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How far can bus capacity be stretched ?

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1. INTRODUCTION

Over the last decades many cities in the developing world have experienced rapid growth in their population. Recent trends (Bayliss, 1981) indicate that the total urban population in developing countries will reach the 2 billion mark by the year 2000, with 60 or so metropolitan areas expected to hold at least four million inhabitants, i.e. doubling the 1980's figures.

One of the greatest challenges faced by these metropolitan areas is that of urban transport. Travel times and congestion do not compare favourably with cities of equivalent size in the developed world. In many cases, fast growth in car ownership, not accompanied by supporting investments in traffic engineering measures, will contribute to further deterioration of the present levels of congestion. Public transport is often considered incapable of coping with this ever increasing demand; users are constantly pressing for better levels of service which usually require new investments in the sector.

During the past two decades several developing countries decided to invest in heavy rail systems as the only solution to cope with increasing demand for public transport. Thus, metros were built in cities like Mexico City, Santiago, Sao Paulo, Rio de Janeiro, Seoul and Caracas. Other cities invested in suburban railways. There is no doubt that rail based systems are capable of moving large numbers of people and offer a very good level of service. Figures of the order of 25 to 60 thousand passengers per hour and direction are often quoted as the ideal ranges of peak demand for metro systems. Rail technology is well understood but expensive. In most cases the resources required were found to be well in excess of the original estimates and metro costs sometimes reached 110 million dollars per kilometre (World Bank, 1986). These investments were often financed through loans, sometimes from the same countries selling the technology, and therefore contributed to the heavy debt burden now faced by most developing countries.

Unless current trends are reversed, the overall situation of urban public transport in developing countries will tend to deteriorate even more over the short run. Minimum-wage urban dwellers find it hard to cope with the ever increasing transport-to-work expenditures; in some cases fares may reach up to 30% of total incomes (Ministerio dos Transportes, 1985). In the past, many countries have relied on cheap foreign money to either upgrade or built new transport systems where fare revenues not even covered the full operational costs. On the other hand, external funds for public transport projects are likely to become scarcer as developing countries struggle to keep debt payments and banks re-evaluate previous lending policies to contemplate countries not in default with the system. Within this context we address the subject of this paper: is it possible to stretch the capacity of lower costs systems, like the humble urban bus, so that more passengers can be moved at a reasonable cost?

2. BUS PRIORITY

It is conventionally accepted that the main differences between urban road and and rail based public transport systems are the flexibility, speed, cost and capacity of the services provided. Most authors in the field attempt to summarise the alternative levels of service in terms of figures and tables where the cheap, slow, flexible and low-capacity small-bus stands at one extreme of the [illegible] whereas the sophisticated metro lies at the other; the intermediate region favours a variety of alternative modes, ranging from buses of various sizes to other forms of rail transit systems. General indicators of performance for such systems and parameters for cost vs. demand relationships can be found in Vuchic (1981) and Armstrong-Wright (1986).

There is no doubt that the performance of a bus on its own, sharing the road space with other traffic, deteriorates very quickly as congestion increases. Many countries have adopted priority measures to protect the bus from congestion and even favour its passengers as they ride a more efficient user of expensive road space. Bus detection and priority at traffic signals, with-flow contra-flow bus lanes, permitting entry or turns prohibited to other traffic and the provision of totally segregated or even elevated busways are some of these measures. Many schemes result from combination of several features as it would be the case of one arising from the introduction of reserved bus lanes, bus detection and off-line bus stops. Most of the schemes are reviewed by studies such as the ones by Levinson et all (1973), Committee on the Challenges of Modern Society (1976) Union Internationale des Transports Publics (1972).

Similar ideas have been tried in developing countries as well, sometimes with limited success. With-flow, kerb-side bus lanes seem to work well for relatively low levels of bus flows or when strict control of stationary and moving violations is maintained. Enforcement seems to be crucial but it is often difficult to maintain for long periods. In other cases, bus flows were high enough on their own to enforce a de facto priority over one and sometimes two lanes. The introduction of a single bus lanes in those cases benefits non-bus traffic much more than public transport operations. The mutual interference generated by numerous buses on some roads plus their sometimes semi-chaotic behaviour around bus stop areas with large numbers of passengers is a critical element in improving the performance and capacity of such systems. These problems are seldom present in developed countries and therefore their priority systems do not cope well with them.

Some countries, Brazil in particular, have tried more innovative bus priority measures trying to solve precisely some of the points above. This paper discusses some of these technological solutions currently available for transport professionals willing to further explore the capabilities of the bus as an alternative mode to cater for high-passenger peak flows.

3. THE CHOICE OF PRIORITY MEASURE

To help with the initial stages of deciding which priority to adopt, different guidelines were established by previous authors. They range from general 'rule-of-thumb' criteria to more detailed indications expressed in terms of results generated by implemented schemes, test track experiments and computer models. A critical review of some of these guidelines is included in Lindau (1985). [illegible] summarise minimum flow and capacity criteria for the introduction of different types of bus lanes along urban avenues for illustration purposes only.

TYPE	MINIMUM FLOW(peak) buses/h	CAPACITY buses/h	pass/h
with-flow bus lane	30-40	150	7500
contra-flow bus lane	40-60	130	6500
Double bus lane	120 +	300	15000
Median bus lane	60-90	420	21000 +

As it can be seen, some of these options provide fairly high capacities, in particular the case of median bus lanes, a type of solution extensively tested and perfected in Brazilian cities. However, these criteria are only approximations and should only provide preliminary guidelines for the types of solutions to consider. Each particular technology should be studied in detail and adapted to the local conditions.

4. CONVENTIONAL BUS LANES

Kerb-side with-flow bus lanes are conventionally seen as a way of protecting buses from congestion generated by other traffic. The provision of a with-flow bus lane permits buses to get ahead of traffic queues, in particular at signal controlled junctions. Such bus lane re-distributes queues and delay but as buses carry more passengers per PCU (passenger car unit) the overall delay is reduced.

If bus flows are low, then it is advisable to interrupt the bus lane before it reaches the stopline. This interruption is called a setback and it is so designed that, while buses clear the junction in the first green, the full width of the approach at the stopline is available to all traffic, thus increasing the capacity of the junction. As a first approximation, the length of the setback can be estimated as two metres per each second of effective green at the downstream junction. Better values can be obtained using detailed models (Oldfield et all, 1977) that estimate setback lengths that minimise overall delay to passengers.

Setback design guidelines assume that bus stops take place away from the stopline and that there are no violations to the bus lane. As bus flows increase buses will begin to interfere with each other, in particular at stops. A bus ready to leave the stop area will be unable to do so because the one in front is not ready to depart. Others will not be able to access the stop area and will begin to drop and pick up passengers wherever possible. This generates a high-friction environment which is very distressing to passengers. In some cases double bus lanes have been introduced to cope with increased bus flows (Pardo and Jofre, 1984); however, this may result in passengers being dropped and collected on two parallel lanes with little protection and thus adding to the chaotic environment. Stationary and moving bus lane violations will further reduce the operational effectiveness of such schemes. These conditions are typical of many cities in the developing world but there is limited research and understanding to support good technical solutions to these problems. Some of this research is reported in this paper.

Contra-flow bus lanes are often introduced where one-way schemes make it difficult to provide good access by public transport to an area. A contra-flow bus lane can cope with similar number of buses as with-flow bus lanes and in suitable cases may generate important time and distance savings. They

have the added advantage of being almost self-enforcing as violations are far less likely to occ
However, they have the same problems with bus stops as with-flow lanes and are thought to be mo
dangerous unless very well signposted and marked. Moreover, good green wave progressions in bo
directions are much more difficult to achieve.

Conventional bus lanes always pose access problems to roadside premises. Special arrangements
needed for loading and unloading goods and passengers. If these are not adequate static violatio
will take place further reducing the efficiency of the bus lane.

5. MEDIAN BUS LANES

Located in the middle of two-way avenues, many median bus lanes make use of the right-of-way form
reserved for tram operation. Up to the late 70's- early 80's median bus lanes were extremely rar
one will find only little reference to them in the European and American state-of-the-art studies
the 70's.

Median bus lanes are recommended in the case of dense urban corridors with somewhat wide lane
avenues, a situation which is representative of many accesses to central areas of cities in
developing countries. Furthermore, if flows are greater than 60 to 90 buses (2400 to 3600 passeng
during the peak-hour, and three or more lanes of traffic are available, median bus lanes as oppo
to the more conventional kerb lanes, are recommended by existing design criteria (National Resear
Council, 1985). Median bus lanes have a big advantage in being easier to enforce; also, they do n
disrupt access to roadside premises. They require, however, a greater effort in design (in partic
for turning movements) and are more expensive to implement than conventional bus lanes.

Perhaps the major contribution towards understanding the full capabilities of median bus lanes h
been provided by bus priority schemes implemented in Brazil. Contrary to other locations where
schemes are implemented to overcome congestion, in Curitiba several structural radials routes we
built as part of a urban development package aimed at regulating the growth of the city. Such radi
routes are formed by three separate roads running in parallel. The middle road consists of an
exclusive 7m-wide 2-lane busway flanked on either side by single direction service roads. The tw
outer roads are single direction multi-lane roads. The busway is separated from the service roads
continuous islands; this protection is only broken at signal-controlled grade intersections. An
overall description of the concept is found in Fouracre (1975).

The median bus lane experience gained in Curitiba was later transposed to other Brazilian cities su
as Goiania, Recife, Sao Paulo and Porto Alegre. However, it was soon realised that unless major
modifications are also introduced at the operational level, the sole implementation of a priority
lane could even deteriorate bus-flow capacity during heavy peak-hour conditions.

6. BUS-FLOW CAPACITY

We have seen that the capacity of bus priority schemes is basically controlled by the traffic
behaviour at bus stops. Capacity is hereby defined as the maximum number of buses being served by
critical bus stop during the period of one hour. The critical bus stop is taken as the most heavily
used of the stops located along the road.

There is very limited understanding of the traffic behaviour at heavily used bus stop areas. The
Highway Capacity Manual (National Research Council, 1985) summarises previous research efforts
conducted in the USA into developing analytical equations to determine capacity at near side bus
stops as function of passengers boarding and traffic signal settings. The model incorporates facto
to compensate for dwell time and arrival variations, as well as one to represent the cumulative

capacity efficiency resulting from varying the number of possible bus loading positions. Studies conducted in Sao Paulo, Brazil (Companhia de Engenharia de Trafego, 1979) established a few simple relationships where bus flow capacity at critical bus stops is expressed in terms of the total number of passengers boarding buses.

Figure 1 attempts to summarise the existing knowledge in the field. Different bands are constructed based on the American and the Brazilian criteria. For the sake of comparison, data from field and theoretical studies conducted in Sao Paulo was fitted to all equations; for details concerning equations and parameters see Lindau (1987). The results produced by the two lower bands indicate that, under usual multi-loading bus boarding conditions it is difficult to expect stop capacities above 300 buses per hour for the case of 1000 or more passengers boarding per hour; note that the upper limit of the Sao Paulo band (before introducing convoys) is determined by the chaotic peak hour boarding conditions. On the other hand, one of the virtues of figure 1 is to show the potential improvements in performance to be achieved if buses travel and stop in ordered groups, or convoys.

7. BUS CONVOYS

During the 60's tests were conducted at the General Motors proving ground (Herman et all, 1970) to study the potential of bus convoy operations. The investigation concentrated in determining the transient characteristics of a convoy of buses starting and stopping at stations in similar conditions to those of the operation of metros. Very high capacities were observed (Scheel and Foote, 1969) along the exclusive bus right of way. The conditions tested were similar to the ones that would be encountered along freeways, in that there were no traffic signals between successive bus stops to disrupt bus convoys.

In the late 70's, a somewhat modified convoy concept was introduced in Brazil (Szasz, 1978). In Sao Paulo, a convoy co-ordination station was built on Av. 9 de Julho in order to improve the performance of a 300 bus per peak-hour volume. Along a 4 km section of the avenue peak-hour speeds increased from 10 to 18.5 km/h when convoys of six buses were used. These improvements in speed and capacity resulted mainly as consequence of better passenger boarding procedures at stops. Instead of the former confusion arising from passengers running to board queued buses sometimes as far as 100 meters from stops, ordered convoys enabled passengers to assemble at previously specified loading positions.

Bus convoys are formed by dividing all bus lines sharing a specific corridor in different groups according to their routes and destinations. At a co-ordination station, usually located at the downtown extremity of the corridor, buses assemble in different queues, one for each alternative group. A convoy is released upon its completion in such a way that the previously established order of buses is guaranteed. Buses travel together and stop almost simultaneously to set down and pick up passengers.

Capacities very close to the lower end of rail rapid transit systems can be obtained with this arrangement, provided the bus drivers maintain the necessary discipline to operate in this way. As several modifications have been recently introduced in Sao Paulo, perhaps nowadays the best examples of bus operation in ordered convoys are to be found along corridors located in Porto Alegre.

8. BUS CONVOYS OPERATING ON MEDIAN BUS LANES

In Porto Alegre, bus priority schemes started in 1980. Some 30 km of median lanes were built along 5 radial roads with total infrastructure costs averaging 1982's US$ 1 million per kilometre (EBTU, 1983).

The overall design concept was greatly influenced by the previous Curitiba experiments. However, the initial plans had to be revised as the private operators failed to amalgamate part of their companies

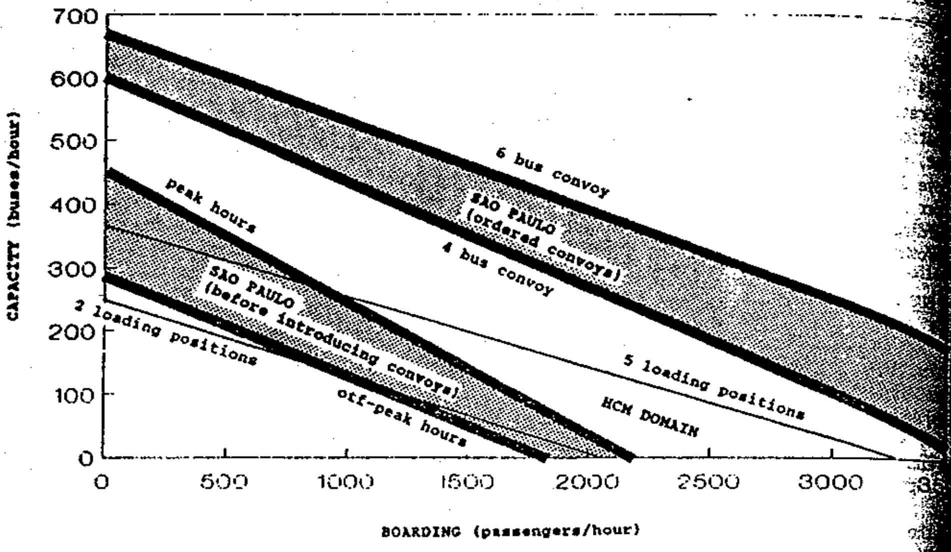

Fig 1: Bus stop capacity

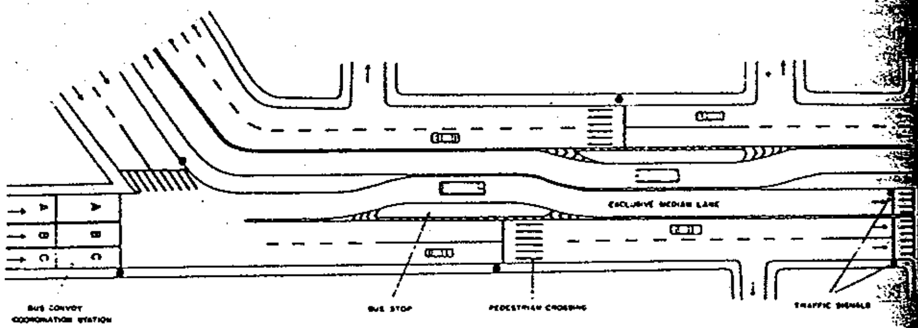

Fig 2: Median bus lanes in Porto Alegre

unto one to provide the trunk service along the median lanes of the two main corridors: Farrapos and Assis Brasil. As consequence, bus stations had to be extended to accommodate a much larger flow of buses and the ordered convoy concept had to be introduced.

In 1981 peak bus flows totalling almost 500 vehicles per hour were registered along the Farrapos corridor; some of these consisted of old and slow moving enlarged buses and many vehicles were still being operated under mixed traffic conditions outside the priority lane. Consequently travel speeds never reached the 25 km/h level predicted by the former operational plan. After the recent upgrading of competitive suburban rail services, bus flows have almost halved. There is now scope for significant improvements in speeds; former convoy settings should be reviewed and traffic signal detection equipment could be implemented. Branco(1985) reports that bus travel times have reduced 14% along the Assis Brasil corridor once loop detectors were inserted on some key junctions.

Figure 2 depicts some of the typical features incorporated in corridors implemented in Porto Alegre. It includes traffic signals at intersections and mid-block pedestrian crossings, specially devised bus-stops for simultaneous boarding of passengers and a bus convoy co-ordination station.

9. RECENT DEVELOPMENTS

In the case of Sao Paulo, it has been difficult to preserve the necessary drivers' discipline to run convoys efficiently. In an effort to overcome system saturation in terms of transport capacity, the early 9 de Julho scheme in Sao Paulo has been recently upgraded. The main improvements include a considerable extension of the median bus lane to offer an 'express system' along the Santo Amaro- 9 de Julho corridor and a main design effort in providing off-line bus stops (Kato, 1986). Along the 11.8 km of the corridor, 16 of a total of 19 stops are provided with an extra lane to allow bus overtaking manoeuvres. The daily demand for bus journeys along the corridor totals 600 000 passengers per day.

The corridor is being used by the same mix of privately owned buses that were formerly running in mixed traffic conditions. Even before the design was fully implemented (bus lanes partially completed and no traffic signal co-ordination) bus operations improved considerably. The travel time by bus from Santo Amaro to the city centre was reduced from 80 to 50 minutes and this has been achieved at the expense of adding 10 minutes to a similar journey by car. More benefits, including environmental ones, are expected to arise when the corridor is operated by trolleybuses. If operated according to original plans the combination of partial stop routes and off-line stations would provide the required grounds for further increasing the currently known levels of bus-flow capacity along median bus lanes.

It is also worth mentioning the 33 kilometres of segregated trolleybus lanes being implemented between Sao Mateus and Jabaquara by the Sao Paulo Metro (Secao Transporte de Massa, 1986). It incorporates operational concepts such as on line computers and radio systems to control a fleet of 141 trolleybuses, 55 stops and 9 terminals. The system is expected to serve 250 000 passengers (15 000 peak direction hourly flow) with average operational speeds of up to 25 km/h.

10. DESIGN METHODS AND MODELS

The design of bus lanes relies on a combination of established manual methods, computer modelling and pragmatic trial and error. Sound design methods exist for conventional bus lanes, with and contra-flow. These were established after several years of experimentation assisted by the use of detailed computer simulations. The role of these computer models was to generalise guidelines and to study the scope for optimisation in the design of such schemes. Probably the best know of this work was carried out at the Transport and Road Research Laboratory (TRRL) resulting in theoretical models to investigate the economic justification for the installation of a with-flow and contra-flow bus la[nes]; see Bly and Webster (1977) and Oldfield et al. (1977).

These were detailed models considering road sections with two or three lanes in each direction with a signal controlled intersection at each end. The models take into account the different behaviour of priority and non-priority vehicles in various parts of the links: at the beginning of the reserved lane, along the section containing the reserved lane, and in the queuing area at the signalised junction beyond the reserved lane. The models estimate delays under different conditions and permit detailed calculations of time and fuel savings to different kinds of users under varying design conditions. Results from these models were used to develop guidelines for practical design using manual methods.

In attempting to overcome some of the 'trial and error' shortcomings experienced in earlier median bus lane/bus convoy designs, a microscopic simulation model was formulated. SIBULA (Lindau, 1983) enables the investigation of a wide range of geometrical and operational concepts behind high-flow bus priority schemes. The model incorporates traffic data collected along radial corridors of Porto Alegre and is the only program capable of simulating median bus lanes and bus convoys in detail.

SIBULA (Simulation of Bus Lanes) is written in FORTRAN and currently runs on a main-frame computer. Its microscopic nature, which enables the detailed representation of individual vehicles in the traffic current, provides an excellent environment to test alternative design concepts; it is even capable to simulate 'do-nothing' conditions where road space is shared by buses, lorries, vans and cars. Amongst its main features is the possibility of representing blocking effects of queues, bus overtaking and forced lane changing manoeuvres in the vicinity of bus stops. On the other hand, such detailed representation can only be achieved after undertaking individual calculations for every vehicle being modelled and consequently detailed data collection and long computer times are required. Nevertheless, much faster computer runs can be achieved if only median bus lanes are simulated in detail.

Results produced by SIBULA show, for instance, that no advantage in terms of system capacity and operational speed of buses was derived from a priority scheme based solely on the provision of a median lane for the exclusive use of buses at high-flow input conditions; a good treatment at bus stops or bus convoys was required for major changes in capacity. It was also found that cars did not always benefit from being physically separated from the bus flow. Implementing signal progression to benefit buses was shown to be an effective measure when fixed boarding times were the norm; this suggests that variability in bus boarding times can disrupt any benefits that would arise from signal offsets specially adjusted to give progression to buses - similar conclusions were derived from extensive field experiments with TRANSYT in Chile (Willumsen and Coeymans, 1987).

Bus fuel consumption was also investigated; it was found to be more related to variations in the number of stop-start cycles than to changes in average travel speeds. The relative fuel economies resulting from large increments in average speeds, such as the ones achieved through the adoption of ordered convoys, were not as significant as the relative economies resulting from a good location of the bus stop in relation to the downstream intersection.

Regarding bus-flow capacity, SIBULA shows that increments in the size of convoys consistently improved system capacity. For practical reasons a maximum size of convoys was considered to be seven buses; very high input flows may cause disruption of convoys at the traffic signals which in turn severely affects the flow of buses. Porto Alegre data fitted to the model showed that capacities up to 420 buses/hour were achieved with corresponding journey speeds just below 15 km/h, when ordered convoys were inserted in median lanes fitted with on-line bus stops and where no bus overtaking manoeuvres were allowed.

11. COMPUTER ASSISTED DESIGN OF BUS LANES

Some detailed models are of use in the development of guidelines and manual methods for the design of bus lanes. However, manual methods necessarily simplify the design problem therefore reducing the scope for making optimal decisions better adapted to the particular conditions and constraints of a site. Manual methods may also fail to estimate the effect of implementations falling short of design standards. Also, general purpose traffic management models like SATURN (Hall et al, 1980) are not formulated to properly represent the performance of bus lanes for design purposes.

What is needed are computer assisted design methods capable of estimating the performance of different arrangements at a site. The software should be easy to use and run on micro computers to extend its application. The model BLISS, developed at University College London by Iunes and Willumsen (1988) attempts to play that role, at least for with-flow bus lanes.

BLISS (Bus Lane Interactive Simulation System) is a specially developed program for modelling bus lanes simulating each second of operation for a given set of flows and geometric features. It estimates queue lengths and average delays to priority and non-priority vehicles and to passengers. The model tries to represent the different behaviour and traffic composition of priority and non-priority vehicles at three key points of the road being simulated: at the merge point at the beginning of the bus lane; along the section containing the reserved lane; and in the queuing space at the signalised junction beyond the reserved lane.

One of the main advantages of BLISS is the visual display of the build-up and decay of queues which facilitates the interpretation of the results. This display also contains information on average delay and queue lengths at the critical points on the link. BLISS uses a platoon dispersion model similar to TRANSYT to study the potential for co-ordinating traffic signals to speed up traffic operations. The model is simple and fast; it can simulate an hour of operation of a bus lane in less than 5 minutes in an IBM PC. This facilitates testing of alternative arrangements. BLISS is being extended to simulate bus stops in detail, this being the main limitation for its use in developing countries.

But the design task requires more than just better practical simulation models. The role of the expert designer is crucial in selecting the right features for a particular situation. The choices will depend on local conditions and practices, in particular in respect to bus operations, role and level of development of private and municipal bus companies, driving practices, traffic regulations, levels of enforcement, roadside land uses, and patterns of behaviour of passengers and pedestrians. There are very few experts world-wide in this field.

Advances in information technology, artificial intelligence and expert systems in particular, are likely to change the way on which transport engineering expertise is translated into software tools. Expert systems provide versatile methods for representing and manipulating knowledge in the computer and using it to complement more traditional programs implemented in procedural languages. The growing importance of expert systems in our field was subject of recent events conducted in Britain (Heydecker et all, 1986; James, 1987; Kirby, 1987). A research project covering computer assisted design of high capacity bus priority schemes has just started at the Transport Studies Group, University College London. It aims at investigating the best way of incorporating the expertise in the field into a CAD system. The tool is likely to be a sort of integrated software package incorporating a bus lane models with an expert system and natural language interface.

A successful CAD system will provide the adequate environment for addressing not only the alternative design concepts but also the much wider institutional questions related to implementing high capacity bus priority schemes. Some of the deterministic design concepts can be investigated by adapting and combining bus lane simulation models such as SIBULA and BLISS. On the institutional side, the challenges lie in inserting advice triggers aimed at overcoming some of the factors reducing effectiveness of technical solutions.

12. CONCLUSION

We have discussed the scope for obtaining the best performance of low-cost and flexible bus pu transport systems. We have seen that novel schemes, like median bus lanes, can improve the capa of bus transyt to levels close to those achieved by many rail based systems. Buses always ad flexibility to transit systems. They can mix with other traffic outside heavily used corridors therefore provide good accessibility to a wider range of users.

The design of innovative bus priority systems is most advanced in Brazil where several schemes been implemented and tested. It is clear from this experience that the success of such sche depends on the ability to adapt design principles to local road space and operating conditions experience in Brazil has shown that a good scheme can sometimes introduce new arrangements bet private and public bus companies and that with a special effort it is possible to change the behaviour of drivers and pedestrians. However, this is not always possible and an effective desi will make the best with the opportunities and resources available.

Bus lane violations are considerably reduced by the adoption, where possible, of physical segregation. Median bus lanes maintain good operating conditions over a wide range of flows bu require relatively wide avenues for their implementation as the provision of bus stops takes additional road space. These high capacity bus lanes are generally more expensive than conventio kerb lanes but considerably cheaper and more flexible than rail based systems.

The critical element in the design of high-capacity bus priority schemes is the provision of suita arrangements at bus stop areas and the control of moving and stationary violations. Our curren understanding of the traffic behaviour at bus stop areas is limited and further research is requi in this field. However, bus convoys and off-line bus stops help to reduce problems at bus stop ar where heavy bus flows are involved.

There is scope for further research on modelling bus stops and priority schemes both to assist in development of guidelines and to provide simpler models for direct design purposes. This researc effort requires additional experimentation and exchange of experiences in different countries as operating conditions, driving standards, traffic behaviour and competitive environment are impor local elements in identifying good technical solutions.

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MOBILITY AND TRANSPORT PERCEPTION IN SOME MEDIUM SIZED CITIES OF JAVA

I. Introduction

Indonesia's National Urban Development Strategy calls for the development of medium sized cities in the country, to achieve a more spatially balanced growth. One of the key factors for securing the successful development of these cities is their urban transportation. Nevertheless, in Indonesia very few studies have been undertaken to specially examine the urban transport needs, problems and issues in these medium sized cities.

In this context, the Pusat Penelitian Transportasi dan Komunikasi - ITB (Bandung, Indonesia) and the Laboratoire d'Economie des Transports with Economic et Humanisme (Lyon, France) have developed a joint research on urban transportation in six medium sized cities in Java: Solo, Cirebon, Kediri, Jember, Tasikmalaya, and Serang[1]. See Table 1 for an overview of the six cities.

The study was expected to present an overview of the quality of the public transport service, travel patterns and needs of the population and the most urgent problems as experienced or perceived by the city's population. However, the study was not done uniformly for all six cities. In Solo for example, no household surveys were done, only interviews with city officials and transport operators. Household surveys were administered first in Cirebon in 1984 (159 households) then in Jember, Kediri, Tasikmalaya, and Serang in 1985 (50 households each in Jember and Kediri and 60 households each in Tasikmalaya and Serang). Interviews with city officials and transports operators were also done in these four cities.

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[1] The Research Center of Jember University (East Java) has cooperated in the household surveys in Jember and Kediri.