BUS STOP SPACING

4.8 Bus stop spacing should be chosen in relation to the density of passenger demands, the locations of large traffic generators, road geometrics and the level of service required. As indicated in Section 2, stop spacing has a large influence on commercial speed (Figure 7), with high performance being associated with relatively longer stop spacings

BUS STOP LOCATION

4.9 The relative locations of traffic signals and bus stops should be determined in relation to local circumstances. However, substantial bus delays can occur where a traffic signal is located immediately downstream from a bus stop This is because without signal pre-emption, it frequently occurs that a bus completes loading, but the traffic signal shows red. The bus is obliged to wait in the bus bay until the signal turns to green, even though other buses may be waiting to enter the stop The following buses therefore suffer a traffic signal delay before even reaching the bus stop and, at the intersection, may incur further delays.

4.10 Placing a bus stop immediately downstream from a traffic signal controlled junction can also cause problems at high bus volumes, because buses queuing to enter the stop may back-up and block the junction (depending upon bus driver training and discipline). Successful design will involve combined consideration of signal design, passenger demand and bus flow in relation to bus stop location. The provision of grade-separated pedestrtan crossings can be considered, particularly where bus stops are located mid-block. However, enforced climbing of stairs may be unpopular with passengers.

5. EVALUATION

DEFINITION OF OPTIONS

5.1 Comparison of bus and rail mass transit options can present problems because of the different characteristics of the two systems. In particular rail systems require a depot (usually in a suburban location because of land requirements) and a substantial track length before they can be effective and attract passengers, whereas busway systems can be developed incrementally Furthermore, rail mass transit is a "closed" system in which all the costs of infrastructure and rolling stock can be attributed to the system, whereas busway transit is an "open" system in which buses may use the busway on only a minor part of the route length, making definition of "the system" and cost allocation difficult.

5.2 It will often be unreasonable to compare the costs and benefits of bus and rail systems over identical route lengths, because bus priorities are only required in congested areas ; elsewhere, buses can run on all purpose roads with general traffic, i e. no special facilities are required. The total length of infrastructure required will therefore be different.

5.3 Bus and rail transit options also have implications for movement patterns and land development: by their nature, rail systems tend to concentrate passenger flows (especially where bus services are "integrated" with rail) whereas bus transit tends to offer a more dispersed pattern of movements Evaluation of these effects depends upon the land use-transport strategy of the particular city.

BUSWAY TRANSIT COSTS

Capital costs

5.4 Out-turn cost data for existing busway schemes vary according to design standards, construction procedures, initial condition of the roadway, local inflation rates, exchange rate variations, and so on However, a typical at-grade, partially segregated busway track might cost of the order of US$ 1 million/km (1989 values), excluding vehicles and terminals, based on the following assumptions.

- no land acquisition would be required and existing road kerblines would not be moved.
- the existing median would be removed in order to allow busway construction.
- existing road drainage would be adequate and would not be modified.
- the existing road pavement would be adequate except in the bus stop area, where complete reconstruction would be required.
- no extensive diversion of public utilities would be required.

5.5 General guidelines for the cost of an elevated busway pose even greater difficulties than those for an at-grade busway, due to the wide range of possible construction techniques, foundation conditions, bus stop treatments and other features. There is little direct experience of the cost of elevated busways since no extensive sections have been constructed, although several are under consideration (e.g. Karachi). Based on UK conditions, a representative elevated busway is estimated to cost of the order of £10 million (US$17 million) per km (1989 values). The approach being taken in several current proposals for elevated schemes is to consider elevation only where traffic capacity at selected junctions is critical. Clearly if bus stops can be accommodated at-grade, considerable cost savings are possible.

5.6 The physical quality of most existing busways is not high and this is reflected in the above cost esti-mates. For example, passenger facilities (stops; shelters; crossings; passenger information sys-tems) are often extremely basic and of low quality, and consequently have a poor image. The bus track is often poor, since existing pavements are often retained in bus stops areas in order to minimise costs. In several existing busways, pavements have deteriorated due to tracking (e.g. Istanbul; Porto Alegre) and in some cases, the pavements have failed (e.g. Abidjan; Recife). The costs of improving the physical quality of an at-grade busway would not be great. The public image would be enhanced, scheme life would be prolonged and maintenance costs reduced. Even with such improvements, the per km costs would still be substantially below those of an equivalent light rail transit (LRT) system.

5.7 The costs of associated infrastructure will vary from place to place and will depend on local require-ments. The cost of a footbridge might typically be the order of US$80-100,000. Where a comprehen-sive busway transit system is to be implemented, new depot and workshop facilities may be required, particularly if high-capacity buses are to be intro-duced Again, costs depend upon many local factors, but a new depot for about 200 buses could cost in the region of US$6-8 million (excluding land costs). A workshop and central stores facility might cost a similar sum, depending upon the scale of facilities required. (Cost estimates 1992 US dollars unless stated otherwise).

5.8 If a trunk-and-feeder system is to be operated, transfer terminals will be needed along the main axes together with a terminal station at the end of each corridor. Costs depend upon many local factors but could be of the order of US$500,000 for a basic transfer station and US$800,000 for a basic terminal station (excluding land costs). The out-turn costs of the various high-quality terminals in Curitiba, for example, were of the order of US$ 1 million for each transfer station and US$3 million for each terminal. However, terminals may offer development opportunities and additional sources of revenue.

5.9 The infrastructure costs of atgrade busways are generally low compared to those of other segre-gated mass transit modes: the typical busway track infrastructure costs of the order of US$1 million per km compares with estimated costs for mass transit railways (including rolling stock and other equip-ment) in the range US$8-27 million/km (1987 values) for at-grade construction, US$22-60 elevated and US$50-165 underground (Fouracre et al, 1990).

5.10 In Ottawa, it was estimated that the capital cost of a busway system would be 68% of the cost of a comparable light rail system. Figures for Pittsburgh indicate the cost of the city's busways were of the order of US$5 million/km for the South corridor and US$10 million/km for the East corridor, compared with some US$27 million/km for the city's LRT (Kain et al, 1990). In Auckland, corridor studies compared LRT and O-Bahn options and the findings suggest that the capital cost of an O-Bahn would be about half that for a comparable LRT (Auckland Regional Authority, 1988). In Adelaide, where an O-Bahn has been implemented, preliminary design estimates suggested that for comparable LRT, busway and O-Bahn systems (including track, control systems, depots, rolling stock etc.) the costs of the conventional busway and O-Bahn systems would be 58% and 65% respectively of that of an LRT system (Wayte, 1988).

5.11 In developing countries, the foreign exchange requirement of a proposed investment can be an important criterion in the selection of a technology. Busway transit offers considerable scope for construction by local contractors and, where a local assembly or body-building industry exists, a substantial part of bus costs can be incurred locally.

Operating costs

5.12 Estimated operating costs of busway transit are in the range 8-12 US cents per passenger km. (from Armstrong-Wright, 1986, with costs factored to 1993 prices). The key components are labour, energy and replacement materials.

THE IMPACT OF BUSWAY TRANSIT

The users

5.13 The majority of beneficiaries of busway transit in developing cities are likely to be existing public transport 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 (although few cities have extensive, high quality, bus priority systems.) There are strong conceptual grounds for believing that most private vehicle users in developing cities are unlikely to be attracted to use of public transport; these travellers come mainly from high income groups, who will value comfort and convenience of personal transport very highly.

5.14 Many earlier studies have attested to the level of user benefits which result from bus priority meas-ures. Typical time gains in European and North American cities, measured over the length of schemes, range between 20-50 per cent. Similar observations have also been noted in Singapore, Bangkok and Porto Alegre, in the latter, journey times were reduced by 29 per cent. Small improve-ments in regularity have also been noted. Busways can result in improvement in the quality of travel, particularly if the investment includes new rolling stock which is clean and comfortable. There is anecdotal evidence from Curitiba and Nagoya that a high quality system will generate new passengers in addition to attracting transfer from other modes.

Transport operators

5.15 Busways can help to reduce bus operating costs in several ways

- bus commercial speeds can be raised by removing buses from general traffic congestion and, since bus operating costs are speed-related, operating costs can be reduced.

- because buses can achieve higher average speeds, fewer buses are required to operate a given service, thus saving in capital costs.

- busway transit may generate opportunities for scale economies which might not otherwise be feasible (e.g. use of high-capacity vehicles).

Non-users

5.16 It is impossible to generalise about the effects of introducing a busway into an existing road network. In a dense road network, a busway may influence traffic flows and journey times both along the busway corridor and on adjacent roads. In such cases, some form of network modelling is required to assess the possible reassignment of general traffic And in any event, some form of junction analysis will be required to estimate the effects of the new junction arrangements on junction capacity and delays (e.g. using software such as SATURN, OSCADY etc).

5.17 In some cases, the improved traffic management associated with bus priorities has led to travel time gains for both buses and general traffic (e.g. Bangkok). In Abidjan, introduction of a median busway across the city centre was perceived to have benefits to both the bus operator ("independence from general traffic") and to general traffic ("getting buses out of the way of cars"). Nevertheless, where a busway or bus lane continues up to a signals stop line, in order to give buses priority, there will be some loss of capacity for general traffic. This may be offset by gains to buses and passengers but the effect must be examined on a case by case basis in relation to person throughput, traffic flows and residual capacity.

5.18 Busways (and transit systems in general) are often promoted on the basis that they can contribute to relief of city centre traffic congestion through encouraging a modal switch from private to public transport. The evidence for success in this objective is, unhappily, not strong, most users of the busway will not have switched modes, but will be using a bus which has simply switched from an unreserved to a reserved track within the same right-of-way. Even where there may have been a switch from private to public transport, the improved traffic conditions on the road network will quickly induce new car traffic to emerge.

5.19 However, there are reasonable grounds for supposing that busways (in common with other mass transit) could have some influence on the spread of traffic congestion. With increasing car ownership and use, city centre traffic congestion reaches what has been described as the threshold of the intolerable, it cannot get any worse, and assuming all traffic engineering measures have been exhausted, can only spread more widely, rather than more deeply. New roads to access the city centre may improve the situation, but there are limits to what can be achieved, simply because the land is not available and the resulting environmental damage is likely to be too great. A mass transit system, making the best use of the existing road system, provides the capacity needed to access the city centre, without the associated penalties of road building. In providing greater access, the mass transit system helps to reduce the spread of traffic congestion.

5.20 The environmental impacts of any particular scheme will require detailed assessment in the light of scheme characteristics and local circumstances. Busways, by their nature, provide a high-speed track in built-up areas where pedestrian activity will be intense. The resulting severance, safety, noise and air pollution effects all warrant particular attention. Severance effects can be minimised, and safety enhanced, by suitable urban design and by the provision of adequate pedestrian crossing facilities. Some busways have been designed so as to minimise the interaction of pedestrians and vehicles; but pedestrian crossing points are inevitably necessary (if only to access the busway), as is interaction with other traffic at grade junctions and along unprotected rights-of-way.

5.21 On-street noise and air pollution effects of busway transit can be minimised through the use of modern, LPG (liquid petroleum gas) or CNG (compressed natural gas) powered buses, or electric powered trolleybuses.

5.22 Because of the severance effect of any at-grade median transit system (bus or rail), local access requires particular attention. Strict parking, waiting and loading controls will be required in order to ensure adequate servicing and roadspace is available for moving traffic along the corridor.

Urban development

5.23 The essence of a city centre is that it is the most accessible point from both within and without the city. This accessibility is important for many activities, and in particular for those central functions which serve a wide area and/or need a wide labour market: head offices, central government offices and legal institutions, financial institutions, media firms, theatres, department stores, etc. and all the supporting organisations (catering, hotels, etc.) that exist to serve these central functions. The fortunes of the city centre are at risk if the public transport system proves inadequate in supporting these central functions. In most developing cities, the majority of commuters to/from the centre depend almost exclusively on road-based public transport. If the city centre becomes congested (because too much traffic is occupying too little road space), then its relative accessibility may suffer, because the public transport system cannot perform effectively. As a result, new central functions will be discouraged from locating in the city centre and old established ones may start to drift away. Clearly, there is an intimate and vital relationship between the well-being of the city centre and its public transport system which should never be overlooked. For this reason, it is becoming increasingly apparent that urban transport development in the major cities may be reaching a stage where priorities have to be imposed, and mode choice has to managed to the advantage of public transport systems; the limited supply of road space feeding the city centre is exhausted, and the only possible relief would seem to be through the development of a mass transit system, like busway transit, which makes best use of the available road space.

5.24 Apart from promoting the performance of public transport, and thereby contributing to the healthy growth of the city, mass transit systems may have their own intrinsic developmental impact on a city Mass transit schemes have sometimes been proposed to enhance or encourage new city development and/or renewal. For example, it is reported that the development of the LRT in Manila has played a key role in shaping the urban development of the metropolis, triggering the redevelopment of the traditional centres of business and trade, and encouraging commercial growth along its route. This impact of mass transit is not fully understood and has not always worked, in particular where planning controls on urban development are weak. Generally, if a city has a buoyant economy then a mass transit system can contribute to and accentuate that condition by removing accessibility constraints; on its own, however, the mass transit system can do little. Thus ideally busways should be developed in unison with other on-going major developments within the city.

5.25 A number of mass transit schemes have managed to capture some developmental benefits for their own financial gain. This has been achieved through the commercial development of the air-space above terminals and interchanges; these revenues can contribute to both the capital cost of the structure and/or to general income.

Other impacts

5.26 Public transport is often used by people who do not have access to private, motorized transport include-ing children, old people and women. This means that improvements to transit services can have important social impacts. For example, suitable bus seances can offer mobility to women who may not otherwise have access to motorized transport, and can increase their access to work opportunities, and to educational and social activities.

5.27 In developing countries, the foreign exchange requirement of a proposed investment can be an important criterion in the selection of a technology. Busway transit offers considerable scope for civil engineering construction by local contractors and, where a local assembly or body-building industry exists, a substantial part of bus costs can be incurred locally.

ECONOMIC EVALUATION

5 28 An economic analysis of any busway project should try to take account of all the impacts which have been discussed. Many of these impacts are clearly difficult to quantify. A busway scheme is likely to improve bus commercial speeds and reliability, and therefore the potential benefits are typically: journey time savings to bus passengers (including the value of increased reliability), and bus operating cost savings (including a possible reduction in fleet size). In general, the majority of benefits are likely to be associated with time savings at junctions. However, the analysis should also take into account changes in journey times and operating costs for other road users, especially if some reassignment of traffic is anticipated. Depending upon local geometry and traffic flows, introduction of a busway may increase or decrease the capacity available for general traffic, particularly at junctions, and detailed junction analyses are required to estimate these effects.

5.29 Finally, no study has examined the crucial issue of the developmental benefit to the city centre of a busway scheme. It is a very complex issue since it raises questions about the city structure and its efficient growth; these are questions which go beyond the bounds of urban transport planning, and pose major conceptual and technical problems of analysis. If the continued growth of the urban centre is an urban development objective then the busway scheme can be considered as a major positive contribution to achieving that end.

6. REFERENCES AND BIBLIOGRAPHY

ALLPORT R J and J M THOMSON, 1990. Study of mass rapid transit in developing countries; *TRRL Contractor Report 188.* Crowthorne : Transport Research Laboratory.

ARMSTRONG-WRIGHT A, 1986. Urban transit systems: Guidelines for examining options. World *Bank Technical Paper No 52* Washington DC: World Bank.