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## A BUS PRIORITY LANE'S IMPACT ON PASSENGERS AND THE OPERATOR

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*Abstract:*

*A key element of an integrated package of bus priority measures which have been recommended for Brisbane is a bus lane on one of the approaches of a major Brisbane intersection.*

*Detailed data have been collected to predict the performance of the bus lane. Significant improvements in both mean travel time and variability are expected. The effect of this on existing patrons is noted. Examination of existing bus timetables of the route involved is undertaken to assess possible operator financial savings. The paper discusses situations whereby potential operator benefits can be realised.*

The views expreseed are those of the authors and not necessarily those of their respective organisations.

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## INTRODUCTION

### Background

Two major corridor studies investigating the feasibility of bus priority measures have been completed in Brisbane (Pak-Poy and Pretty, 1976, 1979) for the Metropolitan Transit Authority. These studies have extended earlier work by Pretty (1975) and established awareness of Brisbane's bus priority potential. A bus lane recommended by Pak-Poy and Pretty (1979) is currently being constructed by the Brisbane City Council (as at July 1980) and will be the first major bus priority facility to be implemented in Brisbane in the last decade. An analysis of the potential impacts of this bus lane on bus passengers and on operator bus schedules is of interest since these comprise the major benefits of bus priority facilities. Such an analysis would also check on the results of the 1979 study to ascertain any possible changes. The authors have extended the results of the analysis to infer the general potential of bus priority measures under Brisbane conditions.

### Site Location and Characteristics

The bus lane when constructed will extend inbound for 700 metres along Kelvin Grove Road from Blamey Street to College Road at the Normanby intersection. Figure 1 displays the location of the bus lane in relation to the Central Business District (C.B.D.).

The intersection is the junction of five major approach roads (two have been converted to one way flow) and is therefore required to handle high commercial vehicle and general traffic volumes. It is under a system of area traffic control and certain traffic movements are banned. With few exceptions the operational cycle time is reasonably constant in the period 6.45 a.m. - 9.30 a.m., fluctuating closely about an average of 2 minutes. In the existing situation traffic and buses may be delayed by up to three signal cycles while they negotiate the lengthy traffic queues that develop through the morning peak period.

Figure 2 illustrates a typical traffic queue build up profile, while Figure 3 illustrates observed bus travel time profiles over the "bus lane" section(1). As is indicated by Figure 3, the range of travel times that are experiences is great (typically from 2 minutes to 12 minutes. 15 minutes has been recorded on a wet day).

### Bus Lane Operation

The bus lane is additional road space that is being constructed in an available reserve and due to careful design is expected to benefit, not adversely affect, general traffic. Vehicles turning left from Kelvin Grove Road to College Road will be able to freely cross the bus lane without suffering the existing delay, when access to the short left turn lane is blocked by vehicles seeking to negotiate the Normanby intersection. (See Figure 4.)

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1 More details on these data are given later.

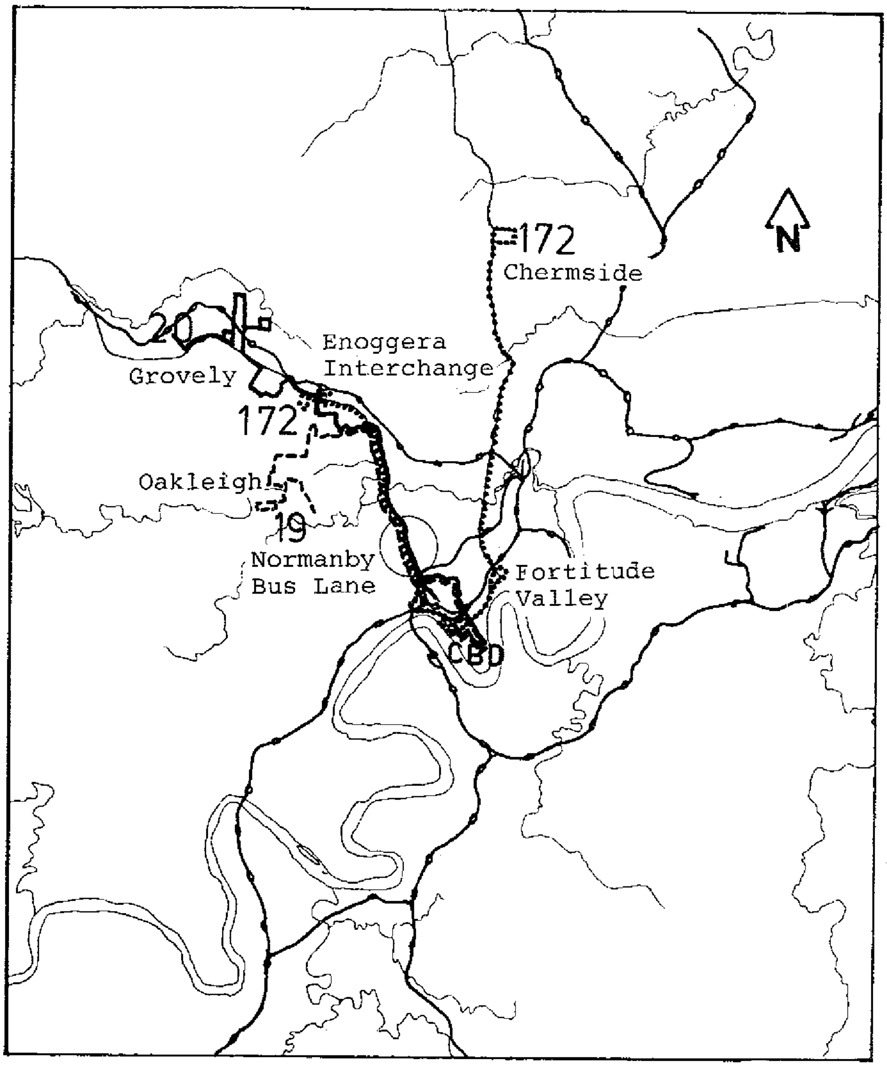
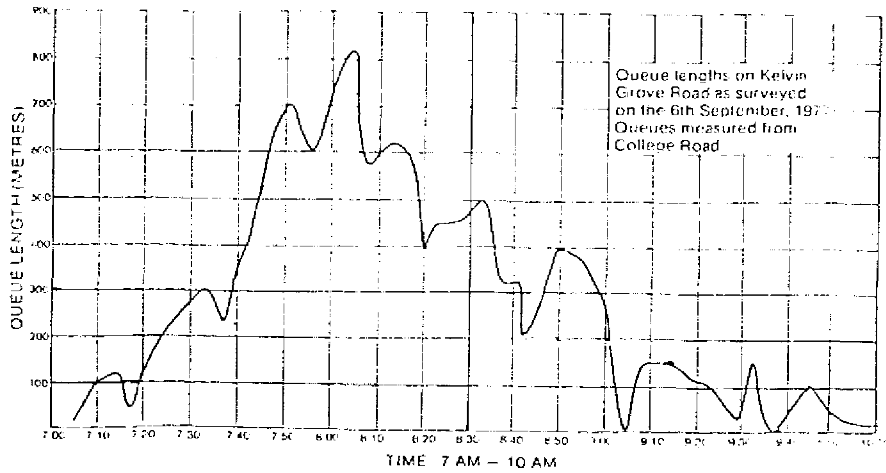



*Fig. 1* LOCATION OF BUS LANE AND ROUTES.




Source:Pak-Poy & Pretty(1975

*Fig. 2* Normanby Traffic Queues-
Morning Peak Period.

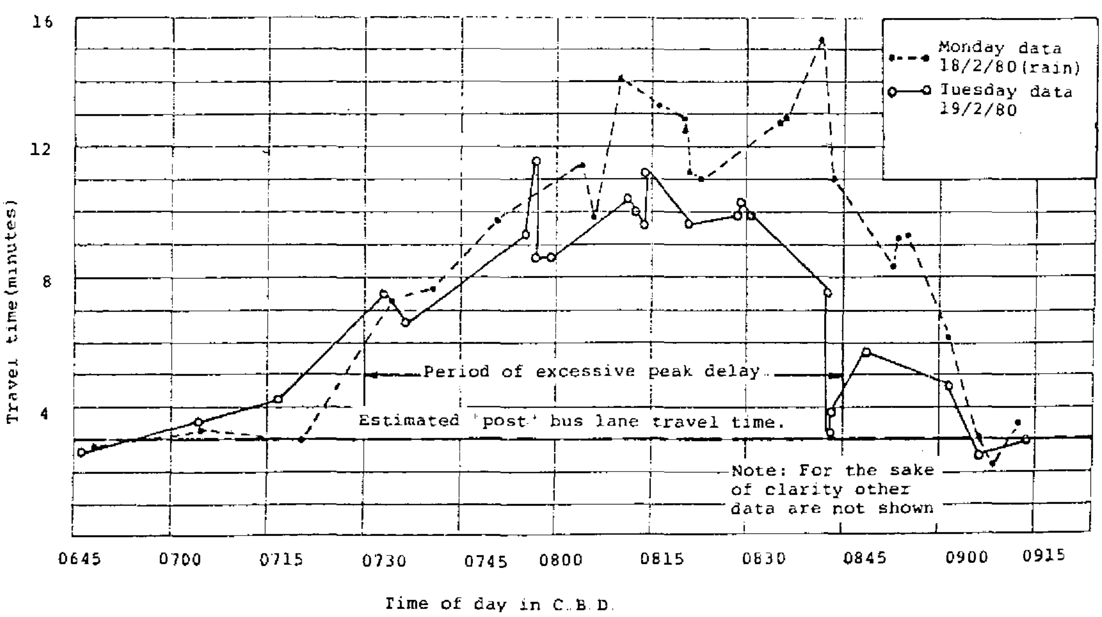
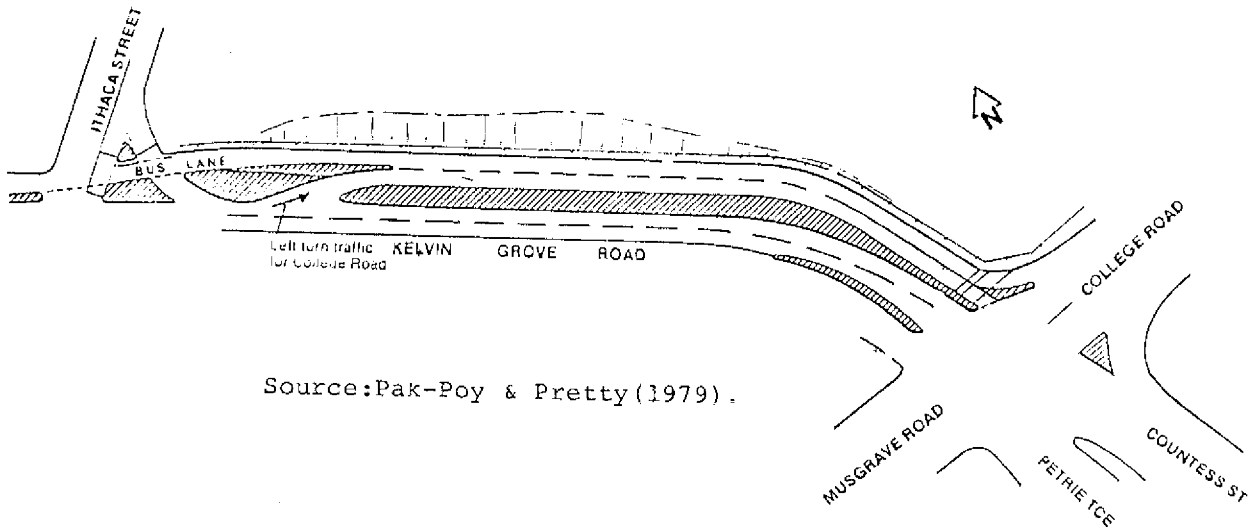



*Fig. 3* Observed Travel Times
Through The Bus Lane
Section(all buses).




Source:Pak-Poy & Pretty(1979).

Fig. 4 Normanby Bus Lane
Ithaca Street-
College Road Detail.

The bus lane is expected to provide significant travel time advantages to buses by allowing them to jump the long traffic queues and move directly to the intersection stop bar.

## Affected Bus Volumes and Routes

Currently, twelve buses per peak hour would benefit from the bus lane but due to its strategic location, and with appropriate re-routing of other bus routes, up to thirty peak period buses per hour could benefit.

The layout of the three existing routes affected is shown in Figure 1. These routes are all operated by the Brisbane City Council (B.C.C.).

Route 172 (Enoggera-Chermside) is the major route. It is a linked route. Two individual bus routes (i.e. Enoggera to the C.B.D. and Fortitude Valley, and Chermside to Fortitude Valley and the C.B.D.) have been combined. This halves the travel time spent in the most congested part of the route (i.e. C.B.D.) where travel speed is slowest.

Route 19 (Oakleigh) serves the Dorrington/Alderley suburbs and terminates in the C.B.D.

Route 20.21 (Grovely/Mitchelton) serves the suburbs west of Enoggera and terminates in the C.B.D.

# EXPECTED TRAVEL TIME CHANGES

## Data Collection Procedures

Data were collected by a series of surveys on weekdays which comprised:-

(i) A three day morning survey of bus stop activity in the bus lane section;

(ii) A three day morning peak period survey of intersection cycle and green time measurements;

(iii) A one week survey of bus travel times of all buses through the bus lane section; and

(iv) For the Enoggera (Route 172) service as for (iii) but terminus departure times and C.B.D. arrival times were also observed.

This survey information allows a comprehensive description of existing travel times to be gained and also the means to reliably predict travel time changes. Bus travel times from the survey are shown in Figure 3. Unfortunately, no seasonal data are available. This will not affect schedule examination (as data were collected outside holiday periods).

## Analysis and Results

Using data from surveys (i), (ii) and (iii) estimates were made of bus travel times through the section of Kelvin Grove Road, using the bus lane. Bus travel times before and after the morning traffic peak were taken as indicative of run times that could be expected in the absence of traffic congestion. It was expected that this average time would have to be adjusted to take account of:-

- increased loading at bus stops in the bus lane in the morning peak period; and
- a longer peak period cycle time.

The bus stop survey showed no significant differences in bus stop activity (either boarding or alighting) by individual bus service throughout the morning peak period. Hence, no adjustment was made.

With an average cycle time during the morning peak of 2 minutes and using the average green time for the Kelvin Grove Road approach it was calculated that the increased delay due to an increased cycle time during the morning peak period would be 14 seconds.

It is estimated that with the bus lane in operation, a bus travel time through the section of 3 minutes will be achieved and this value is believed to be conservative. The variability of "post" bus lane travel time is expected to be low and the authors expect 3 minutes to be towards the upper limit of possible travel times. (It is also expected that buses will derive further travel time savings downstream by moving away from the stop bar ahead of general traffic.)

With the assistance of detailed existing travel time information by bus and the predicted "post" bus lane travel time various travel time statistics can be derived. For example, the mean travel time savings are estimated to vary from 1.3 minutes (prior to 7.30 a.m. and after 8.30 a.m.), up to 6.5 minutes between 7.30 a.m. and 8.30 a.m. whereas over the period 7.00 a.m. to 9.00 a.m. would be 4.2 minutes. Refer to Figure 3 where the estimated 3 minutes post bus lane travel time has been indicated.

Such detailed information also allows the estimation of new total bus run travel times (terminus to C.B.D.) for the Enoggera service. This enables the bus trips on the affected routes to be re-scheduled with greatly increased accuracy. Appendix A tabulates these daily (Monday to Friday), observed and estimated travel times by bus(1).

IMPACT ON BUS PASSENGERS

Improvements in the reliability of buses gained through bus priority measures has received considerable attention in the literature (Chapman, 1976 and Richardson, 1978). In this case the major reliability improvement is a reduction in travel time variability. Benefits accrue to the operator and bus passengers as stated previously.

1 Because of the low passenger demand in the bus lane section, interaction of buses at bus stops is negligible and hence, it is reasonable to estimate new travel times in this manner.

From the point of view of the daily trip maker, Chapman (1976) argues that it is the travel time of the bus at XX:XX hours to carry him from A to B which is important. The data given in Appendix A can be analysed from this point of view. However, the nature of reliability improvement can be readily understood by examining Figure 5, which displays observed "before" and estimated "post" bus lane travel time distributions for all Enoggera buses passing through the bus lane section between 7.00 a.m. and 9.00 a.m. Each datum point represents an observation rounded to the nearest minute.

Although the data given in Figure 5 does not truly represent the fluctuation of travel times of an individual bus (or tight group of buses), but rather describes the overall travel time performance of all Enoggera buses throughout the morning peak period, it can be used to illustrate the general nature of reliability improvement to the bus passenger.

For example, it is apparent that the estimated "post" bus lane data not only exhibits a lower mean travel time but a much tighter spread when compared to the observed "before" data. Furthermore, the observed "before" data are more inclined towards extremely long travel times. The point being that although the <u>mean</u> travel time is used in traditional assessment of transport improvement actions, a different result would be obtained by using changes in a particular upper percentile of the two distributions (Knight, 1974, Richardson, 1979). An additional benefit over the mean time saving may thereby accrue (Knight, 1974), dependent on the degree of lateness that the individual may tolerate. For example, if the 42 minutes point in Figure 5 (before situation) represented the desired arrival time of the individual in the C.B.D. and the degree of acceptable lateness was nil, then the potential benefit in the "post" bus lane situation could be of the order of 8 minutes. Compare this to the estimated mean travel time saving of 4.2 minutes between 7.00 a.m. and 9.00 a.m. Perhaps, in certain situations this could allow an individual passenger to catch a later bus. Whether or not this is achievable, the removal of annoying, remembered extremes of travel time and the sheer size of the mean improvement is likely to favourably affect passenger perception of the bus service and hence their resultant attitudes (Chapman, 1976, Ritchie and Richardson, 1979).

## EFFECT ON BUS OPERATIONS

The improvements in travel time were incorporated into the scheduling process to ascertain their effect on existing bus operations[1].

### <u>Operator Savings</u>

Operator savings can accrue in any of three areas:- There can be a reduction in number of:-

- buses needed;
- drivers needed; and

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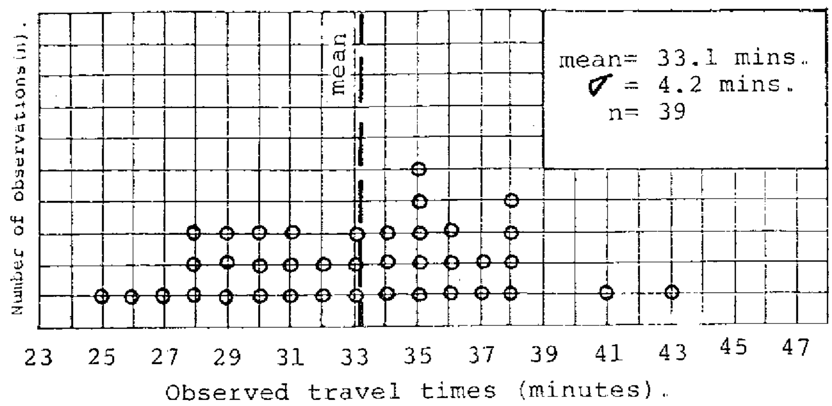
1 The effect of the Enoggera bus-train interchange on patronage and bus requirements on the three routes in the vicinity of the bus lane is expected to be insignificant.

Observed "before" Enoggera bus travel times.




Estimated "post" Enoggera bus travel times.

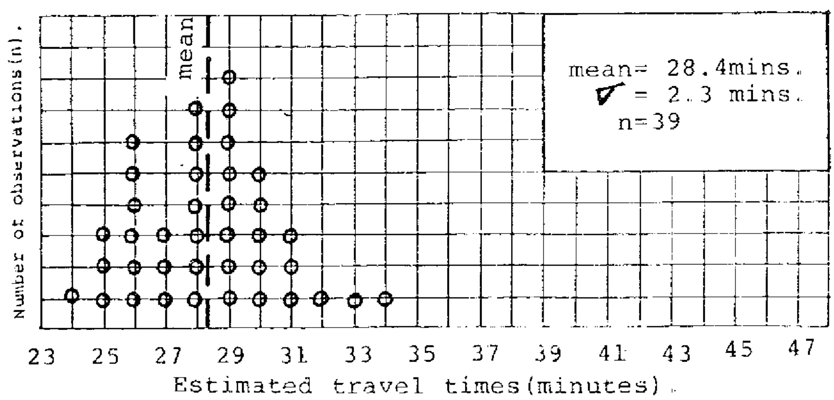



Fig. 5 Observed and estimated travel times(terminus to C.B.D.)of Enoggera buses.

- hours run or distance travelled which contribute towards operating costs and driver time costs.

Bus Savings

Because of the overlap in desired travel times by students and workers in the morning peak period and their separation in the evening, it might be expected that more buses are required in the morning peak. Brisbane City Council (the bus operator) has for several years had a policy of requiring a full fare from students who wish to travel on bus services early in the morning peak period (approximately prior to 0800), though concessions are of course available where need is established. This policy has flattened morning peak demand characteristics and so significantly reduced the number of buses required to satisfy morning peak period demand. This has occurred to the extent that the evening peak period now dictates the number of buses that are operated. Because the Normanby bus lane is an inbound (to the C.B.D.) priority measure, its effect on evening peak operation is expected to be negligible. Consequently no bus savings are expected. Minor savings are expected in operating costs. These savings are in fuel and in drivers time where the run can leave the depot later due to the time saved. These time based costs of buses are not specifically discussed in this paper.

It is possible, however, due to industrial and social constraints on the duration of work times of drivers, that major savings can be made in this area. This is the subject of detailed discussion below.

Driver Savings

Theoretically, a driver can be saved where the travel time on a particular trip is reduced sufficiently so that one driver can complete two trips that formerly took two drivers. The above is complicated of course by the presence of "broken shift" drivers in Brisbane (so that it is normally necessary to save a driver in both peaks). It also assumes that any other work performed by the "saved" driver in the same peak period can be diverted to other drivers.

The two routes remaining after the implementation of Enoggera Interchange were therefore examined to assess whether any driver savings would accrue from the Normanby bus lane.

EXAMINATION OF THE ENOGGERA-CHERMSIDE ROUTE

As stated previously this is a linked bus route and its overall route length is approximately 18 or 19 kilometres dependent on direction. To assess savings that are due to the Normanby bus lane alone it proved necessary to optimize the existing timetable which had not been reviewed for some time. In this period, patronage had generally fallen and, during the morning peak period, traffic congestion had increased significantly. The net effect had been "loose" travel times in the early morning and part of the off-peak and too "tight" travel times in the peak.

To assess the improvement due to the bus lane, the existing timetable was replicated, but using realistic running times (derived in Appendix A). Running time improvements from the Normanby bus lane were then incorporated into a third timetable. The "public" timetable, and the blocks of work for the three timetables, are shown in Table 1[1]. Block numbers adopted for the purposes of this paper were assigned and the legend presented as part of the Table 1 shows the block's previous history. It is evident that the Chermside section has a higher level of service than the Enoggera section. By judicious selection of departure times it was possible to link different trips in the early morning but this improvement is not due to the bus lane, so is common to the optimized, and optimized with bus lane, timetables.

Figure 3 showed that the bus lane achieves most travel time improvements for buses departing Enoggera between 0720 and 0800. Due to the long route length, these buses do not arrive at Chermside until approximately 0840 and allowing for recovery and layover time cannot begin a new trip until after 0854. The bus lane enables a new trip at 0846 (see Table 1 block 13). As the buses are required for the "on the streets" peak at approximately 0800 it would seem inter alia that no driver savings can be made.

It should be noted though that the trips departing Chermside at 0840, 0846 and 0854 (blocks previously departing Enoggera at 0720, 0730 and 0740) are known to be consistently running late. Existing run and recovery times are inadequate. In the optimised timetable the 0840 and 0846 trips are assigned to new blocks of work (i.e. 30PU and 31PU). The optimized timetable incorporating bus lane travel time savings only requires one trip assigned to a new block of work. The investigation given below determines whether existing buses which have previously been utilised but are not then required in service could do that work or whether two "new" buses would have to be brought from the depot.

While the bus requirements peak at approximately 0800, because of the nature of the patronage demand during the morning peak, those buses not required after this time are invariably located in the C.B.D. In fact, two existing blocks of work were identified which finished in the C.B.D. at 0802 and 0806 respectively and which originated from appropriate depots. Even allowing for recovery and layover time, these buses could assume the 0840 and 0846 trips from Chermside by dead running to that terminus. The cost of this is two extra return trips, Chermside to C.B.D. and the loss of some system flexibility. The benefit is expected to be a reduction in waiting time brought about by better schedule adherence for all patrons on the existing 0840, 0846 and 0854 services.

The end result of the examination is that for the Chermside-Enoggera route, no savings in driver's time can be made. Large savings in travel time will accrue to patrons, mostly to the Enoggera section, <u>but also a significant amount to the three Chermside services mentioned</u>. In the event that the time to traverse the Chermside-Enoggera route was shorter by 20 minutes, driver savings would have resulted. The Oakleigh route, having a shorter run time, was therefore examined.

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1 For the purpose of this paper a block of work is the sum of the trips taken by a particular bus and includes layovers, dead running, etc.

TABLE 1

EXISTING, OPTIMIZED, AND OPTIMIZED WITH BUS LANE

TIMETABLES

| Depart Enoggera | Existing | Optimized | Optimized with Bus Lane |
|---|---|---|---|
| 0535[1] | 11D | 11D | 11D |
| 0612[1] | 14D | 10C | 10C |
| 0632 | 10C | 14D | 14D |
| 0655 | 18D | 12C | 12C |
| 0708 | 12C | 19D | 19D |
| 0720 | 13C | 13C | 13C |
| 0730 | 23D | 11C | 11C |
| 0740 | 15C | 23D | 23D |
| 0750 | 11C | 15C | 15C |
| 0800 | 16C | 16C | 16C |
| 0814 | 17C | 17C | 17C |
| 0825 | 19C | 18C | 18C |
| 0842 | 14C | 20C | 20C |
| 0856 | 24C | 14C | 14C |
| 0907 | 31OR/10C | 25C | 25C |
| 0917 | 27C | 27C | 27C |

| Depart Chermside | Existing | Optimized | Optimized with Bus Lane |
|---|---|---|---|
| 0522[1] | 10D | 10D | 10D |
| 0557 | 12D | 12D | 12D |
| 0610 | 13D | 13D | 13D |
| 0625 | 15D | 11E | 11E |
| 0640 | 11E | 15D | 15D |
| 0657[1] | 16D | 16D | 16D |
| 0650 | 17D | 17D | 17D |
| 0700 | 19D | 18D | 18D |
| 0710 | 20D | 10E | 10E |
| 0720 | 14E | 20D | 20D |
| 0722[2] | 21D | 21D | 21D |
| 0725[3] | 22D | 22D | 22D |
| 0735 | 24D | 14E | 14E |
| 0742[2] | 25D | 24D | 24D |
| 0748 | 10E | 25D | 25D |
| 0752[2] | 26D | 26D | 26D |
| 0758 | 27OR | 27OR | 27OR |
| 0802[2] | 28OR | 28OR | 28OR |
| 0810 | 18E | 12E | 12E |
| 0820 | 29OR | 29OR | 29OR |
| 0830 | 12E | 19C | 19C |
| 0840 | 13E | 30PU | 30PU |
| 0846 | 23E | 31PU | 13E |
| 0854 | 15E | 13E | 11E |
| 0903 | 30OR | 32OR/11E | 31OR/23E |
| 0915 | 32OR/11E | 33OR/15E | 32OR/15E |

where D = Bus from Depot
C = Bus from Chermside Trip
E = Bus from Enoggera Trip
OR = Bus from other route
PU = Bus previously unassigned

1 Bus departure times different but within 5 minutes on existing and optimized routes.
2 Limited pick up trip.
3 Express trip.

EXAMINATION OF THE OAKLEIGH ROUTE

Analysis of the Oakleigh timetable (Figure 1 displays the route) indicated that one block of work in the morning peak period could possibly be saved on the introduction of the bus lane. To confirm this, checks on the running times of Oakleigh route services were performed. These revealed wide disparities in running times for trips. In one case the range varied from 29 to 51 minutes for the same inbound trip on different mornings. This variation was attributed to the route structure (and length) and would not be wholly removed by the introduction of the bus lane. The proposed linking of the block of work therefore proved unacceptable and no major driver savings resulted on this route.

RESULTS AND CONCLUSIONS

Results

The results of this detailed investigation of the chosen aspects of the Normanby bus lane are:-

(i) No savings in drivers or buses will result from the introduction of the Normanby bus lane.

(ii) Minor savings in fuel, maintenance and driver's time (theoretically the travel time saved by the bus lane) are available. Driver work is being reorganised by the B.C.C. to take advantage of these travel time savings.

(iii) Pak-Poy and Pretty (1979) estimated bus travel time savings to average 3.5 minutes between 7.00 a.m. to 9.00 a.m. The authors estimate this will be 4.2 minutes. As well, waiting time savings averaging approximately 5 minutes will accrue to three services in the Chermside part of the Enoggera-Chermside route.

(iv) Reliability of buses through the introduction of the bus lane is predicted to significantly improve. For example, as shown by inspection of Figure 5, the spread of "post" bus lane (terminus to C.B.D.) travel times is expected to be from 24 to 34 minutes as compared to the existing spread between 25 and 43 minutes. Furthermore, the estimated maximum "post" bus lane travel time would lie 5 minutes above the mean whereas in the existing situation the appropriate figure is 10 minutes.

Conclusions

Travel time savings for public transport users are expected of all priority measures. Congestion induced delays of similar sizes could be expected to result in similar savings in travel time for the individual patron on the application of queue jump schemes such as the Normanby bus lane. These travel time savings are easily quantifiable by standard methodology. Small savings in drivers time worked (if the operator reschedules) and operating costs are also expected of all priority measures.

The success of the B.C.C. policy (full fare payment on early morning peak period services) in suppressing morning peak period bus requirements predicates that for Brisbane, bus savings, due to priority measures, will only result when such measures affect favourably evening peak period travel times.

Driver savings which may result are dependent on:-

- intensity of service levels and their duration;
- return route length of routes affected;
- travel time reliability (i.e. variability) by route section; and
- period of congestion.

The authors have concluded that as a general rule, driver savings can be expected on the implementation of priority measures where the intensity of peak period services is approximately uniform and its duration, and that of traffic congestion, is in excess of the routes return trip travel time. Driver savings did not result in either of the routes studied because in each case the round trip time was in excess of the period of peak bus service provision - which in the case of the Enoggera-Chermside route was approximately two hours.

This rule can be extended as follows:-

- relinking of Enoggera services to another route of shorter length than Chermside would probably result in a driver being saved, at least for the morning peak.
- in Brisbane where the period of traffic congestion in the morning peak is approximately 1¼ hours, driver savings are not expected to result unless the round trip times of the routes involved are less than this. If the period of traffic congestion continues to increase, driver savings from the Normanby bus lane may eventually result on the existing routes.
- savings in off-peak daytime travel time, because they are likely to be constant (construction of new road space etc.) and the supply of services is uniform, would result in driver savings.

All queue jump schemes, where there are similar levels of delay, will result in similar travel time savings per person. Operator savings, even where similar travel time savings result, are dependent on the characteristics of the routes affected.

## REFERENCES

Chapman, R.A. (1978). "Bus Reliability - Definition and Measurement". Transportation Operations Research Group, Working Paper No. 18, University of Newcastle-Upon-Tyne, pp 9-12, 27.

Knight, T.E. (1974). "An Approach to the Evaluation of Changes in Travel Time Unreliability: A Safety Margin Hypothesis". Transportation 3(4), pp 393-407.

Pak-Poy, P.G. and Pretty, R.L. (1976). "Bus Priority Treatments for Brisbane". A report prepared for the Metropolitan Transit Authority, Brisbane.

Pak-Poy, P.G. and Pretty, R. (1979). "Bus Priority Treatment North West Corridor". A report prepared for the Metropolitan Transit Authority, Brisbane.

Pretty, R.L. (1975). "The reduction of Traffic Delays for Buses". A.R.R. Report No. 39, Australian Road Research Board.

Richardson, A.J. (1978). "Developments in Transport Systems Management Evaluation". Working Paper No. 78/13, Department of Civil Engineering, Monash University, Melbourne.

Ritchie, S.G. and Richardson, A.J. (1979). "Mode Choice Implications of Priority Lanes". Paper presented at the Transportation Conference, Adelaide, November 1979.

APPENDIX A

TABLE A.1

EXISTING AND ESTIMATED BUS LANE TRAVEL TIMES FOR ENOGGERA (172 BUSES) (MINUTES)

INBOUND ENOGGERA TERMINUS TO C.B.D. (CNR. ADELAIDE AND GEORGE STREETS)

| As measured at the END OF THE BUS LANE | Monday | | Tuesday | | Wednesday | | Thursday | | Friday | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (+) | (*) | (+) | (*) | (+) | (*) | (+) | (*) | (+) | (*) |
| 7.10 | 26.16 | 24.77 | 27.73 | 26.15 | 27.80 | 26.93 | 27.69 | 25.57 | 26.20 | 25.02 |
| 7.35 | 30.58 | 26.45 | 32.00 | 27.73 | 32.65 | 28.71 | 33.73 | 29.00 | 29.13 | 26.46 |
| 7.51 | 37.33 | 30.62 | 42.94 | 34.41 | 38.39 | 29.44 | 35.87 | 29.10 | 34.43 | 28.83 |
| 8.00 | 46.26 | 35.26 | 33.07 | 27.50 | - | - | 36.18 | 28.29 | 37.35 | 32.50 |
| 8.10 | 37.23 | 27.75 | 34.66 | 28.00 | 38.10 | 29.80 | 37.55 | 30.80 | 35.20 | 29.28 |
| 8.16 | 49.31 | 39.11 | 37.98 | 29.77 | 33.10 | 28.00 | 31.93 | 24.70 | - | - |
| 8.41 | 46.60 | 34.30 | 36.62 | 29.80 | 35.20 | 31.30 | 40.88 | 30.95 | 36.47 | 31.78 |
| 8.54 | - | - | 34.67 | 30.14 | 35.22 | 30.20 | 31.11 | 25.66 | 34.47 | 28.72 |
| 9.00 | 38.06 | 31.84 | 29.29 | 26.40 | 30.28 | 25.84 | 27.09 | 24.89 | 30.90 | 27.34 |
| 9.02 | 26.41 | 23.31 | 29.43 | 27.80 | 29.58 | 26.90 | 30.96 | 29.12 | 29.73 | 27.91 |
| | - | - | - | - | - | - | 24.80 | 24.42 | - | - |

NOTES: (+) Existing Travel Time.
(*) Estimated BUS LANE Travel Time.
(-) Data incomplete.