A METHODOLOGY TO DETERMINE OPTIMAL TRANSFER TIMES AT INTERCHANGES IN A LOW FREQUENCY TRANSIT SYSTEM.

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ABSTRACT: *During the late seventies modal or bus-bus interchanges were developed in many of Australia's capital cities. A similar trend occurred overseas. The paper examines the rationale for the use of interchanges, concluding that the trend will continue. It is also argued that a fundamental difference exists between local and overseas transit systems in that low frequency transit systems are common in Australia. Transfer times between modes or vehicles are vital in low frequency transit systems, as long wait times are incurred at interchanges if designed connections are missed.*

The author has developed a simple empirical two-step methodology to determine the optimal transfer time for any trip serving an interchange in low frequency transit system. The procedure has application not only in refining bus operations at existing interchanges but also in the evaluation of potential interchange operations.

INTRODUCTION

Australian Interchange Development

During the late seventies, several studies of the potential for bus-bus and/or bus-train interchanges in Brisbane were prepared by consultants for the Metropolitan Transit Authority. (Corner and Sayeg (1979) and Johnston and James (1979)). As a result of these studies, Toombul Bus-Bus Interchange(1) and Enoggera Bus-Train Interchange were implemented in Brisbane in November 1980 and April 1981, respectively. See Figure 1.

In other Australian cities a similar committment to interchange operations was being made. Notably, Noarlunga Bus-Train in Adelaide; Woden, Belconnen and City Bus-Bus in Canberra; Kelmscott Bus-Train in Perth and Bondi Junction and Edgecliffe Bus-Train in Sydney. This acceptance of the interchange concept was largly due to Australia's rather unique land-use/socio-economic characteristics.

Why Interchanges?

There would seem to be three main reasons for the introduction of interchanges in Australia.

(i) Australian cities have low urban densities by world standards. See Table 1. While Sydney and Melbourne have urban densities slightly higher than those in Western U.S.A. they are still appreciably less than Eastern U.S.A. cities. The lower the urban density, the less opportunity for a public transport operator to generate patronage per route kilometre of service run.

(ii) Despite the already low urban density, the reduction in the household formation rate over the last several decades, especially in older suburbs, has led to a real reduction in population in many of the old inner and north-eastern suburbs in Brisbane. In the Toombul Interchange catchment area, the population declined nearly twenty percent in the last decade. The author understands this trend is occuring in other Australian cities.

(iii) Due to Australia's higher family income, it has been possible for the great majority of families to purchase a private automobile and reduce or eliminate their use of public transport.

These three factors have placed so much pressure on public transport operators that all public transport in Australia is now being provided at a deficit[2]. On the other hand Oxlad (1979) has shown that there remain significant groups in society who still require the provision of public transport if their personal mobility desires are to be satisfied.

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1 A detailed account of the planning, design and monitoring of Toombul Bus-Bus Interchange was given by Avent and See (1981).

2 Source: various operator annual reports.

FIGURE 1

SITE LOCATIONS

TABLE 1

URBAN DENSITY

a) In Australian Capital Cities[1] (1971)

CITY	DENSITY (people/km2)	INNER AREA DENSITY[2] (people/km2)
BRISBANE	1127	2204
PERTH	1218	1651
ADELAIDE	1459	2177
SYDNEY	1918	4018
MELBOURNE	1811	3677

b) Central City Densities for Big Cities; Australia and East and West U.S.A.[3]

CITY	DENSITY OF CENTRAL CITY AREA (4) Persons/km2	TOTAL CITY POPULATION '000
SYDNEY	2600	2765
MELBOURNE	2600	2479
BRISBANE	1350	893
ADELAIDE	1330	857
PERTH	1110	731
WEST U.S.A. cities (average)[5]	1700	1830
EAST U.S.A. cities (average)[5]	4480	2791

Notes

1 Source Newman & Kenworthy (Population/area for all collectors districts with greater than 200 people/km2).
2 Area within approximately 5 to 7 kilometres of city centre.
3 Source: Atlas of Australian Resources, Third Series, Volume 2 on Population Division of National Mapping, Canberra 1980.
4 Central city area is a U.S.A. statistical area. Areas of equivalent size (about 400 km2) were used for calculating densities of Australian cities.
5 Calculated from the maps "Major Urban Areas: Population Distribution" and from statistics for cities of similar or larger size in the East and West regions of the U.S.A. (Advisory Commission on Intergovernmental Relations (1977), Trends in Metropolitan America: An information Report, the Commission, Washington).

In an effort to maintain traditional service frequencies whilst improving bus utilisation, Australian operators have introduced public transport interchanges. This is also in accord with overseas practice as reported by Sullivan (1980) and Bakker (1976) in Canada, Khosla (1973) and Sharma (1975) in India, Schneider and Smith (1981) in U.S.A. and Elmberg and Quarmby (1981) in Europe.

Many authors including Schaeffer and Sclar (1975), Meyer, Kain and Wohl (1965) and Poulton (1980) have concluded that no new mode will break the existing public transport paradigm this century, if at all, and that future improvements will just be a refinement of existing modes and their operation. In this case Australia is likely to see more interchanges being introduced in the future. However, the authors interest in the evaluation of Toombul Interchange and his subsequent involvement in the design and monitoring of bus operations at Enoggera Interchange in Brisbane led him to believe there were fundamental differences between Interchanges operating in Europe and those in the Australian environment. This related primarily to interchange operation in a low frequency transit system.

OPERATING INTERCHANGES IN A LOW FREQUENCY TRANSIT SYSTEM

Definition of a Low Frequency Transit System

For the purpose of this paper, transit networks are categorised into high and low frequency systems based on the daytime off-peak frequency at the system location where interchanging is being considered. The distinction is based on the observed difference in people's behaviour as headways increase. Passengers tend to arrive randomly for routes with short headways. Where headways exceed about ten minutes, an ever increasing proportion of passengers use timetables to minimise their travel time. This proposition has found support in Bakker (1976), Finnamore and Jackson (1978) and Elmburg and Quarmby (1981).

For this paper, a transit system which has day-base headways greater than ten minutes at the point being considered for interchanging has a low frequency. Under this definition, much of Brisbane has a low frequency transit system.

Transfer Times in a Low Frequency Transit System

Throughout most of Europe, interchanges operate in a high frequency environment and transfer times are not critical. (It is perhaps for this reason that the subject has not been reported in the literature). In Brisbane's low frequency operating environment one should be concerned about transfer times for three main reasons:

(i) during the day-base, people may have to wait 15 to 30 minutes on inbound trips to the city, and 30 to 40 minutes in the outbound direction, if their connection is missed.

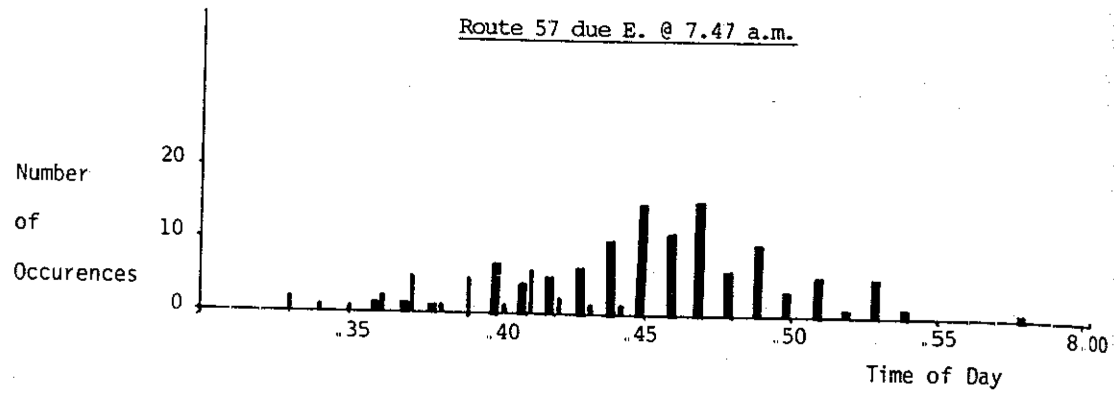
(ii) feeder and trunk buses in Brisbane have a large range of arrival times. That is, the probability density function of the arrival time distribution is quite dispersed for some trips as shown in Figure 2. There is also great differences between trips.

(iii) Passengers perception of transfer time is different from travelling in a bus to the extent that a weighting factor of 2 is often used.

For the above reasons, it is important that the transfer time component has been significantly underestimated in the Brisbane studies on which interchange decisions were based. In the Enoggera report 5 minute transfers were assumed while 3 minutes was used in the Toombul evaluation. Neither report investigated the reliability of bus services passing the potential Interchange site. It seemed that research directed towards obtaining an optimal transfer time methodology could be usefully employed in refining the operation of existing interchanges and in evaluating the potential at future sites.

FIGURE 2

LEGEND School term arrival times (thick line)
School holiday arrival times (thin line)



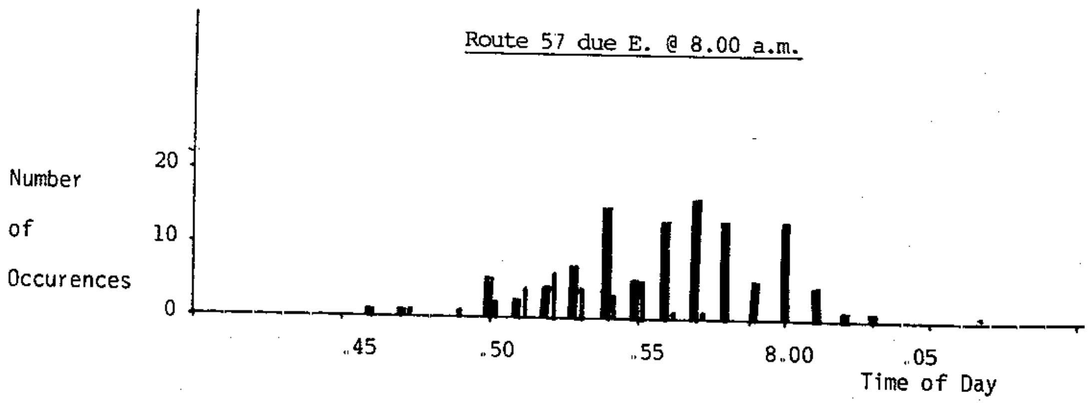
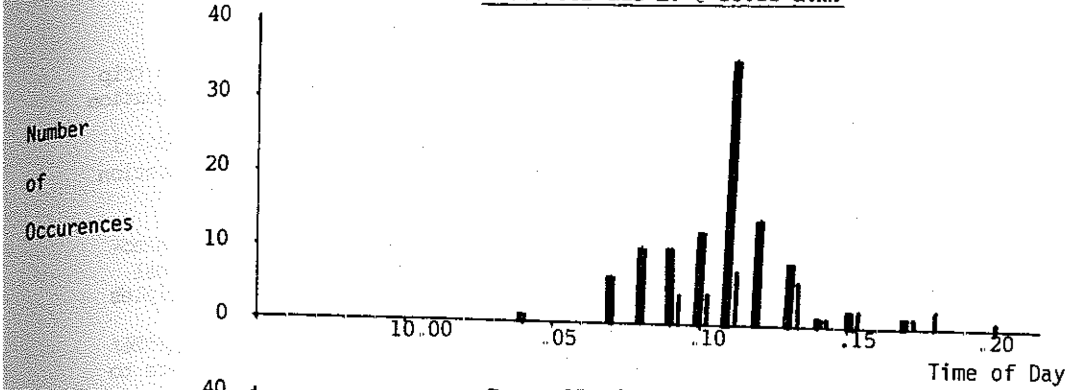
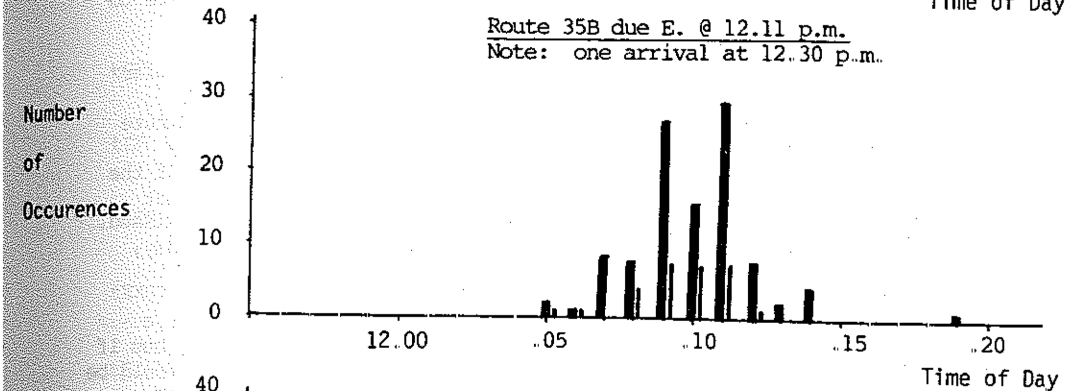


FIGURE 2 (Continued)

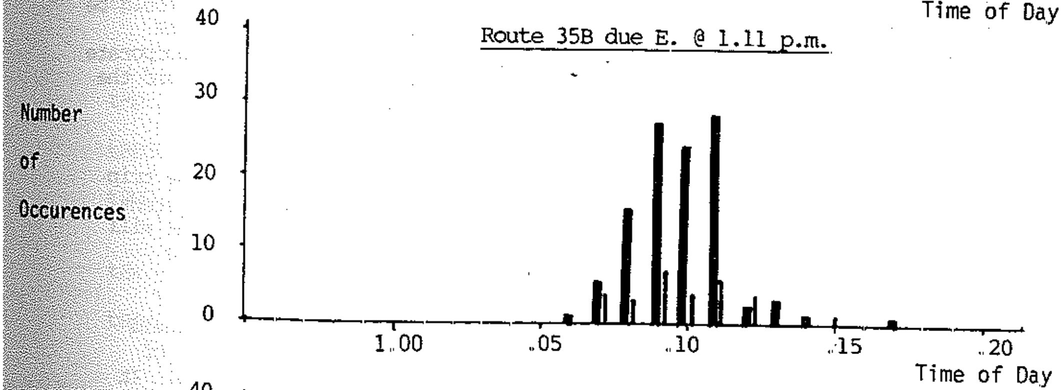
Route 35B due E. @ 10.11 a.m.



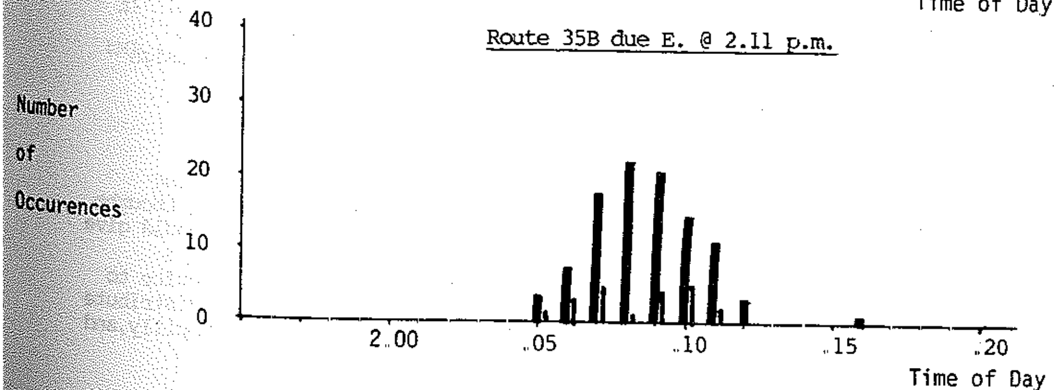
Route 35B due E. @ 12.11 p.m.
Note: one arrival at 12.30 p.m.



Route 35B due E. @ 1.11 p.m.



Route 35B due E. @ 2.11 p.m.



THE OPTIMAL TRANSFER TIME METHODOLOGY

The Approach

The problem of specifying an optimal transfer time for each trip was initially addressed at the theoretical level. A generalised equation for the round trip cycle time of a feeder or trunk bus serving an interchange was developed. See Figure 3. Although this was accomplished, the twelve terms in the equation prevented its calibration and subsequent application to the optimal transfer time problem.

Therefore it was necessary to attempt an empirical solution to the optimal transfer time problem. It was realised that this optimal transfer time would involve a trade-off between the opposing principles of minimum and reliable. The shorter the transfer time at an interchange, the faster the average trip time but the greater would be the possibility of missing the planned connection. Respondents were to be asked to make this trade-off.

It became apparent that the optimal wait time for a particular trip is dependent on the headway of the connecting trip. If, for example, the connecting trunk bus at the interchange is on five minute headways, it is conceivable that passengers would not feel greatly inconvenienced if they missed their connecting bus quite often. If the connecting trunk bus was on a half hour headway, it is probable that passengers would feel greatly inconvenienced if the transfer was missed. It it was evening and the connecting bus was the last bus of the day, missing the transfer would be unacceptable.

So one parameter when seeking an optimal transfer time for a given trip must be the extra time to wait for the next connecting bus if the designed connection was missed. To assess this parameter it would be necessary to conduct a survey to elicit passenger response. If the survey design was appropriate, the result would automatically incorporate any variations in the value of time between the normal wait time and the extra wait time if the designed connection was missed.

A second parameter must be the reliability (that is, repetitiveness) of the round trip cycle time for the trip. If the trip length is short, patronage is steady and traffic conditions consistent, travel times are likely to be reliable. The optimal transfer time will then be short. On a long route with varying patronage and traffic congestion, optimal transfer times would have to be longer.

It was expected that examination of the first parameter would yield some sort of relationship between the tolerated probability of missing a connection, depending on the wait time for the next bus. It was hoped that analysis of bus reliability would yield a model to determine optimal transfer times that would satisfy the trip's design tolerated probability.

The Survey

The survey used a self-administered, mail back, self coding questionaire. Only bus passengers were to be surveyed as it was thought that non-passengers unfamiliarity with the interchange concept would give their responses little validity. To ascertain whether there was a divergence of response between passengers using a direct bus service to the city, or those who bus-bus or bus-train, it was decided to distribute the questionaire to teenage and older bus passengers at Indooroopilly,and

FIGURE 3

GENERAL EQUATION FOR BUS CYCLE TIME

The general information for the kth feeder route round trip on route i

t total ik = f (tPDES + tSTC + tDB + mtTP + tEXSTC + tRiVO + TMP + tRECO
+ tDBO + tEX + tRIvi + tMP)

Where

f	=	function of
tPDES	=	the difference between the minimum transfer time and the arrival time prescribed on a Probability basis to maintain the Designed connections
tSTC	=	the time required to walk between the furthest two vehicles at an STC
tDP	=	the time needed to complete drivers procedures at the STC
mtTP	=	the time required to transfer m passengers at the interchange
tEXSTC	=	time wasted at the interchange, perhaps by the need to meet trips arriving or departing some time apart
tRiVo	=	time excluding passenger boarding/alighting time for a vehicle of certain performance characteristics to traverse route i outbound
tMp	=	time for m passenger movements to occur
tRECO	=	recovery time needed at the outer terminus
tDBO	=	time to complete drivers procedures at the outer terminus
tEx	=	excess time at the outer terminus
tRIvi	=	time excluding bus stop time for a vehicle of certain performance characteristics to traverse route i inbound
tMP	=	time for m passenger movements to occur

Enoggera and Toombul Interchanges. As shown in Figure 1 the sites are in different corridors. Their catchments also have widely differing socio-economic characteristics.

To maintain survey control it was decided to nominate the possible extra wait time and associated tolerable probability points for the crucial question seeking the respondent trade-off. See Appendix A. It was thought that each respondent should not have to make more than four trade-off's to maximise response. However, so that more data sets were available the nominated trade-off points were different on every alternative form. Four pilot surveys were needed to finalise the wording of the crucial question seeking the respondent trade-off between the extra wait to the next bus if the designed connection was missed and the associated tolerance on a probability basis to missing that connection.

The questionaires distributed at the interchanges were also different from those used at Indooroopilly. More information was sought on interchange respondents' previous trip history; specifically whether connections had been missed and the frequency this had occurred.

About a third of the 2150 questionaires were distributed at each site. Just over 500 responses were received giving a response rate of 19.6 percent. The low response rate is not crucial as will be seen later.

Analysis and Results

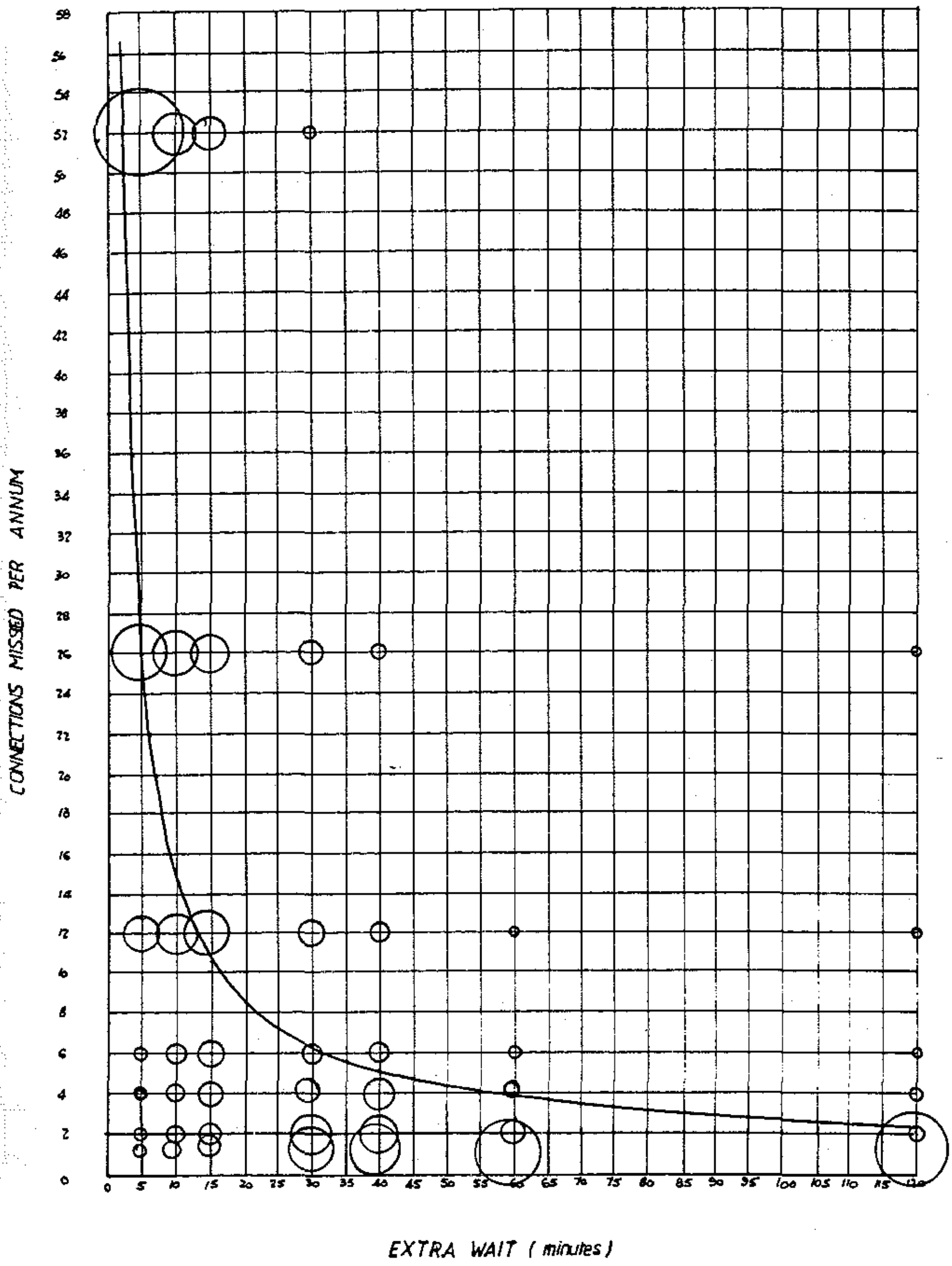
The SPSS computer suite was used for the regression analysis with mathematical transformations being used to derive a curvilinear result. Data manipulation, and a small program capable of representing the regression equation within ranges specified by the user on an A4 size sheet of paper, were accomplished by Mr Gwynn Thomas of the EDP Branch, Department of Finance and Management Services, Brisbane City Council.

Several different forms were considered for the regression equation which describes the trade-off between a tolerable frequency of annual connections missed and the extra wait time to the next bus. A reciprocal and negative exponential form gave the best fit with the coefficient of determination being 0.68. Figure 4 shows the frequency of response as represented by circles overlaying the derived regression equation.

In determining the effect of the extra wait to the next bus on respondents' tolerance towards the frequency of missed connections at an interchange, it is argued that more credence should be given to the responses of some user groups than others. Some people are more regular users of bus services than others and it would be expected that this would enable them to make a more informed response. Other groups place a greater value on time and their responses should also be given more consideration.

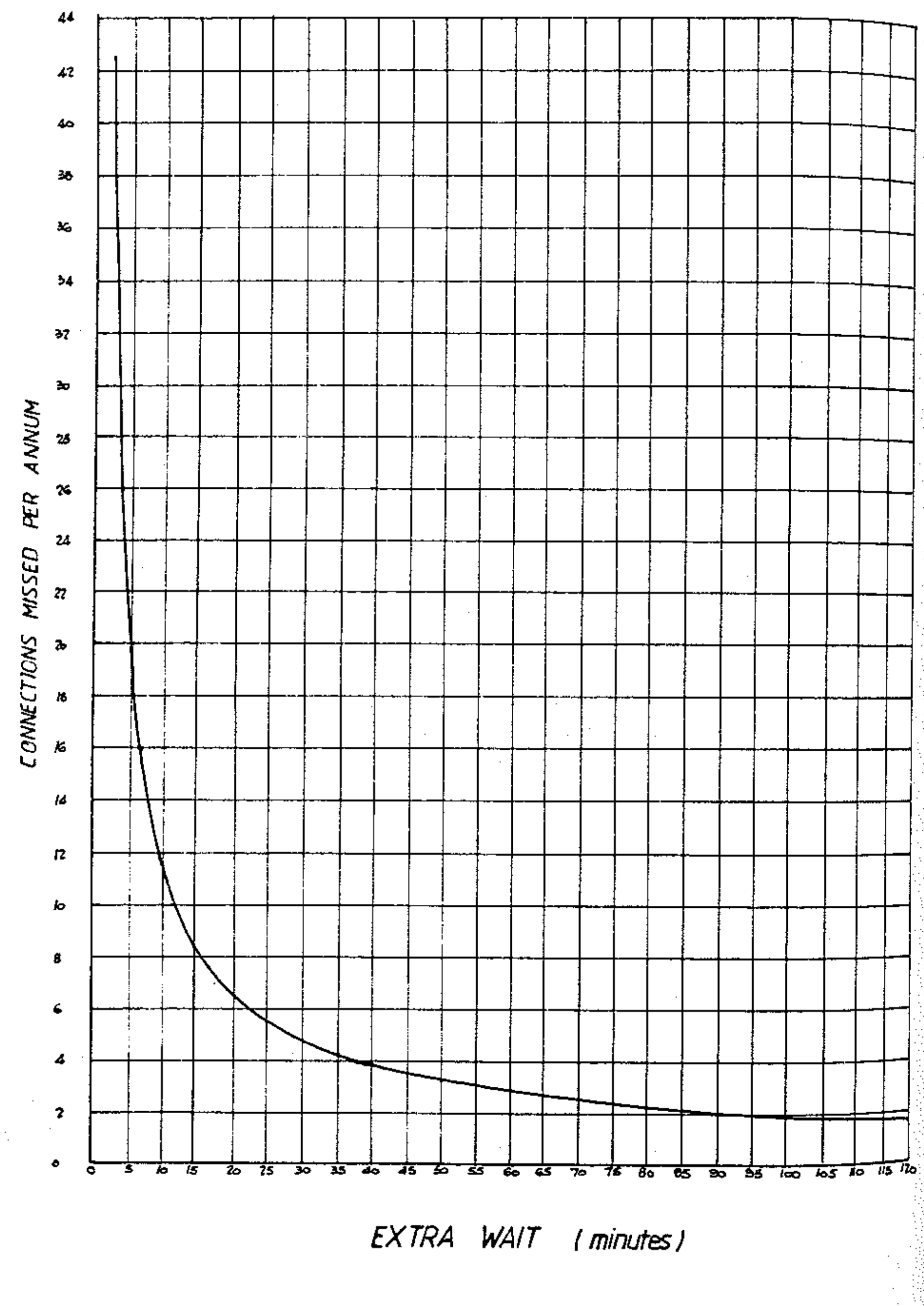
It was finally decided that the responses of those who have missed a connection at an interchange are the best basis for determining the regression analysis. Those who have experienced this situation have formed an experienced judgement on their value of travel time. Figure 5 shows the tolerated frequency of missed connections per annum depending on the wait time until the next bus.

FIGURE 4



BEST FIT EQUATION ALL DATA

FIGURE 5



PREFERRED TRADE-OFF EQUATION

Trip Arrival Distributions

Once the tolerated probability of missing a connection is specified for any trip, an optimal transfer time can be derived providing the probability density function for that trip's arrival time distribution can be described mathematically. Most trips have a probability density function similar to that shown in Figure 6. Constraining the period for collecting data, and ignoring major delays on the basis that they happen so rarely and are so significant that they shouldn't be included when assessing an optimal transfer time, gives a relatively simple form. Chapman et al (1976) and Sayeg (1981) have instanced normal distributions being used to model bus link travel time distributions. As the arrival time probability density function is dependent on the travel times on the various links comprising the trip, the author represented this by the normal distribution.

It is possible therefore to derive a nomograph which expresses the variance component of the optimal transfer time in terms of the tolerated number of connections missed annually, providing that the standard deviation of the (assumed normally distributed) probability density function of the trip arrival time distribution is known. See Figure 7. To determine the optimal transfer time the interchange walk component is simply added.

FIGURE 6

POSTULATED PROBABILITY DENSITY FUNCTION OF A TRIP'S ARRIVAL TIMES AT AN STC

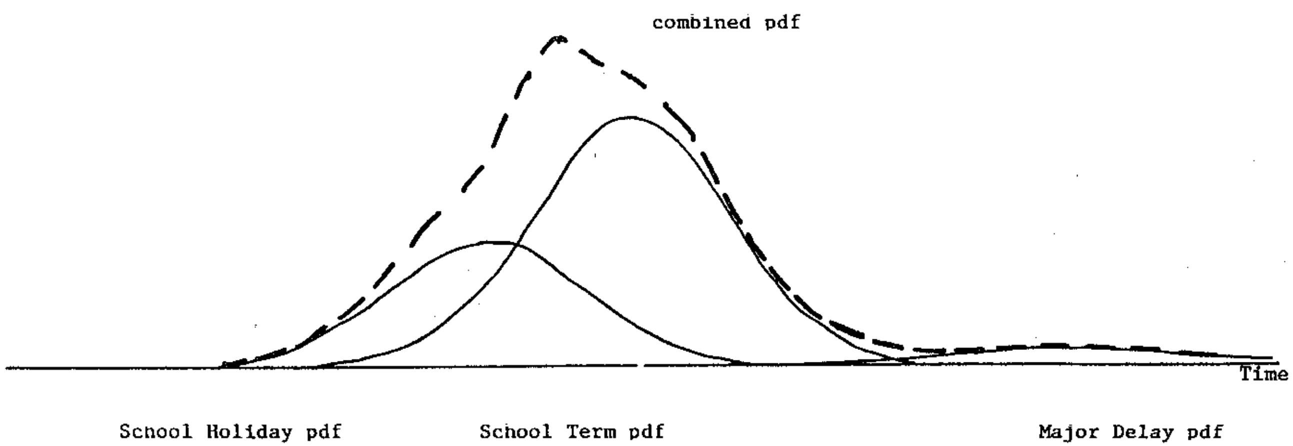
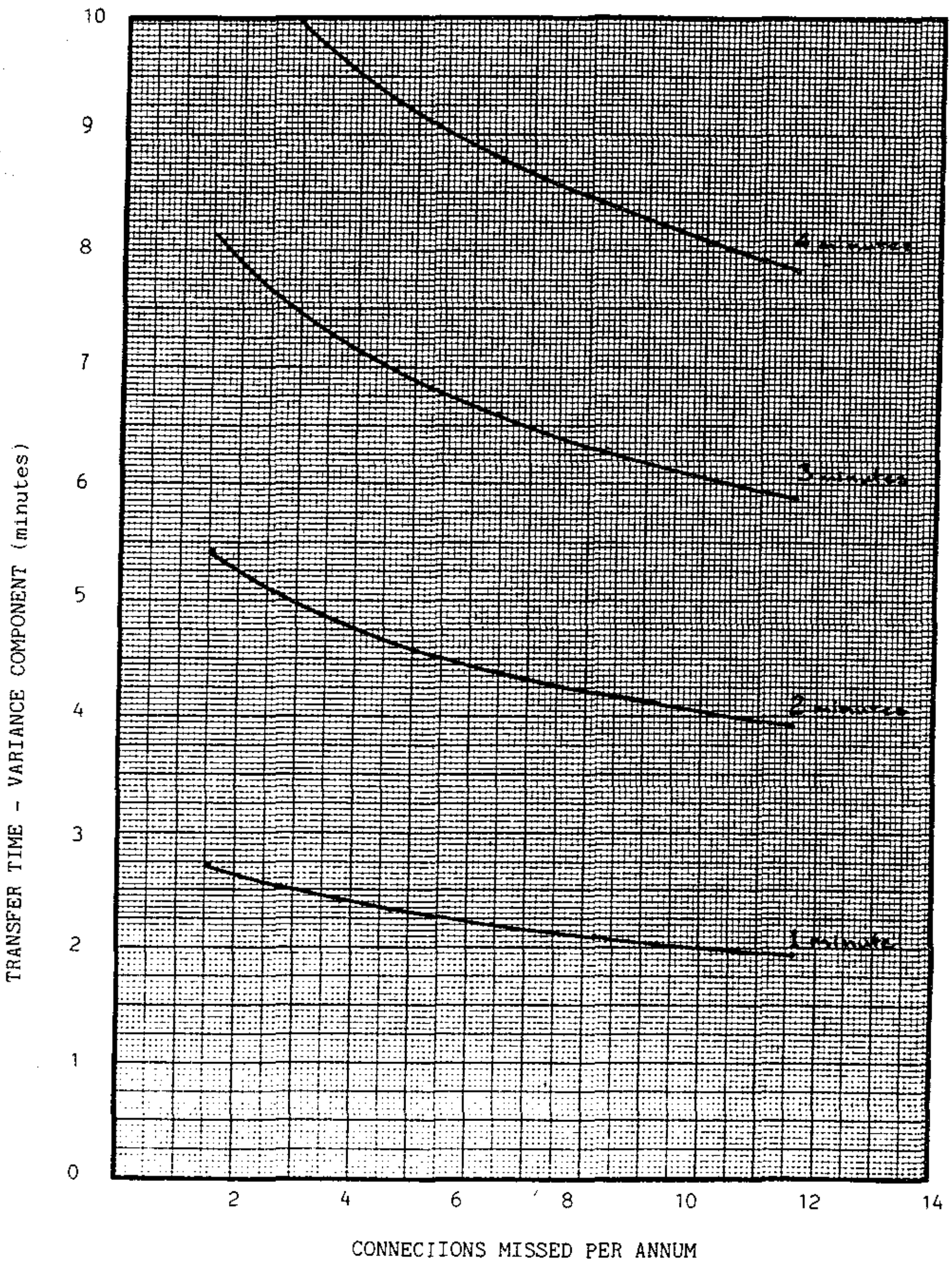


FIGURE 7

RECOVERY COMPONENI OF OPIIMAL IRANSFER IIME

Legend: ———— standard deviation of trip arrival time probability density function



THE OPTIMAL TRANSFER TIME MODEL

An Example

Figures 5 and 7 can be used to derive the variance component of optimal transfer times for any trip serving an interchange. The one, two, three and four minute lines on Figure 7 refer to standard deviations of the probability density function of any trip's arrival time distribution. The distance along the ordinate is linear so can be proportionately scaled.

Briefly the procedure is to gather sufficient data on the feeder route passing time to calculate the standard deviation of the assumed normally distributed probability density function of the feeder (or trunk) buses[1]. This, and the proposed cycle time of the inbound trunk buses or outbound feeder buses is used to derive the variance component of the optimal transfer time. For example, during the day-base a feeder route may operate on an hourly frequency to an interchange where it connects with a fifteen minute trunk to the City. Assume the walk component at the interchange is 1½ minutes. Therefore taking the inbound direction the extra wait time if the designed trunk connection is missed, is 15 minutes[2]. Using figure 5 patrons (based on Brisbane surveys) will be prepared to miss connections 8 times per annum. If the standard deviation of feeder bus reliability is about 1.7 minutes (say) the variance component of the optimal transfer time is 3½ minutes. Adding the walk time gives an inbound transfer time of 5 minutes. Note that the outbound direction commonly has a reduced feeder frequency and the trunk bus may be less reliable due to central city congestion.

Clearly the methodology is simple enough that it can be used by roster clerks in the various bus operations who do not generally have tertiary level numeracy skills. The model, though easy to use, also provides a conceptually valid basis to derive optimal transfer times. It replaces the "questimating" procedure which has previously been used. So the model can be used to eliminate timetabling practices which allow excessive running time on links near the interchange resulting in seemingly good reliability.

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1. In Brisbane despatchers at Enoggera and Toombul Interchanges record the arrival times of all in-service buses (trunk and feeder, inbound and outbound) - though their primary purpose is to ensure connections are made in the event of a perturbation to the operation. Thus the raw data which forms the pdf of the arrival times for any trip is readily available. The standard deviation for any trip can then be calculated easily.

2. The extra wait to the next connecting bus can be gauged by referring to the public timetable. A note of caution should be expressed at this point. The next connecting bus is the bus on the lowest headway route to which transfers will take place. If a feeder bus arrives at the interchange where a connecting trunk bus route has a frequency of five minutes then five minutes is the extra wait time to the next bus. If the feeder bus also transfers passengers to another trunk bus with a forty minute frequency, then forty minutes is the extra wait to the next connection which defines the optimal transfer time. Similarly if at a bus-train interchange, a trunk train has a thirty minute frequency and a trunk bus route fifteen, the larger trunk train headway defines the optimal transfer time.

Value of the Model

As well as being a tool to refine bus operations at interchanges (as described above), the model can be applied to aid in the evaluation of potential interchange sites by estimating the likely transfer times[1]. Figure 7 shows that where the standard deviation of arrival times of feeder (or trunk) buses at an interchange are greater than 2, and the off-peak cycle time is a half hour or longer, the optimal transfer time has hitherto generally been underestimated. Previous Brisbane studies of Toombul and Enoggera interchange potential used values of three and five minutes for transfer. Where a feeder trip's standard deviation of arrival times is 2, the optimal transfer time (variance component only) would be four minutes plus the interchange component. If the standard deviation was 3, an optimal transfer time of more than six minutes is required for the same 30 minute cycle time. Both Interchanges have a walk component of approximately 2 minutes.

Lest it be thought that these values are rather high, Table 2 presents the standard deviations for a number of routes serving Enoggera Interchange in Brisbane. The standard deviations were calculated using nineteen data points for each trip. It can be seen that the dispersion in arrival times as measured by the standard deviation is very high for some trips - especially for the afternoon outbound trunk buses.

The model is also independent of the modes at the interchange or synchrocentered transit centre. It can be applied equally well to bus-bus and bus-train connections and presumably also to tram or ferry connections, providing the probability density function of their arrival time distribution approximates a normal distribution.

1 This assumes that consideration is being given to changing existing bus operations to incorporate an interchange. A time series of bus passing times can be measured near the site so that estimates of transfer times can be made.

TABLE 2

ARRIVAL TIME DISTRIBUTION VALUES FOR ENOGGERA INTERCHANGE

ROUTE	PERIOD	RANGE OF STD. DEV. (mins)				
		1-2	2-3	3-4	4-5	5+
35/35A 35B	ALL DAY	8	8	9	2 high 4.95/ 3.97 low 1.04	-
20	ALL DAY	7	12	4	- high 3.17 low 1.27	-
172	PM PEAK	1	1	3	5 high 7+ low 1.76	3
57	AM PEAK	2	1	2	1 high 4.33 low 1.16	-
43A	AM PEAK	-	3	-	1 high 4.10 low 2.06	

Note: Range over a 19 weekday period.

DISCUSSION AND FURTHER RESEARCH

Robustness of the model

There are two parts to the optimal transfer time model, the trade-off between tolerated annual probability of missing a connection and the extra wait time to the next bus and the relationship between the derived probability and the optimal transfer time.

The first relationship (Figure 5) is dependent on analysis of Brisbane surveys. This relationship was found to have a reciprocal and negative exponential form with the reciprocal form being dominant for headways of less than 15 minutes. The derived model postulates that existing bus passengers are only prepared to miss a connection about 20 times a year if they have to wait five minutes for their next connection. This is nonsense as approximately half of the respondents on whose answers the model depends are making about 360 trips annually and their existing average transfers would be in the range of five minutes.

Two points should be noted. By definition, where the next bus is about five minutes extra wait, the optimal transfer time is not critical. Such a system has a high frequency, and therefore transfer times are not nearly as important. Secondly, when the results of this step are applied to Figure 7, it will be noted that the relationship between connections missed per annum and the optimal transfer time (variance component) becomes inelastic in the high frequency area. The model was developed for use in a low frequency transit system and when used in that capacity, appears robust. Certainly the tolerance towards missing connections when the extra wait for the next bus is greater than ten minutes appears realistic. Further work may be needed to test the validity of the relationship for use in other cities, or its temporal stability.

Examination of the second relationship (Figure 7) reveals that it is predominantly the reliability of the arriving bus trip which determines optimal transfer times, not the extra unit time to the next bus if the designed connection is missed. Thus the low survey response rate is not crucial. The basis for derivation of the relationship is the assumption that the probability density function of the arrival time distribution is normally distributed. It is intended to examine other mathematical distributions to determine firstly whether they are more appropriate and secondly how sensitive the determination of the variance component of optimal transfer times is to their use.

Issues arising from application of the model

Many transit systems operate policy clockface schedules during the weekday daybase. However, even in the suburbs, run times and reliability varies throughout the daybase in response to traffic congestion and passenger activity. Clearly there is a degree of conflict between operating a synchrocentered transit system on a clockface timetable and with optimal transfer times. The degree of conflict and its resolution depends on the variation in run times throughout the day.

The second aspect is the application of the model to transfers between buses at points other than interchanges. At interchanges it was effectively assumed that the connecting bus was always waiting.[1] However for suburban connections, bus movements are uncontrolled. Further work is required on application of the model to this situation and the most practical solution to ensure that the transfers are achieved.

CONCLUSION

This paper has described the development and application of an optimal transfer time model to be used at interchanges in a low frequency transit system. It was shown that the model was mode independent, could be usefully applied in refining bus operations at existing interchanges, and evaluating potential ones. The robustness of the model and areas for future research have also been discussed.

[1] For most routes this would be true as the interchange also is the bus terminus and the layover should be adequate to allow on time departure.

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Dear Passenger,

A Metropolitan Transit Authority survey conducted, on board feeder buses to Enoggera Interchange in June, 1982 indicated that many people were concerned about missing their intended bus or train connection. This survey will provide information that will be used to help design a better bus service.

In particular questions 7 and 8 will help in designing appropriate transfer times between buses or trains. As you know the shorter the transfer time at an interchange, the faster the average trip time, but the greater would be the possibility of missing the planned connection due to traffic delays, etc. Your answers will enable us to design better transfer times at Enoggera and Toombul Interchanges by assessing the most acceptable balance between these two effects.

So that you can think about the questions a pre-paid self addressed envelope is provided. Alternatively you may like to hand in your completed form to the Council Bus Inspector in the Despatch Office at the Interchange.

Thank you for your co-operation.

K. B. DAVIDSON
MANAGER
BRISBANE CITY COUNCIL
DEPARTMENT OF TRANSPORT

Printed by B.C.C. Dept. of Transport.

SURVEY № 2880

Please tick the appropriate box. On completion post in the attached envelope or hand to the Inspector at the Interchange.

1 How many times per week do you use public transport for this trip?

☐ 8 or more ☐ 7 to 3 ☐ less than 3

2 Do you catch this bus at this time.

☐ more than 75% of the time? ☐ 75% to 25% of the time? ☐ less than 25% of the time?

3 When you reach the Interchange do you normally

☐ stay on this bus? ☐ change to a train? ☐ change to another bus? ☐ other?

4 Where are you going to?

☐ work ☐ shopping ☐ education ☐ personal business ☐ other

5. Have you ever failed to make your planned connection at the interchange?

☐ No GO TO QUESTION 6

☐ Yes

If yes, approximately how often has that occurred?

☐ once a week or more ☐ once every 2 months
☐ once a fortnight ☐ once every 3 months
☐ once a month ☐ once every 6 months
☐ once a year or less

6 a) If you have ever missed a connection at the Interchange on your journey from home (going to work, shopping etc.) did you.

☐ wait for the next bus or train?
☐ try to catch a taxi?
☐ Phone somebody and arrange a lift?
☐ walk?
☐ other / what was that?

b) If you missed a connection on your way home did you

☐ wait for the next bus or train?
☐ try to catch a taxi?
☐ Phone somebody and arrange a lift?
☐ walk?
☐ other / what was that?

How far from the Interchange do you live?

☐ less than 1 mile ☐ one to two miles ☐ more than two miles

P.T.O

8 Assume you are on a bus travelling to the interchange where you have to change to another bus or train to make your connection. Would you please tick how many missed connections you would tolerate if you had to wait 5 minutes for your next connection. Please also answer for the three cases where you would have to wait 10 minutes, 30 minutes and 60 minutes for your next connection.

Example:
If you are prepared to tolerate missing your connection once a fortnight when you have to wait 5 minutes for your next connection you would tick box 14-2. However, if you had to wait 60 minutes you might only tolerate missing your connection once a year and would tick box 19-7.

Connection Missed (Assume two trips per day)	5 mins	Time to Wait for your next connection 10 mins	30 mins	60 mins
once a week or more	☐	☐	☐	☐
once a fortnight	☐	☐	☐	☐
once a month	☐	☐	☐	☐
once every 2 months	☐	☐	☐	☐
once every 3 months	☐	☐	☐	☐
once every 6 months	☐	☐	☐	☐
once a year	☐	☐	☐	☐

Any comments? ....

9 Again assume you are on a bus travelling to the interchange where you have to change to another bus or train to make your connection. However, also assume you have a car available for this trip if you want to use it. Would you please tick how many missed connections you would tolerate before you decided to use the car rather than public transport, if you had to wait 5 minutes for your next connection. Please also answer for the three cases where you would have to wait for 15 minutes, 40 minutes and 120 minutes for your next connection.

Connection Missed (Assume two trips per day)	5 mins	Time to Wait for your next connection 15 mins	40 mins	120 mins or more
once a week or more	☐	☐	☐	☐
once a fortnight	☐	☐	☐	☐
once a month	☐	☐	☐	☐
once every 2 months	☐	☐	☐	☐
once every 3 months	☐	☐	☐	☐
once every 6 months	☐	☐	☐	☐
once a year	☐	☐	☐	☐

Any comments? ....

10 Your Age and Sex?

☐ Female ☐ Male

☐ Under 10 ☐ 10 - 16 ☐ 17 - 24 ☐ 25 - 29 ☐ 30 - 39

☐ 40 - 49 ☐ 50 - 59 ☐ 60 - 69 ☐ over 70

THANK YOU FOR YOUR CO-OPERATION

K.B. Davidson
MANAGER
BRISBANE CITY COUNCIL

8 Assume you are on a bus travelling to the interchange where you have to change to another bus or train to make your connection. Would you please tick how many missed connections you would tolerate if you had to wait 5 minutes for your next connection. Please also answer for the three cases where you would have to wait 15 minutes, 40 minutes and 120 minutes for your next connection.

Example:
If you are prepared to tolerate missing your connection once a fortnight when you have to wait 5 minutes for your next connection you would tick box 14-2. However, if you had to wait 120 minutes you might only tolerate missing your connection once a year and would tick box 20-7.

Connection Missed (Assume two trips per day)	5 mins	Time to Wait for your next connection 15 mins	40 mins	120 mins or more
once a week or more	☐	☐	☐	☐
once a fortnight	☐	☐	☐	☐
once a month	☐	☐	☐	☐
once every 2 months	☐	☐	☐	☐
once every 3 months	☐	☐	☐	☐
once every 6 months	☐	☐	☐	☐
once a year	☐	☐	☐	☐

Any comments? ....

9 Again assume you are on a bus travelling to the interchange where you have to change to another bus or train to make your connection. However, also assume you have a car available for this trip if you want to use it. Would you please tick how many missed connections you would tolerate before you decided to use the car rather than public transport, if you had to wait 5 minutes for your next connection. Please also answer for the three cases where you would have to wait for 10 minutes, 30 minutes and 60 minutes for your next connection.

Connection Missed (Assume two trips per day)	5 mins	Time to Wait for your next connection 10 mins	30 mins	60 mins
once a week or more	☐	☐	☐	☐
once a fortnight	☐	☐	☐	☐
once a month	☐	☐	☐	☐
once every 2 months	☐	☐	☐	☐
once every 3 months	☐	☐	☐	☐
once every 6 months	☐	☐	☐	☐
once a year	☐	☐	☐	☐

Any comments? ....

10 Your Age and Sex?

☐ Female ☐ Male

☐ Under 10 ☐ 10 - 16 ☐ 17 - 24 ☐ 25 - 29 ☐ 30 - 39

☐ 40 - 49 ☐ 50 - 59 ☐ 60 - 69 ☐ over 70

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