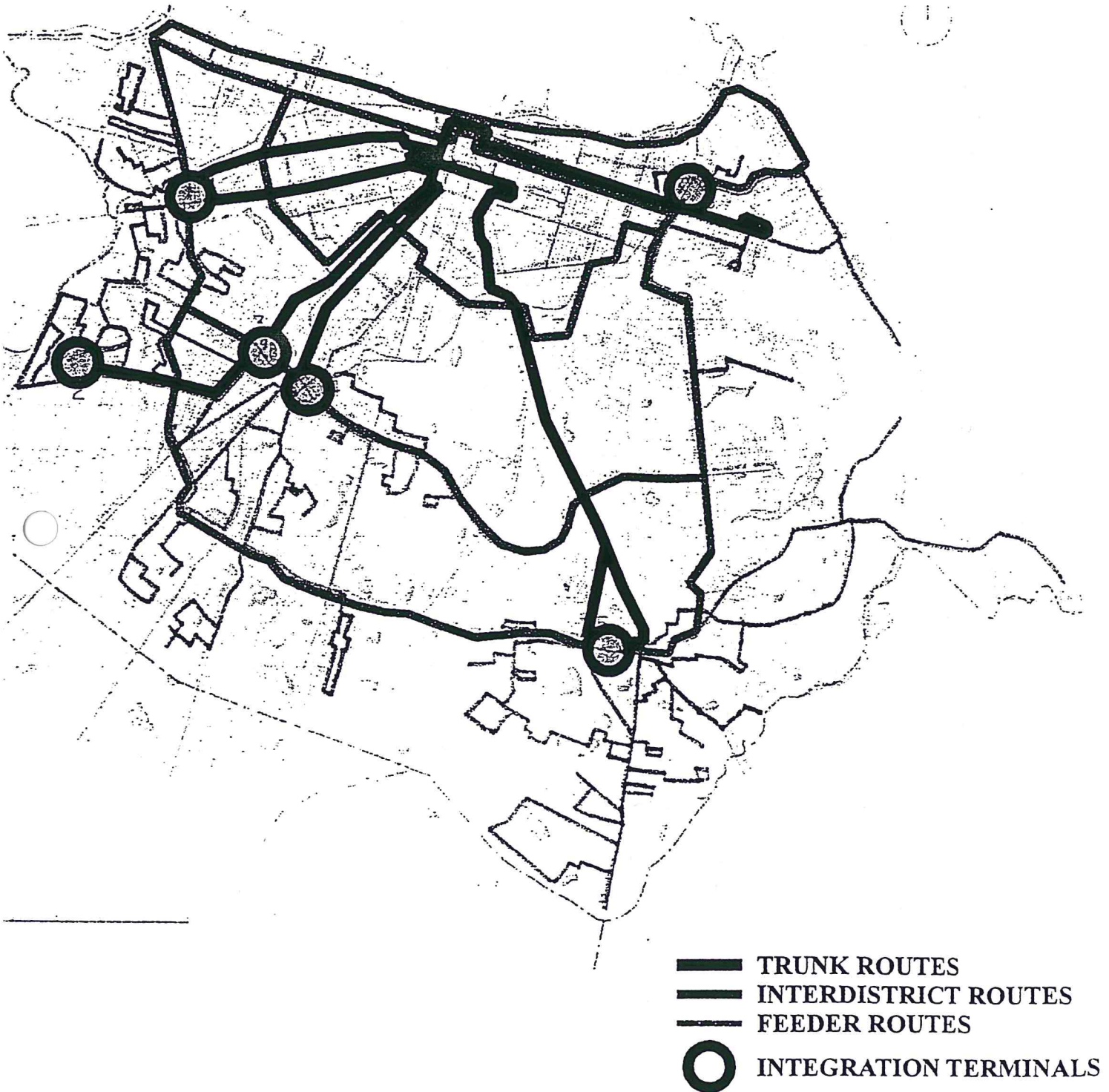
City	Estimated population (millions)
Curitiba	2.0
Fortaleza	2.1
Aracaju	0.9
Campo Grande	0.7
Santos	0.8
Blumenau	0.3
Joinville	0.6
Piracicaba	0.3
Recife	2.5
Vitória	1.6
Campinas	1.8
Londrina	0.6
Maringá	0.3
Cascavel	0.2
Ponta Grossa	0.3
Petropolis	0.4
Ribeirão Preto	0.4
Uberlândia	0.6
Goiânia	2.0
Manaus	1.2
Belém	0.9
São Paulo(*)	11.0
São Luis(*)	2.0
Florianópolis(*)	0.6

(*) approved for financing

11. Most of these cities do not use exclusive busways, the principal components being the terminal and the trunk, feeder and interdistrict routes. Once the demand has been concentrated downtown and at the terminals, it is also possible to bring in new trunk routes linking these points or using non-stop services.

12. The example shown in fig. 2 illustrates the use of the basic concepts of an Integrated System. As is usual, the interdistrict routes between the terminals did not exist before the introduction of the System and were planned largely using intuitive experience - without the bus routes, of course, any O/D data on bus passengers cannot identify latent demand. As the bus mode is extremely flexible, route capacity is built up according to demand; articulated buses now operate on these routes. Although no exclusive busways are provided, capacity is extremely high: the two parallel SW corridors carry together over 300.000 passengers/day. Express services also operate during the peak hours directly between the terminals and the downtown stops.

FIG. 2 INTEGRATED TRANSPORT SYSTEM OF FORTALEZA



FURTHER DEVELOPMENTS IN THE CURITIBA SYSTEM

12. Although the Curitiba system has no direct subsidy, the growing complexity of the system, however, has led to the creation of a permanent structure charged with the planning and administration of the system. The problem of the distribution of fares between the different operating companies, for example, was first handled by a "Compensation Chamber", which, through a private account in a bank of the operators choice, transferred funds from the "surplus" to the "deficit" routes, based on statistics and calculations agreed upon by the municipality and the companies. Today the operators are contracted and paid by the mile according to effective mileage by type of bus per type of route. These functions are handled by URBS, a company largely owned by the municipality, which controls the timetables, costs, routes and general conditions of the fleet.

13. With the continued growth of demand and the saturation of some of the transport axes, however, Curitiba opted for the development of new technology to increase the efficiency of the bus as a means of mass transport. The first solution was the introduction of the "speedy" buses, a direct service between "tube" stops, placed, on average every 3.2 km. This factor, plus the at-floor, pre-paid boarding permits an operational speed of up to 30 kph. The units have doors on the left and a capacity of 110 passengers, including access and space for wheelchairs. The 13 existing routes carry 250.000 passengers/day and 8 more routes are in the pipeline.

14. The second solution was the Bi-Articulated bus to increase the capacity on the high demand corridors. Developed in Brazil, with the support of the Volvo Bus Corporation, the Bi-Articulated bus project was initiated at the request of the municipal Administration as part of it's Expansion Plan.

15. The total length of the Bi-Artic, with coachwork, is about 22 m; each unit having a nominal capacity of 270 passengers and using at-floor, pre-paid boarding technology. The first line of 11 km was built in 1992 on the Boqueirão Route and today carries 110.000 passengers per day. The second line, on the principal N-S transport corridor will operate in July 95 with 66 units carrying some 200.000 passengers/day, substituting a light-rail scheme which had been previously detailed as the definite transport solution for the routes of highest demand.

16. This System proved to be extremely popular with passengers when compared to the pervious Articulated buses:

- 77% thought the service had improved;
- 84% considered the Bi-Artic to be more comfortable;
- 81% believed the system to be safer;
- 87% preferred the new boarding access;
- 93.5% found the Bi-Artic more spacious,
- 80% found it quieter and 92% considered the design to be more attractive.

17. Upgrading the existing busway is relatively simple and consists in repaving the busway and the correct leveling of the "tube" stations by means of a reinforced concrete base. The "tubes" are set on a concrete base and put in place just before operations start. The Terminals are modified by raising the platforms to the correct height above a reinforced concrete loading bay.

20. Bus priority at intersections along the route is guaranteed by a synchronized traffic light system. As the delay at stops is almost uniform and independent of the number of passengers, the Bus-TRANSYT computer model can be used for programming the timings. Detectors in the busway also give additional priority at junctions according to the direction of flow: the extra green is only given for the units in peak flow direction, as this reduces "bunching" on the return journey.

21. The new N-S route has also proved to be an attractive project for international lending agencies. External funding has been provided for infra-structure by the InterAmerican Development Bank and the private sector investment for the new fleet has been included as city "counter part". The BNDES has offered "very special" 7 year financing for the units, thus allowing the operating company to spread the initial capital costs over the main part of the operating life of the vehicle.

22. Operating costs of the Bi-Articulated units per passenger-km are, in fact, less than those of conventional buses. This is largely due to the fact that the "dead" weight of the vehicle per passenger is far less than other modes, as can be seen from Table 2. This means that diesel consumption, tire wear, etc. are on average, lower - as is general maintenance. Even though each "tube" station requires a fare conductor, overall manpower costs are lower as each unit carries 275 passengers per driver.

TABLE 2. DEAD WEIGHT PER PASSENGER PER MODE

Mode	Capacity	Dead Weight kg/pass.
Typical Rapid Transit	(83 seats)	458 (per seat)
Padron Bus	100	105
Articulated Bus	180	85
Bi-Articulated Bus	275	71

Source: Wright, (1992)/Transcraft

23. As an efficient solution to the mass transport problems of major cities, the Bi-Articulated bus offers enormous advantages when competing with other modes:

- costs, both of construction and operational are greatly reduced. As the Bi-Articulated bus can operate on ramps of up to 13%, the scale of civil works can be kept to the minimum required to guarantee an exclusive track with limited interference. No external resources are required, so the costs of putting in cables, transformers, electrical sub-stations and costly underground ducts is simply eliminated.

- execution of the System is flexible and rapid. During the construction of the Mass Transport System, whole sections can be put into operation without the need to complete costly signaling and maintenance yards.

A complete operation can be planned and put into operation within 2 to 3 years.

- the units can be bought and run by private companies as a profit making enterprise under limited city control, without the need for a special public company to purchase and operate the units.

- the fact that the units run on tires and can turn within a small radius means that connection to Metro, rail or bus terminals is greatly simplified. The Bi-Articulated bus can also serve as a pre-metro, increasing demands and revenues on the underground infrastructure without incurring prohibitive civil works costs.

- this System is definitely Mass Transport. The capacity figures reached in Curitiba are comparable to some Metros and similar to Light Rail.(Table 3).

TABLE 3. CAPACITY FIGURES FOR MASS TRANSPORT SYSTEMS

System	Peak Direction Load (1000pphd)
São Paulo Metro	57
Cairo Metro	22
Rio de Janeiro Metro	22
Pusan Metro	13
Alexandria LRT	13
Manila LRT	19
Tunis LRT	9
Curitiba Boqueirão Bi-Artic	8
Curitiba N-S Bi-Artic	15

Source: Project Report 69 R5596 TRL/Transcraft

24. These advantages became clear during a tender for a privately operated Mass Transport System for the District Capital of Bogotá, Colombia, which was awarded to the "Sistema Metrobus de Bogotá" company after a careful analysis had eliminated the other competing bids.

25. Other cities are now examining the role that modern bus technology can play in Mass Transport. Curitiba has shown that levels of quality and capacity that were thought exclusive to rail-based modes can be achieved for a much lower cost and that the operation of the system can be undertaken by the private sector on a profit making basis.

REFERENCES

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2. Gardner, G. Rutter and J. Kukn, F. Project Report 69: R 5596. The Performance and Potential of Light Rail Transit in Developing Cities. Transport Research Laboratory - O.D.A. England 1994.