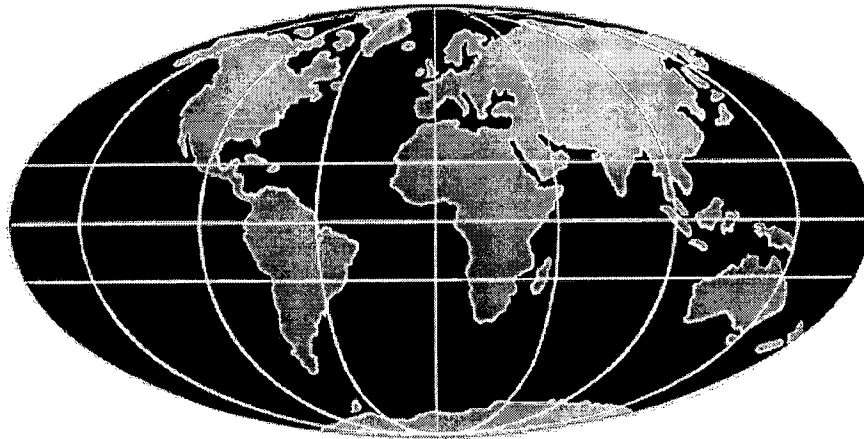


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FOURACRE, P R and G GARDNER, 1992. Mass transit in developing cities: the role of high performance bus systems. In: **Proceedings of the Conference, 'The expanding role of buses towards the 21st century'**, Institution of Mechanical Engineers, London, March 1992.

Mass transit in developing cities: the role of high performance bus systems

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SYNOPSIS

With the background of increasing problems of urban traffic congestion and pollution, and the great dependence on public transport for access and mobility, many developing city authorities are searching for cost-effective ways of providing mass transit facilities. Metro systems have been constructed in some 20 developing cities over the last 20 years, and systems are being actively planned in others. During the same period, some cities (including a few which have built metros) have adopted a less costly approach to enhancing mass transit provision, giving priority to buses in order to increase effective public transport capacity. This paper examines the potential for such high performance bus systems in Less Developed Countries, based on case-study material gathered as part of the research programme of the Overseas Unit of the Transport and Road Research Laboratory.

1. INTRODUCTION

Public transport is a growth sector in most Less Developed Country (LDC) cities. Jacobs et al (1) recorded considerable increases in conventional bus fleets, routes operated and passengers carried during the seventies and early eighties. A World Bank estimate put the number of daily bus trips in 1980 at 600 million, with the expectation that this number would double by the year 2000 (2). For a variety of reasons, data of this type is not easily established, but recent evidence from a limited number of cities suggests no change in these general trends. For example in the African cities of Abidjan, Nairobi and Kinshasa, bus passenger trips have been increasing at average rates of between 6 and 10 per cent per annum during the last decade (3).

Increasing demand for urban public transport is being driven largely by population growth. This growth not only generates more trips, but with increasing city area (and hence longer trips), there is a greater likelihood that public transport will be used in preference to walking or cycling. As a result, it comes as little surprise that public transport use is growing at a faster rate than population. The same three African cities, noted above, have experienced population growth of around 4 per cent per annum.

Personal motorised transport is still beyond the reach of the majority, and any general increases in real incomes are still likely to encourage greater use of public transport, as well as higher car-ownership levels. Indeed, in many African countries the economic down-turn has been reflected in static, or even declining vehicle ownership levels (4), which is likely to place a further burden on the public transport facilities of larger cities.

Also contributing to the seemingly inexorable growth in demand for public transport are the locational patterns of the urban poor, resulting in a need to cater for long distance commuting at low cost (5). Changing life-styles, more women in the labour force, and the youthful age structure of society, all contribute to the increasing demand for travel (6). To avoid public discontent, many countries maintain policies which actively encourage use of public transport, e.g. subsidised fare levels and significant fare-discounts for students (of all ages), and other privileged groups.

LDC cities exist today (e.g. Sao Paulo and Mexico City) which have populations in excess of 15 million, and which have to provide for 10-15

million public transport trips per day (7). By the year 2000 there will be several more of these mega-cities, and many more 'lesser' cities with populations greater than 5 million - over 40 according to one estimate (8). Road based public transport is the main carrier (1); suburban rail systems are important in only a handful of cities (for example, Bombay and Calcutta), and metro systems (of which some 20 have been built in developing cities over the last two decades), may contribute significantly along their corridors of operation, but not on a city-wide basis. In the developing world, only the Mexico City and Sao Paulo metro systems carry more than one million passengers daily (9).

In his celebrated Smeed Memorial Lecture in 1981, Bayliss (10) confidently predicted that 'the bus will become an even more important carrier in large [LDC] cities, because the expansion of car ownership and rail facilities will be unable to keep pace with growing demand.' Eleven years on there is nothing to discredit this view. In their recent study of metro development in LDCs (11), the TRRL indicated that such projects could only be sensibly justified in economic terms for very high-flow corridors (more than 700,000 passenger trips per day), associated with other ingredients for success, like high and sustained growth (in population and wealth). Few corridors in few cities will be able to match these criteria for success.

Bus transportation in the LDCs is plagued with a reputation (not always justified) for poor productivity, long journey times and excessive over-loading (see, for example, Ref 12). With the bus remaining the work-horse of urban transportation well into the foreseeable future, then ways and means have to be sought to improve its performance. One technique for increasing bus output, and also for promoting the ability of buses to handle mass movements of passengers along corridors with speed and reliability, is to provide bus priority measures, and in particular to provide reserved tracks for buses. This paper examines the development of busways in LDCs their characteristics and performance, and their likely prospects for the 21st century.

2. BUS PRIORITY

During the 1970's bus priority systems were implemented in many cities. Measures included with-flow and contra-flow bus lanes, bus streets and spot improvements. While some schemes were very effective many were ineffective due to enforcement difficulties, poor design and other factors (see, for example, Ref 13).

The main feature of bus priority schemes is the separation of buses from other traffic, either at selected locations (like bus-stops) or along running sections. Bus lanes involve 'paint and signs' to demonstrate the bus priority while busways involve construction which physically segregates lanes from other traffic. A busway may be implemented as a traffic management measure, without complementary improvements to bus operations and management, but busway transit involves a package of such measures with the general aim of promoting high output. Thus busway transit includes a right-of-way for the exclusive use of buses, with at least one section of busway and some additional features like well designed bus stops, special operating methods (bus convoys or express operations) and efficient fare collection methods.

Busways can be introduced along existing roads or be purpose-built. Along an existing road, a busway can run along the middle of the carriageway (median busway) or next to the kerb (lateral busway). Purpose-built busways can comprise a dedicated at-grade bus road (eg Runcorn New Town, UK), a dedicated right-of-way along a new road (eg Avenida Cristiano Machado, Belo Horizonte, Brazil) or an elevated busway (under consideration in Karachi, Pakistan, and elsewhere).

The earliest schemes were introduced in Europe in the early 1970's but in the late 1970's and early 1980's a series of innovative busways was implemented in various Brazilian cities, many with World Bank encouragement and assistance. Other examples of LDC busways are in Abidjan, Ankara, Bogota, Istanbul, and Lima; plans exist for others in Bangkok, Jakarta, Karachi, Nairobi and Shanghai.

3. BUSWAY PERFORMANCE

The TRRL study of busway performance (14) identified about 40 operational schemes throughout the world; eight of these, from the developing world, were selected for detailed surveys to identify operating performance. Table 1 summarises the main characteristics of each of the busways, and Table 2 the principal findings from the surveys.

The highest recorded passenger throughput on a 'basic busway' ie one with no special operational feature, was 19500 passengers per hour per direction in Abidjan; but this was achieved under conditions of extensive bus queuing, severe crush loading on many buses and poor operating speeds (8-12 kmph).

Measures to enhance the performance of a basic busway include: bus overtaking facilities at stops; trunk-and-feeder operations; bus ordering; use of high-capacity buses; off-board ticketing;

traffic signal techniques to favour bus movements; bus dwell time limitations. Some of these can have a dramatic effect on busway performance. For example, the provision of overtaking facilities alone can both increase throughput, and reduce travel time through busy bus stops by nearly 50 per cent. The use of bus ordering (where buses are arranged, as far as possible, to travel in small groups which arrive at bus stops in the correct order corresponding to the layout of the bus stand) has enabled the Assis Brasil busway (outbound section) to accommodate up to 18300 passengers per hour per direction without bus overtaking facilities or other special measures, and despite very high passenger transfer demands at one particular bus stop; this is achieved without extensive bus queuing, or severe crush loading, and at high operating speeds of around 20 kmph.

TABLE 1 Characteristics of busways surveyed

City	Busway scheme	Length surveyed (km)	Average stop spacing (m)	Average junction spacing (m)	Special features
Abidjan	Bvd de la Republique	1.3	400	160	none
Ankara	Besevler-Dikinevi	3.6	310	410	none
Belo Horizonte	Av Cristiano Machado	8.6	610	920	overtaking at stops
Curitiba	Eixo Sul	9.5	370	430	Trunk & feeder
Istanbul	Taksim-Zincirlikuyu	2.8	310	410	none
Porto Alegre	Assis Brasil	4.5	560	530	bus ordering*
Porto Alegre	Farrapos	2.8	560	390	bus ordering*
Sao Paulo	Av 9 de Julho	7.9	600	530	overtaking at stops

* Bus ordering in direction outward from city centre only (surveyed in p.m. peak)

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 (kmph)	
	am	pm	am	pm	am	pm	am	pm
Abidjan, Bvd 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	215	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	32300	15300	17500	21.9	19.7
Sao Paulo, Av 9 de Julho	230	221	20300	19400	18600	20300	19.6	16.3

These high-capacity configurations can offer substantially superior performance over basic busway schemes. From the case-study observations, four of the five schemes with special features were accommodating passenger flows in excess of 15000 p/h/d and bus flows in excess of 200 p/h/d at speeds of 17-30 kmph.

None of the busways surveyed represents an optimum design; the authorities in Sao Paulo are trying to squeeze even more capacity out of busways by making passenger transfers more simple, using metro techniques- high level platforms and wide access doors to buses. From an estimation procedure based upon the case study results, the provision of overtaking facilities at bus stops is found to be a particularly effective way to increase throughput (up to a theoretical estimate of 30000 p/h/d) and decrease journey times, particularly when semi-express or express services are operated. Trunk-and-feeder operations (in which a dedicated fleet of buses operate solely on the busway, which is 'fed' by other bus lines) also offers the possibility of high throughput (up to about 24000 p/h/d), though institutional arrangements are necessarily more complex because of the need for through-ticketing and revenue-sharing agreements.

4. THE IMPACT OF BUSWAYS

It is worth noting that there are many examples of LDC urban corridors which already carry high bus and passenger volumes without bus priority. Where road space allows, there may be no need for bus priority measures in order to achieve high bus and passenger flows as buses in very high numbers will 'create' their own priority. Even under these circumstances, however, it is likely that the provision of physical priority will create more order in the use of road space, which should increase speed and reliability for bus users and reduce the negative impacts of buses interfering with other traffic.

4.1 The users

The majority of beneficiaries of busways are likely to be existing bus-users; there has been no evidence of any major switching to bus from private modes, as a result of the introduction of priority measures in the industrialised world.

(15, 16). Though there is no comparative data from the developing world, it seems likely that the situation would be similar. (Indeed, even Third World metros have drawn their patronage almost exclusively from existing public transport users, or through generation effects - Ref 11).

Many earlier studies have attested to the level of user benefits which result from bus priority measures. Typical time gains in European and North American cities, measured over the length of the scheme, range between 20-50 per cent (16,17). Similar observations have also been noted in Singapore (18) and Bangkok (19). Small improvements in regularity have also been noted (17,19).

4.2 Bus operators

Very little quantitative work seems to have been done to assess how bus operators benefit from bus priority schemes. The benefits are likely to occur either through reduced fleet size (required to service the same route headway along the busway) or improved output per unit of cost. Where frequency and reliability in the service is improved, in response to the priority scheme, new passenger trips may be generated; there is no documented evidence for this, however.

4.3 Non-user

The impact of bus priority schemes on other road users may well negate the value of the scheme. A recent and very comprehensive evaluation of bus-lanes in the UK, using modelling techniques, has indicated that user savings have been outweighed by non-user disbenefits for some bus lane projects, but that this is usually traceable to some technical design feature which could be modified (20). This study focussed on schemes with flows up to ten times lower than in Brazil, but against this, real (and especially perceived) values of time in LDCs are very much lower than in the UK.

Interestingly, in both Singapore (18) and Bangkok (19) the improvements in bus speeds, resulting from bus priority schemes, were complemented by improvements in the speed of other traffic, a pattern which can probably be attributed to improved driver behaviour (on both sides)

resulting from the segregation of vehicles with widely differing characteristics.

In any event, urban transport development in the major cities may be reaching a stage where priorities have to be imposed. The highway network has a limited capacity, and the enhancement of public transport (in all its forms) must remain the most cost-effective way of supporting continued city centre growth.

4.4 Other impacts

The lateral position of a bus in a busway is restricted, and this can lead to tracking problems where the bus wheels make ruts in the road surface. The environment impact (both noise and emissions) of 200 buses per hour is not insignificant, and at a local level is worse than a rail based system. (Though the use of trolley buses eliminates this).

5. THE FUTURE FOR BUSWAYS

In looking at the future for busways in Third World cities, reference is inevitably made to metro construction as an alternative development option. Many city authorities have opted for a metro where a busway might equally well have served their purpose, particularly in the shorter - medium term. It is instructive to try to understand the reasons, and hence to see how busways might be better promoted.

The additional capacity which metros undoubtedly offer must be off-set against very much higher investment costs. It is difficult to make strict comparisons because metros tend to be 'closed', whereas busways often form part of an 'open' system in the sense that they may be used by many routes sometimes over the whole length, and sometimes over only short lengths. An at-grade, partially segregated busway track (excluding vehicles and terminals) costs in the order of US \$1 million per km; an elevated track may be ten times this. Metro costs range from around US \$20 million per km for an at-grade system using light technologies, to US \$100 million per km for an underground heavy system.

Operating costs of metros are similarly higher than comparative bus costs. Armstrong-Wright (23) estimated that bus costs range from 2-8 US cents

per passenger-km, whereas metro costs range from 10-25 US cents per passenger-km. Perhaps not surprisingly, few metros cover even their direct operating costs (excluding depreciation on assets).

The great advantage of busways, in particular over metros, is in their flexibility: the ability to change alignments relatively quickly in response to changing demands; the ability to implement progressively as demand increases or as funds become available; the ability to implement piecemeal projects in key areas; the ability to penetrate development, not necessarily where the main right-of-way exist. Perhaps most important of all, the development of busways builds on the cities existing wealth of experience in bus operations; as already noted the majority of public transport provision in most developing cities is, and will remain, bus-based.

The paradox remains, however, that despite the importance of buses, they receive very little support in the way of priority measures. It seems that because neither the suppliers of buses or bus services, nor any single public transport agency have complete control over the provision of track, busway transit has no natural promoter in the way that metro schemes have. Bus operators clearly have an interest, but some are very conservative in what they believe buses can achieve, and in other cases the bus operating industry is too 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 the few successful busway schemes has perhaps not received sufficient attention.

The construction of a metro is a very costly way of upgrading public transport, particularly so in a developing city with very scarce resources. Despite this, and despite the evidence relating to the problems of metro implementation and performance (11), many cities have gone along this road; furthermore, virtually every developing city which has built a metro wants to extend it. Civic prestige and the 'newness' of metros may help explain these developments; the bus is cast in the role of the traditional and somewhat hackneyed

transport, which has little more to offer in the modern world. The metro (which ironically pre-dates the inception of motor-buses) is seen as an example of high-technology; it has a modern image and invites political support as a high-profile gesture towards tackling urban transport issues.

There are important city corridors (particularly in large cities) where, if demand is to be met, there is no technical alternative to a metro. And in the right conditions, it is likely that such a metro would achieve a respectable economic rate of return. In smaller cities and along lower demand corridors busway transit could equally well meet the requirement. It seems reasonable to accept that passenger flows of 20-25,000 per hour per direction can be achieved by busway transit with appropriate infrastructure design and operational characteristics.

Funding sources will obviously be critical to any new development. Finance packages from the aid agencies and manufacturers of industrialised countries seem readily available for metro projects, but there seems little encouragement for busway projects, probably (as indicated earlier) because recipients cannot yet be convinced of their worth. Ultimately the problem may be one of image, and it may be a question of how to present busways as a new and imaginative method of transport which is as attractive as a metro. This might involve, for example, the use of new buses in special livery operating along the busway. The use of Guided Buses along the busway might also enhance the industry's image while at the same time offering the prospect of higher long-term capacity on the corridor.

Buses are going to make a continuing and strong contribution to the urban transport of developing cities well into the 21st century. The findings from the TRRL study show how to maximise output from buses, so that they may play their part in mass transit most effectively.

REFERENCES

1. JACOBS, G D, D A C MAUNDER and P R FOURACRE. A review of public transport operations in Third World cities. In 'Moving people in tomorrow's world', proceedings of a conference organised by the Inst. of Civil Engineers, London, 1986, pp 7-18 (Thomas Telford)
2. WORLD BANK. Urban transport. A World Bank Policy Study, 1986, (The World Bank).
3. TRANSURB CONSULT - INRETS. Urban transport policy in sub-Saharan Africa. In 'Satisfying urban public transport demands', a conference organised by UITP and the World Bank, Yaounde, 1991 (The World Bank).
4. BARRETT, R. Strategy Paper of The Urban Transport Working Group, Second United Nations Transport and Communications Decade (UNTACDA II). In 'Satisfying urban public transport demands', a conference organised by UITP and the World Bank, Yaounde, 1991 (The World Bank).
5. MAUNDER, D A C. Trip rates and travel patterns in Delhi, India. TRRL Research Report 1, 1984 (Transport and Road Research Laboratory).
6. FOURACRE, P R and D A C MAUNDER. Travel characteristics in three medium sized Indian cities. TRRL Research Report 121, 1987 (Transport and Road Research Laboratory).
7. THOMSON, I. The impacts of subsidies, regulation and different forms of ownership in urban but transport in Latin America and the Caribbean. In 'Urban Transport in Developing Countries', full texts of the CODATU V Conference, Sao Paulo, 1990 (CODATU Association).
8. UNITED NATIONS. Demographic indicators of countries estimates and projections as assessed in 1982. (United Nations)

9. ALLPORT R J and J M THOMSON. Study of mass rapid transit in developing countries. TRRL Contractor Report CR 188, 1990 (Transport and Road Research Laboratory).
10. BAYLISS, D. One billion new city dwellers - how will they travel? Reuben Smeed Memorial Lecture, University College, London, 1981.
11. FOURACRE, P R, R J ALLPORT and J M THOMSON. The performance and impact of rail mass transit in developing countries. TRRL Research Report 278, 1990 (Transport and Road Research Laboratory).
12. JACOBS, G D, D A C MAUNDER AND P R FOURACRE. Characteristics of conventional public transport services in Third World cities. Traffic Engineering and Control, 27(12), pp 6-11.
13. JMP CONSULTANTS. Bangkok traffic research project. TRRL Contractor Report LR84, 1988. (Transport and Road Research Laboratory).
14. GARDNER, G and P R FOURACRE. Busway transit - the TRRL study. In PTRC 18th Transport and Planning Summer Annual Meeting, University of Sussex, Sept 1990 (PTRC).
15. COMMITTEE ON THE CHALLENGES OF MODERN SOCIETY. Bus priority systems. NATO/CCMS Report No 45 1976 (Transport and Road Research Laboratory).
16. INTERNATIONAL COLLABORATIVE STUDY OF THE FACTORS AFFECTING PUBLIC TRANSPORT PATRONAGE. The demand for public transport, 1980. (Transport and Road Research Laboratory)
17. OECD. Bus lanes and busway systems. 1976 (OECD)
18. TANABORIBOON, Y, K K CHIN and H C CHIN. Performance of bus lane in Singapore - a case study. Transport and Planning 13(8), pp 136-146.
19. MARLER, N W. The performance of high-flow bus lanes in Bangkok. TRRL Research Report SR 723, 1982. (Transport and Road Research Laboratory).
20. HOUNSELL N B, and M McDONALD. Evaluation of bus lanes. TRRL Contractor Report CR87, 1988. (Transport and Road Research Laboratory)
21. ARMSTRONG-WRIGHT, A. Urban transit systems. Guidelines for examining options. World Bank Technical Paper No 52, 1986. (World Bank)

ACKNOWLEDGMENT

The work described in this paper 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.

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