STUDY OF BUS PRIORITY SYSTEMS IN LESS DEVELOPED COUNTRIES

ETUDE DES PRIORITES AUX AUTOBUS DANS LES PAYS EN DEVELOPPEMENT

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SUMMARY:

The paper describes the results of research into high-capacity bus priority systems carried out by the UK Transport and Road Research Laboratory (TRRL) during 1988-90. Field surveys were conducted to measure bus flows, bus commercial speeds, passenger capacities and flows along busways in Abidjan (Cote d'Ivoire); Ankara and Istanbul (Turkey); Belo Horizonte, Curitiba, Porto Alegre and Sao Paulo (Brazil). Selected surveys were also carried out at high-volume bus stops in the above cities, as well as in Bangkok, Hong Kong and Singapore. The paper summarises some of the survey results and draws some initial conclusions concerning the performance of Busway Transit systems.

RESUME:

Le document présente les résultats des recherches des systèmes de sites propres aux autobus, menées par le Transport and Road Research Laboratory (TRRL) du Royaume Uni en 1988-90. Des enquêtes ont été menées afin de mesurer les flux des autobus, leurs vitesses commerciales, les capacités en passagers et les flux de passagers aux sites propres à Abidjan (Côte d'Ivoire); Ankara et Istanbul (Turquie); Belo Horizonte, Curitiba, Porto Alegre et Sao Paulo (Brésil). Des enquêtes ont été menées aussi aux arrêts d'autobus, bénéficiant de charges de passagers importantes, dans les villes mentionnées ci-dessus et à Bangkok, Hong Kong et Singapour. Le document résume quelques résultats des enquêtes et tire des conclusions concernant la performance des systèmes de "Busway Transit".

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1. INTRODUCTION

In order to combat worsening problems of road traffic congestion and pollution, authorities in many cities are searching for cost-effective ways to provide "mass transit". The general aim of such mass transit is to meet the travel demands of existing public transport users and to provide an acceptable alternative to the use of private vehicles for travel in congested parts of the city.

Whilst metro may be appropriate in the main corridors of the largest cities, there are serious concerns about the cost and affordability of such systems elsewhere. Prompted by these concerns, and the increasing number of funding requests received by the United Kingdom Overseas Development Agency (ODA), the World Bank and other international agencies, the Transport and Road Research Laboratory (TRRL) carried out a Study of Mass Rapid Transit in Developing Countries (1).

Since there was also a clear need to examine lower-cost public transport alternatives, TRRL undertook this complementary "Study of Bus Priority Systems for Less Developed Countries". Although targeted at cities in less developed countries (LDCs), the results are relevant for developed countries (DCs) too.

The objectives of the study were to:

(a) review the performance of existing bus priority systems (BPS);
(b) review existing BPS planning and design techniques to determine their appropriateness and scope for general application;
(c) carry out detailed case studies in selected cities in order to establish relationships between passenger demand, on-street priorities, bus facilities and operation; and
(d) propose planning and design guidelines, based on the above evaluation of BPS performance and impacts.

2. BUS PRIORITY SYSTEMS

During the 1970s, bus priority systems were implemented in many cities in both LDCs and DCs. Measures included with-flow and contraflow bus lanes, bus streets and spot improvements (eg bus gates). While some schemes were very effective, many were ineffective due to enforcement difficulties, poor design and other factors (2).

This study set out to consider the full range of bus priority systems. An initial review drew distinctions between Traffic Management BPS and Mass Transit BPS; and also between High-capacity BPS and High-quality BPS (2). Based on this early work, the Team decided that the priority was to investigate the performance of high-capacity systems which physically segregate buses from general traffic over at least a part of their length (ie busways). We stress, however, that other bus priority measures are vital as part of an overall bus priority system.

3. BUSWAY TRANSIT

The gradual realisation that the car cannot be accommodated fully in larger cities, that good public transport is indispensable and that metros are very expensive has stimulated the search for medium-capacity, cost-effective, affordable and acceptable public transport. The options in both LDCs and DCs centre on families of light rail transit (LRT) and what we term here "Busway Transit".

We use the term "Busway Transit" to denote a system which includes a right-of-way for the exclusive use of buses, with at least one section of busway physically segregated from general traffic, and some or all of the following:

(a) a collector/distributor system at one or more ends of the busway, most likely including bus priority measures in the "CBD" area;
(b) bus stops (physical layout; management etc.);
(c) fare collection methods (eg on- or off-board collection);
(d) bus fleet (vehicle capacity; door configuration etc);
(e) operations (eg bus ordering; express services), and
(f) marketing (passenger information; corporate image etc).

It must be said that relatively few cities have treated buses in a comprehensive way and taken action in all these areas, notable exceptions being Curitiba (Brazil) and Ottawa (Canada).

The busway itself is a section of road, usually (but not necessarily) one traffic lane in each direction, dedicated to the exclusive use of buses at all times. In general, busways are either located along the centre of the road, with island stops, in order to minimise enforcement problems and disruption to frontage access, or are totally segregated new roads. Passengers usually walk to and from bus stops via traffic signal controlled crossings of general traffic lanes. In high-capacity schemes, bus overtaking facilities at stops and grade separation at intersections may be provided. This particular definition excludes high-occupancy vehicle lanes (HOVs) as used for car pooling and bus services in the USA.

For the busway track, many physical cross-sections and configurations are feasible, which makes generalisations about performance and impacts almost impossible. The comments in this paper concentrate mainly on busways constructed along existing roads (in much the same way as street-running LRT) although many of the comments apply equally well to purpose-built new roads (at-grade or elevated) constructed solely for use by buses.

4. WHERE HAS BUSWAY TRANSIT BEEN IMPLEMENTED?

The earliest schemes were implemented in Europe - for example, the first of three radial busways was built in Liege (Belgium) some twenty years ago. And the first purpose-built busway roads were commenced in Runcorn New Town (UK) in 1971. Then in the late 1970s and early 1980s a series of innovative busways was implemented in various Brazilian cities. Perhaps the most famous of these is Curitiba, where busways form structural axes which are integral with the city land use plan. Detailed and sophisticated attention has been given to passenger interchanges, bus design and many other aspects. Busways were also implemented during this period in Sao Paulo, Porto Alegre, Belo Horizonte, Recife and elsewhere, many with World Bank assistance.

In Abidjan (Cote d´Ivoire) three busways were implemented as part of World Bank-assisted projects. And busways have also been built in many other cities: Ankara (Turkey), Bogota (Colombia), Hamburg (West Germany), Istanbul (Turkey), Lima (Peru), Nagoya (Japan), Ottawa (Canada) and Pittsburgh (USA).

Busways are being planned currently in various other cities, including Bangkok (Thailand), Jakarta (Indonesia), Karachi (Pakistan), Nairobi (Kenya) and Shanghai (People´s Republic of China).

5. CASE STUDIES

Eight busway case studies were carried out, including one in Sao Paulo. Main features of the sample busways are summarised in Table 1. One or more team members visited each scheme and surveys were carried out by staff supervised by the research team. Bus flows, available passenger places and passenger flows were measured at between two and four locations on each busway. The survey sites included a location at or near the maximum load point. Bus commercial speeds were measured between the survey points. Surveys were carried out during morning and evening peak periods on two weekdays at each site.

Bus and passenger volumes were also measured on selected bus lanes in Bangkok, Belo Horizonte, Hong Kong and Singapore; and at high-volume bus stops in Abidjan, Ankara, Bangkok, Belo Horizonte, Curitiba, Hong Kong, Istanbul, Porto Alegre, Sao Paulo and Singapore.

The capacity of a busway is influenced by many factors including the degree of segregation from other traffic, bus stop spacing and layout, bus design and performance, fare collection systems, passenger demand characteristics, bus operational systems and junction operations. It is important to note that busway capacity is dependent on the nature of passenger demand. As the number of boarding or alighting passengers at a bus stop increases, so bus stop dwell times increase, and bus and passenger flows along the busway tend to diminish.

Busway passenger capacity also depends on the capacity of the buses used to operate services. For each busway surveyed, the Team determined three measures of capacity: "seated places", "nominal capacity" (taken to be heavy, but acceptable, bus loading) and "crush load". The prime measure of bus capacity used here is nominal capacity which corresponds, for each bus, to all seats occupied plus standees at a density of 6-9 passengers/m2, depending on the city.

While surveys of existing systems provide a reference point for establishing busway performance, it should be noted that:

(a) the surveys measured the performance of existing busways, as configured and operated at the time of the surveys. In some cases, the Team judged that busway design could be improved, that poor maintenance of the bus "track" was constraining performance and that bus characteristics and operations left scope for improvement. It would therefore be a mistake to interpret the survey results as demonstrating the best possible performance that might be obtained.

(b) the surveys measured actual passenger flows and "available passenger places" (based on nominal bus capacity) on buses at particular locations during peak periods. The "supply" of places may or may not correspond to the ultimate passenger capacity of an existing busway since, as passenger boarding/alighting increase, potential bus/passenger flows tend to diminish.

6. THE SAO PAULO CASE STUDY - AVENIDA 9 DE JULHO BUSWAY

One of the case studies was of the Avenida 9 de Julho/Avenida Santo Amaro Busway in Sao Paulo (Figure 1).

Location: With an estimated metropolitan area population of about 16 million, Sao Paulo, capital of the State of Sao Paulo, is one of the world's largest cities. The survey section of Avenida 9 de Julho/ Santo Amaro Busway extends for 8 km along a radial corridor to the southwest of the city centre. COMONOR was implemented as a pilot project along this corridor in 1977 (4) but when the scheme was changed from lateral bus lanes to a median busway with overtaking at bus stops, COMONOR was no longer necessary.

Design: Avenida 9 de Julho is a median busway with one lane in each direction. The busway is discontinuous for two short sections; one through a tunnel where there is inadequate width for the full busway/road cross section and one through an underpass. A key feature of the busway is that overtaking lanes are provided at all but two stops, enabling buses to leave the bus stop platforms when loaded without waiting for the bus in front to move and, enabling semi-express bus services to be operated. Bus stops are long - typically 250 m - and accommodate a bus stop bay for 3 buses (typically 36 m), a manoeuvring length (typically 26 m) and a further bus stop bay for 3 buses (typically 30 m) - the manoeuvring length allows easier bus access to/from the two bays. General traffic engineering design standards are high. All pedestrian and passenger movements along the route, at junctions and at bus stops, are controlled by guard rails and by signals. The busway tracks, divided by a median, are separated from general traffic between stops by heavy road studs. The median is fenced to discourage random pedestrian crossing. Within the bus stop areas, buses in opposing directions are separated by New Jersey barriers which also prevents random passenger crossing. Only two junctions along the busway allow turning movements for general traffic across the busway (controlled by signals); other traffic turning movements are accommodated by G or Q turns.

Operations: Bus services are operated by the municipal bus company, CMTC, and by various private companies in a regulated environment (inspectors are present at critical stops to control bus movements; the busway has an associated tow-truck to remove broken down buses; the busway is regularly patrolled to identify signal failures etc). CMTC uses large single-deck diesel-powered buses and trolleybuses, as well as double-deck buses; private companies use conventional single-deck, diesel-powered buses.

Performance: The peak directional bus flows recorded at the survey points was 230 buses/hour inbound at Lisboa in the morning peak and 221 buses/hour outbound at BANESPA during the evening peak. (Peak 5-minute bus flows were up to double these rates). The peak estimated crush capacity was 24,000 passengers/hour/ direction at BANESPA; corresponding to a nominal capacity of 20,300. Maximum recorded passenger flows were 18,600 passengers/hour/direction inbound during the morning peak and 20,300 outbound during the evening peak (averages of 82 and 92 passengers/bus respectively). In order to achieve these loadings, 12% of buses were crush loaded during the morning peak and 59% during the evening peak at the peak load point. Commercial speeds averaged 19 and 16 kph during the morning and evening peak periods respectively (speeds over individual sections ranged from 14 to 30 kph).

Comment: The Avenida 9 de Julho Busway is probably the best designed and most effective of the busways surveyed during the Study. However, there is a lack of passenger information which, given the mix of bus services (over 150 bus routes/lines use the scheme) and the mix of express/semi-express and local bus services, inhibits efficiency at bus stops. One of the non-overtaking bus stops causes congestion problems (Joao Lourenco) and long queues of buses wait to access the stop during the evening peak period.

7. INITIAL CONCLUSIONS FROM SURVEY RESULTS

Some key results from the case study surveys are given in Table 2 and are discussed below:

(a) it is well known that bus passenger boarding is slower than alighting and this is reflected in the maximum passenger flows of over 26,000/hour/direction where alighting predominated, against passenger flows of 20,000/hour/ direction where boarding predominated. Clearly, busway planning should concentrate on the boarding condition.

(b) in order to achieve high passenger flows at reasonable bus commercial speeds, the surveyed schemes employed some form of operational or physical measures at bus stops. For example, to achieve 20,000 passengers/hour/direction, the design of Avenida 9 de Julho, Sao Paulo, permits bus overtaking at stops and employed a degree of on-site stop management; to achieve 18,300 passengers/hour, Assis Brasil, Porto Alegre, operates bus ordering. While Boulevard de la Republique, Abidjan, recorded high passenger flows without such measures, these were achieved at low bus commercial speeds and, subjectively, under poor passenger conditions.

(c) maximum hourly nominal available bus passenger places in the peak direction were recorded as 39,400 (predominant alighting direction) and 31,300 (predominant boarding direction). Further work is continuing to form a view as to the degree to which these available places might be utilised.

(d) the busways surveyed did not necessarily operate under optimum conditions. Decreased boarding times at stops could result in larger line-haul passenger flows and measures such as off-bus ticketing, improved bus stop management and provision of larger, wide- and multi- door buses, could increase passenger flows.

(e) to achieve the recorded passenger flows on the most heavily used busways, a significant proportion of buses operated at crush capacity (40% to 60%). Such passenger conditions may not be consistent with a high quality public transport system and must be considered in busway planning. The problem is not unique to busways; if an LRT was subject to the same passenger demands, it is probable that crush loading would occur.

(f) with respect to bus commercial speeds, the busways appeared to divide into two groups. First, where bus stop and junction spacings were relatively close and no special operational measures were taken, average commercial speeds were low - between 8 and 14 kph. Secondly, where bus stop and junction spacings were greater, and where some operational measures were taken, bus commercial speeds ranged generally between 17 and 22 kph (and 29 kph was achieved). Such speeds coupled with one way hourly passenger flows of between 26,000 (alighting direction) and 20,000 (boarding direction) demonstrate the effective nature of busways in meeting high transit demands. On busways with lower bus flows, it may be possible to make greater use of traffic signal priority (as in Curitiba) and other traffic management measures to increase speeds further.

(g) there is little available data on safety aspects of busway operation. Some busways have experienced accident problems (notably Avenida Cristiano Machado, Belo Horizonte) but where intensive traffic engineering measures and effective control of conflicts have been undertaken, as in Avenida 9 de Julho, Sao Paulo, there are no reported serious accident problems.

8. CONCLUDING REMARKS

Busway technology has been around for more than 20 years. Yet after a burst of activity, particularly in Brazil, during the late 1970s and early 1980s, few new schemes have been implemented. Why? Are busways ineffective? Are they too difficult to implement and to manage? Or have other factors camouflaged or overshadowed their achievements?

There are no simple answers. Some schemes are well-designed and function effectively (eg Avenida 9 de Julho, Sao Paulo), whereas others function despite a series of adverse influences ranging from past political neglect (eg Porto Alegre), through poor design (eg pavement failures in Abidjan and Recife) to organisational difficulties and inadequate technical support.

The TRRL study has confirmed that Busway Transit is capable of carrying high passenger volumes at attractive commercial speeds - stated simplistically, existing (sub-optimal) schemes carry: "up to 18-20,000 passengers/hour/ direction at about 18-20 kph". And it can be argued that the busway schemes surveyed compare very favorably with a string of less-than-successful rail mass transit schemes in the same cities and elsewhere (eg Belo Horizonte; Istanbul; Porto Alegre etc) (4).

At the time of writing, work is proceeding to try to define some planning guidelines, but it seems reasonable to suppose that for general planning purposes, passenger flows of up to 20-25,000 passengers/hour/direction can be achieved with appropriate infrastructure design (track and stops), vehicle fleets, and assuming well-managed operations. The precise figure in any particular location will depend on very many factors including: right-of-way characteristics; degree of segregation from general traffic; local traffic engineering capability; passenger demands (boarding/alighting); passenger characteristics; and so on.

Despite the potential of Busway Transit to carry very large numbers of passengers, the bus manufacturing industry seems to have been unable to develop a sustained market for such systems.

Bus finance and management packages may be readily available, but track provision remains a local responsibility, largely outside the supplier's control (except in very special cases like the O-Bahn, where the track is an integral part of the package).

Local governments do not generally seem to have undertaken a concerted effort to introduce bus priorities or Busway Transit schemes. In a recent survey of transport developments in 21 major Third World cities (1) where metros are in use or planned, only six had any effective bus priority measures and/or bus transit (six other cities having abandoned earlier schemes).

We can advance some possible reasons for this. Because neither suppliers nor any single public agency control the provision of track, Busway Transit has no natural promoter in the way that metros and light rail schemes have. Bus operators clearly have an interest, but some are very conservative in what they believe bus transit can achieve and in other cases, the bus operating industry is fragmented and has no clearly represented voice on operational requirements. Furthermore, there are few examples of Busway Transit which can demonstrate to transport decision-takers what can be achieved; the performance of successful Busway Transit schemes in Brazil, Australia, Europe and North America has not received enough attention.

So what of future prospects? Given the physical difficulties, and the practical skills needed to insert an at-grade busway into an existing road, some cities are turning their attentions to elevated busways (eg Jakarta and Karachi). In principle, there is no reason why elevated busways should not function effectively, if appropriately designed and operated. But it seems unlikely that city authorities will be prepared to pay around US$10 million/km for a simple elevated bus track unless it comes with more advanced technology (eg possibly guided bus) and new management techniques (eg computer systems).

This paper has argued that the potential performance of Busway Transit has been amply demonstrated. The cost-effectiveness of good, at-grade schemes should make them particularly attractive to transport planners and decision-makers in developing countries. If their image and quality can be improved by a combination of modern technology, finance and marketing, plus good management and imaginative organisation, Busway Transit should be irresistible.

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ACKNOWLEDGEMENTS

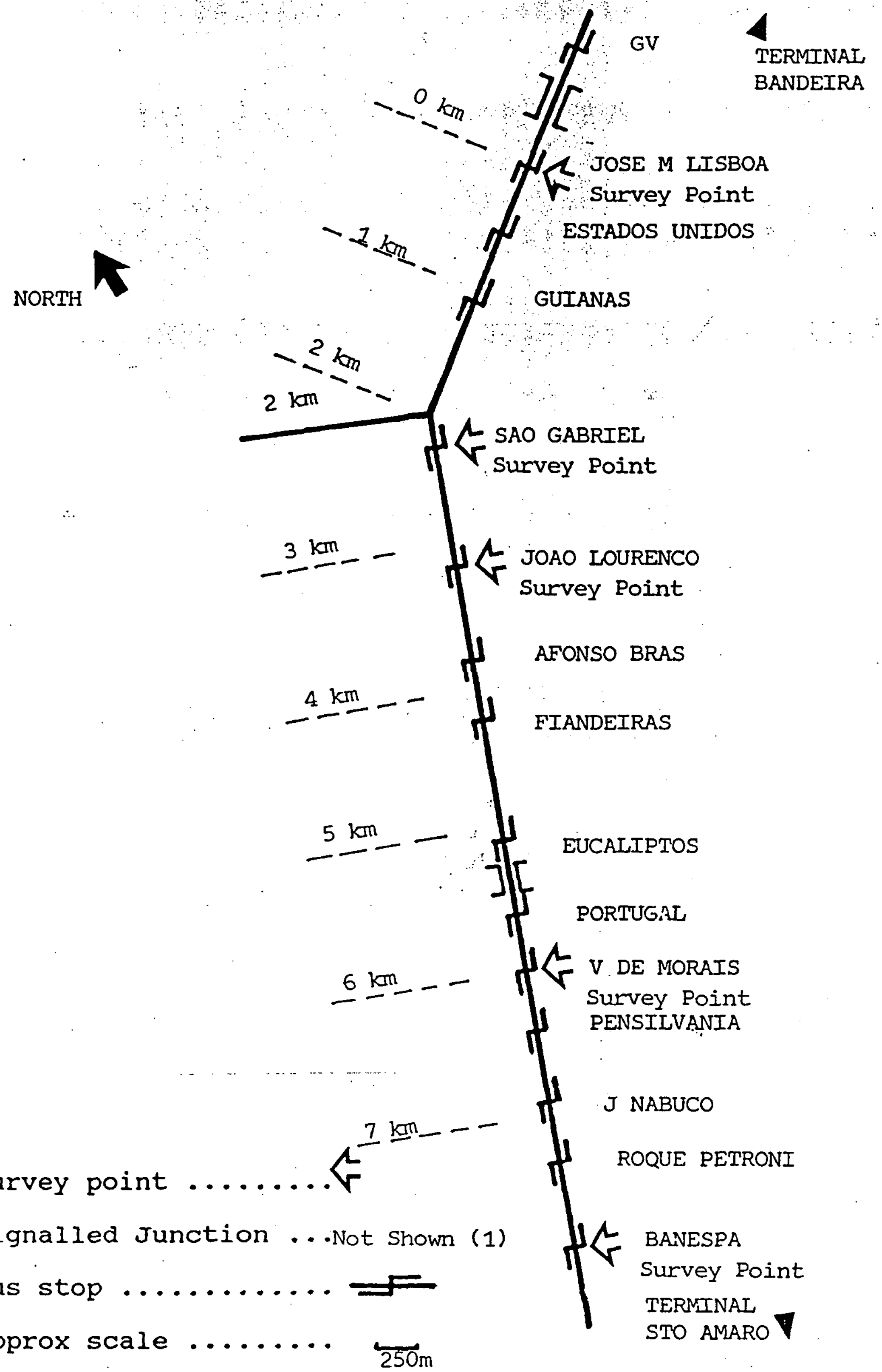
This work forms part of the programme of the Urban Transport and Traffic Management Section of the Overseas Unit (Unit Head: J S Yerrell) of the Transport and Road Research Laboratory, and is published by permission of the Director.

Table 1 - BUSWAYS SURVEYED

COUNTRY	City	Busway Scheme	Length Surveyed (km)	Average Stop Spacing (m)	Average Junction Spacing (m)
IVORY COAST	Abidjan	Blvd de la Republique	1.3	400	160
TURKEY	Ankara	Besevler-Dikimevi	3.6	310	410
BRAZIL	Belo Horizonte	Av Cristiano Machado	8.6	610	920
BRAZIL	Curitiba	Eixo Sul	9.5	370	430
TURKEY	Istanbul	Taksim-Zincirlikuyu	2.8	310	410
BRAZIL	Porto Alegre	Assis Brasil	4.5	560	530
BRAZIL	Porto Alegre	Farrapos	2.8	560	390
BRAZIL	Sao Paulo	Av 9 de Julho	7.9	600	530

Table 2 - SUMMARY OF BUSWAY PERFORMANCE

City, Busway	Peak Bus Flows (buses/hour in one direction)		Peak Available Passenger Places (pass/hour in one direction)		Peak Passenger Flows (pass/hour in one direction)		Average Commercial Bus Speed (kph)	
	AM	PM	AM	PM	AM	PM	AM	PM
Abidjan, Bvld de la Republique	204	197	20200	19600	16000	19500	12.8	8.0
Ankara, Besevler-Dikimevi	91	91	7300	7300	7300	6500	12.0	10.4
Belo Horizonte, Av Cris. Machado	216	205	19200	18200	15800	14500	24.6	29.3
Curitiba, Eixo Sul	94	80	11400	9800	9900	7000	21.0	21.3
Istanbul, Taksim-Zincirlikuyu	169	143	12800	11000	10700	7300	14.0	11.3
Porto Alegre, Assis Brasil	326	260	33600	27000	26100	18300	22.7	17.8
Porto Alegre, Farrapos	378	304	39400	31300	15300	17500	21.9	19.7
Sao Paulo, Av 9 de Julho	230	221	20300	19400	18600	20300	19.6	16.3



Notes: (1) 18 traffic signal controlled junctions located on the busway

Av 9 de Julio/Santa Amara

Sao Paulo

FIGURE 1