Approach to Developing Transport Improvement Proposals

Occasional Paper

This Occasional Paper summarises the procedures and findings of a series of investigations undertaken to identify transport disadvantaged groups of urban residents. It clarifies the assumptions underlying the systematic planning procedures adopted and outlines an approach for identifying and analysing suitable improvement options for particular consumer segments in accordance with the particular issue under study. The approach is discussed in the context of transport related criteria and the role of urban transport improvements in assisting in achievement of objectives.

BUREAU OF TRANSPORT ECONOMICS

AN APPROACH TO DEVELOPING TRANSPORT IMPROVEMENT PROPOSALS

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FOREWORD

This Occasional Paper was originally prepared by the Commonwealth Bureau of Roads in 1976 and released as Commonwealth Bureau of Roads Occasional Paper Number 2. Stocks were exhausted in 1976.

On 30 June 1977 the Commonwealth Bureau of Roads was amalgamated with the Bureau of Transport Economics. The new Bureau of Transport Economics brings together the roles of both former organisations and has the primary function of assisting and advising the Commonwealth government on economic, technical and financial aspects across the whole field of transport.

In the interests of helping to identify and solve transport problems and to plan transport developments, the Bureau has reprinted this paper in its original format within its Occasional Paper series. Full acknowledgment of the authors, contributions etc. is given in the preface.

G.K.R. REID
Acting Director

PREFACE

This occasional paper summarises the procedures and findings of a series of investigations undertaken to identify transport disadvantaged groups of urban residents. Chapter One introduces the objectives of the study and clarifies the assumptions underlying the systematic planning procedures adopted. The second chapter outlines an approach for identifying and analysing suitable improvement options for particular consumer segments in accordance with the particular issue under study. The approach is discussed in the context of transport-related criteria and the role of urban transport improvements in assisting in achievement of objectives. These preliminary chapters describe the theoretical and conceptual underpinnings of the study.

The remaining chapters are specifically concerned with urban road-based public transport as a means of alleviating disadvantage. These summarise the results of an application of the procedures using certain assumptions. Sydney is selected as the case study metropolitan area.

Chapter Three describes the empirical study undertaken to identify the ranking of all urban locations with respect to transport service, and the selection of transport/location disadvantaged groups of travellers. Chapter Four provides details on the collection of data and estimation of a travel choice model for the subsequent generation of projects designed to reduce the relative level of transport disadvantage for the residents of the outer urban area of Green Valley. The next chapter reviews a range of transport policy options and technological alternatives for their suitability in providing increased benefits to the disadvantaged group, via a consideration of the important factors influencing travel choice. Critical factors likely to constrain the implementation of an option are accounted for in the selection of projects.

Chapter Six describes the identification of a particular travel corridor (Green Valley – Bankstown) which has a sufficient number of work journeys to justify an investigation of transport improvements that have a high probability of meeting the criterion of reducing the total generalised cost of travel for the identified transport disadvantaged groups. Chapter Seven outlines the project evaluation procedure for the major proposals with emphasis on the identification and measurement of the costs and benefits required as inputs into a cost-benefit analysis and an assessment of the financial viability of the transport improvement from the operators' viewpoint. Other smaller projects are discussed and evaluated in Chapter Eight.

The final chapter summarises the procedures and results of the study both in general and for Sydney in particular. The overall contributions of the study are reported.

This occasional paper is written by Dr. D.A. Hensher, Mr. R.A. Smith and Mr. P.G. Hooper of the Evaluation Branch under the direction of Mr. J.K. Stanley. The Bureau would like to acknowledge work undertaken by its staff and the assistance provided by Messrs. J.M. Ravallion, G.D. Sheather and E. Pollnow of the Planning Research Centre (University of Sydney), the Urban Transport Study Group, the Public Transport Commission of New South Wales, The Department of Motor Transport (N.S.W.), the Bus Proprietors Association of N.S.W. and the private bus operators in the south-western suburbs of Sydney who gave their time in a detailed study of the private bus industry.

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CHAPTER 1

INTRODUCTION

The objective of this study is to develop a systematic planning approach for identification of inadequacies in the existing level of personal transport service, and identifying means of removing such inadequacies. The available policy instruments are drawn from a wide range of urban improvement options, including non-transport improvements.

1.1 UNDERLYING ASSUMPTIONS OF THE APPROACH

There are two broad approaches within any planning philosophy, one emphasising the level of service afforded to particular groups and the other efficient operation of facilities. The first approach might be called the "equity" or distributive justice approach, and the second the "efficiency" approach. A unifying feature which should be common to both approaches is the use of consumer preferences as the basis for developing improvement projects. This requires a market orientation in the identification of benefits and costs.

The role of planning is seen as the provision of knowledge to assist decision-making. Regardless of whether distributive justice or strict efficiency is emphasised, the degree of certainty or uncertainty is an important influence throughout the planning process as it determines the level of significance the decision-maker can place on the results. Planning should be flexible in order to respond to changing circumstances. The systematic and comprehensive assessment framework of the present study is consistent with incremental planning. This permits the flexibility of planning which provides relative certainty in the achievement of benefits from the existing road and transport infrastructure in the realization of ultimate goals.

As nearly all project development is efficiency orientated, in the present study the distributive justice approach has been selected for detailed investigation so as to emphasise the importance of this alternative criterion. Distributive justice can be stated as the provision to all individuals of opportunities to enable them to enjoy a way of life not below an acceptable basic level and to enable them by their own efforts to exceed this level. As discussed in subsequent chapters, when using the distributive justice approach, equity between individuals should be judged in terms of some external criteria.

1.2 THE ROLE FOR LOW-COST SOLUTIONS

In the long term there are many desirable transport and non-transport policies which should be directed towards improving accessibility to opportunities and the achievement of distributive justice. However there are also many transport options available for implementation in the immediate future, and these have formed the basis for the policy options discussed in this study.

There is a wide range of technological possibilities and investment options enabling the planner to cope with varying situations to meet evolving needs. These can be broadly categorised into large, capital-intensive investment programs having long gestation periods (e.g. construction of railway infrastructure), and low-cost programs involving small-scale improvements to existing facilities, which typically achieve their effect after a minimal period.

The relative merits of each ought to be taken into account in the formulation of transport planning strategies. However, up till the present, planning schemes have been concerned more with long-term capital-intensive improvement programs. Financial assistance has tended to follow the same pattern. Transport management and other short-term improvements have more often been practical solutions introduced on an *ad hoc* basis to meet problems observed in the field. As a result, the basis for implementation of these policies has not necessarily been compatible with a systematic assessment of alternative ways of improving the transport system. Urban transport planning in Australia has almost exclusively emphasised efficiency-oriented high-capital cost programs designed to expand capacity, especially road and rail capacity.

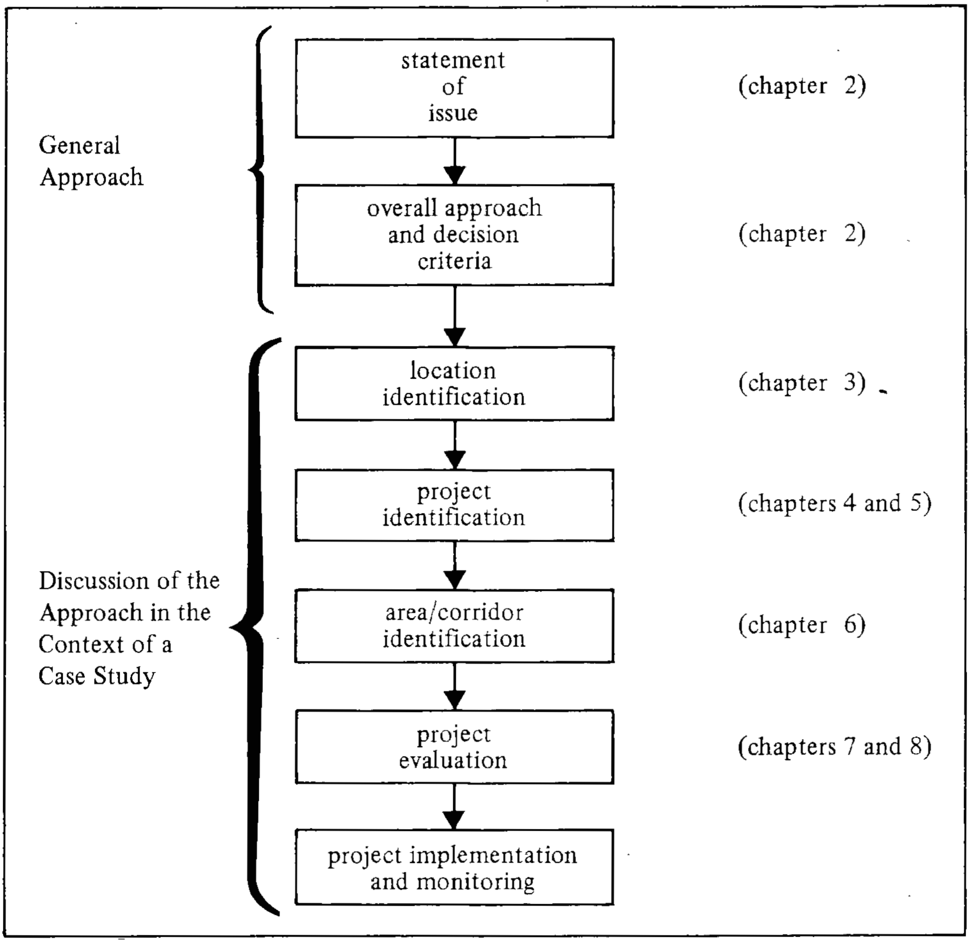
While there is a valid argument that policies designed to relieve the combined pressures on the environment (the air breathed, the noise endured and the quality of surroundings) require the development and demonstration of new systems technology, there are low-cost options available which can significantly improve urban accessibility and also offer environmental and energy conservation benefits, and which can be implemented immediately.

Extensive research and experimentation has occurred with short-term low-cost investment options in recent years in countries other than Australia. This experience has made it possible to predict, with a relatively high degree of confidence, the results of each option when applied in particular circumstances. It has been found that in each case the benefits are not immense but that the combined impact of a concerted planning effort may well be substantial. Because of the relative neglect of low-cost options in the past and the promise afforded by this type of investment, it forms an appropriate orientation for this study. We have thus chosen in this study to concentrate on low-cost, positive-benefit, short-implementation-period options, which make better use of existing road and rail transport infrastructure. Such options can provide a means of achieving both greater distributive justice for particular groups and improved efficiency in the provision of transport service.

This study has three key emphases. The first is the framework within which issues may be investigated (Figure 1.1), broadly expressed as a sequence of location identification, corridor or area identification within a predetermined location, project identification, project evaluation, project implementation and monitoring. The second emphasis is the particular criteria to adopt at the various stages within this sequential framework. Finally, the first two phases of the methodology are combined in a real-world setting to identify and evaluate projects to illustrate the application of the approach.

FIGURE 1.1

PROPOSED PLANNING FRAMEWORK



CHAPTER 2

THE APPROACH

2.1 THE PLANNING APPROACH

2.1.1 Selection Of An Objective

The total approach is directed towards the establishment of recommendations for warranted projects based on the collection of empirical evidence. Traditionally, economic analysis has been the basis for decision-making with an ever increasing trend towards the inclusion of non-monetary benefits. Too often, however, cost-benefit analysis as a technique is mistakenly identified with project evaluation. Project evaluation should be concerned with much broader issues, including the selection of the "right" projects. Whatever the outcome of cost-benefit analysis (or any other quantitative assessment method), a right decision cannot possibly be made with the wrong projects. With a systematic procedure as a basis for generation of the right projects at the right time, for a particular set of issues, it is then acceptable to continue the total project evaluation process.

Identification of goals, and from those goals identification of specific issues for investigation is an important part of any planning process. The selection of a target issue is a difficult task given the many issues that are relevant to the various entities in the economy (politicians, citizens, planners, consumers etc.). While it is desirable to have a mechanism by which a target issue can be investigated the present study has taken as given an issue which is important to the tasks of the Bureau of Roads. That issue is the transport disadvantaged.

The planning approach involves the development of criteria and decision rules to identify and rank "locations" within the metropolitan area experiencing transport problems and to which transport solutions might be applied. The "locations" were defined as groups of people, zones, or links, according to the various sub-issues. The concept of accessibility while fundamental to the issue of transport disadvantaged, cannot form the basis of the study because of measurement problems.

2.1.2 Assumptions Underlying The Analysis

The basic unit of analysis is a crucial determinant of the approach adopted in pursuance of an understanding of the role of transport in aggravating and also alleviating social and/or economic inefficiencies. It is desirable that the unit of analysis for investigations relating to welfare considerations be the individual or the group of individuals who make decisions concerning the use of physical units (subject to individual and household constraints). For strict efficiency studies, however, a physical unit is usually utilized (e.g. a road link) and then related to the use of such a physical entity in achieving a desired end.

The choice of equity or efficiency as the base assumption may influence the criteria and decision rules selected to rank areas in accordance with the issue, to arrive at a set of individuals or facilities that will be subject to further investigation at the project level. An important aspect of the methodology adopted in this study is that all of the groups of people or road links selected for detailed investigation at the project level are defined relative to all individuals or road links in an entire metropolitan area. This perspective is considered necessary for effective allocation as it provides a sound basis for the selection of particular groups of individuals or road links for project analysis, rather than other possibilities.

2.1.3 Simplifying The Issue For Analysis

In any study of complex behavioural intention such as individual travel decision-making, it is necessary for operational reasons to distinguish and restrict the range of decisions and outcomes. It is useful to suggest a mechanism of selection which identifies the journey purposes, and the particular mobility and travel choices relevant in this study. The actions of an individual consumer in the market place can be said to include the following set of mobility choices: choice of residential location, choice of dwelling type, choice of car ownership level, and choice of employment location.

2.1.4 Choice Of The Work Trip

The work trip's place in the hierarchy is different from that of trips for other purposes. The mobility choices determine all the travel choices for the work trip except the possible short-term adjustments of mode, route and perhaps time of day for employees without fixed working hours. The journey to and from work is an important trip for most households and generally has a greater influence on mobility decisions than other trip purposes. Thus, for workers the choice of mode to work is a higher level choice than travel choices for other trip purposes. The work trip is therefore justified for initial investigation, with limited system effects in the immediate future on the other journey purpose choice acts; and for low-capital, short-gestation-period options (see Chapter 5), it is argued that only changes in mode and route choice need to be analysed.

An operationally-related argument for suggesting the work journey for initial investigation is that the journey to work lends itself to being served by public transport because it is the dominant journey purpose in the period when the greatest demand for person movement occurs. The only other travel purposes amenable to the public transport facility on any scale would be centrally-oriented shopping, social and recreational activities, using "central" in a broad sense. It is at the peak time that initial attempts should be made to make better use of existing transport infrastructure. This is an alternative argument to that commonly adopted to justify consideration of the work trip only, which is

> "The focus is on the problem of moving passengers into and out of cities during the peak or rush hours, occurring morning and afternoon on weekdays. It is these movements that tax the capacity of existing urban transport facilities and create the congestion and delays that most people associate with .... the urban transportation problem."*

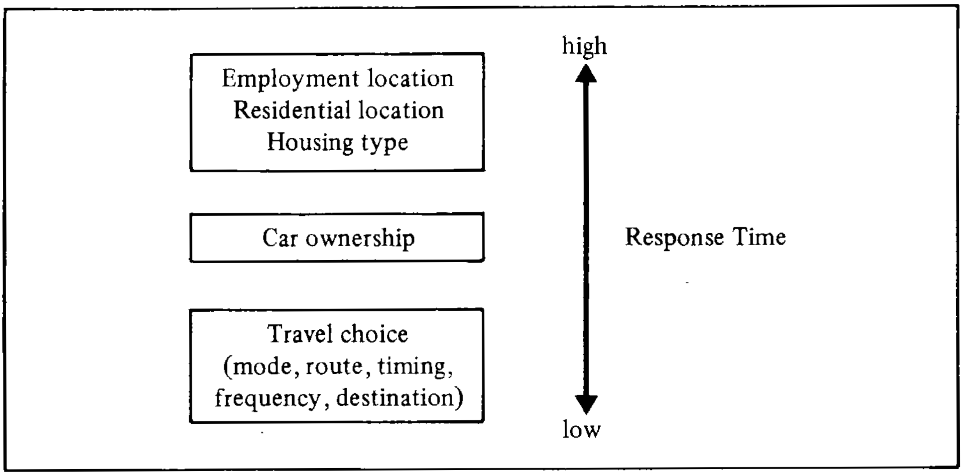
From the viewpoint of an individual trip-maker, a trip decision for a specific trip purpose can be described as consisting of the following set of travel choices: choice of trip frequency, choice of destination, choice of time of day, choice of mode and choice of route. The consumer typically makes his mobility decision in a longer time frame than that of his travel decisions. The hypothesized hierarchy of mobility and travel choices is essentially a result of the different time frames in which the various choices are made (see Figure 2.1).

In the short term the assumption can be made that mobility decisions are fixed and only travel choices vary. At any point in time, however, a consumer has different levels of commitment to the different choices previously made. Therefore, given a change in policy, it will take each choice a different time period to respond to or reach its new equilibrium. For example, in response to a change in the level of transport service, it is assumed that in the immediate future only the mode of travel and route can be changed for the work trip. In the medium term car ownership level may be altered. The hierarchy suggested places mobility choices on a higher level than travel choices.

* Meyer, J.R., Kain, J.F. and Wohl, M. (1965) **The Urban Transportation Problem** (Harvard University Press, Cambridge), p. 5.

FIGURE 2.1

A DECISION SEQUENCE



Of all the mobility choices, car ownership decisions are on the lowest level followed by housing type, residential location, and then employment location.

The choice of journey to work does not deny that non-transport policy options (e.g. flexitime) will not have an impact on both work and non-work travel, but only that the work trip-specific policy options (e.g. express bus services introduced for peak-hour work travel) will have limited immediate effects on other travel patterns. In contrast the longer-term effects of low-cost options arising from the present study may be significant. Since, however, a limited number of such projects will be recommended as demonstration projects as a real-world test of the effectiveness and appropriateness of the method, we have assumed negligible overall long-term effects. The empirical illustration expanded in the following chapters is concerned only with the choice of mode for the work journey. However, if many supply strategies and projects arose from the selected issue, a more complex choice set would be required to fully assess the issue. The same general framework would still be appropriate.

2.2 THE TRANSPORT DISADVANTAGED AND THE JOURNEY TO AND FROM WORK

The target issue of the study is the improvement of transport for transport/location disadvantaged groups of people in urban areas. More specifically the objective was to identify those groups in the community who are relatively disadvantaged from a transport/location viewpoint. Accessibility which is poor for physical reasons (health etc.) was not a prime concern of this study. Low car availability combined with a commitment to car usage for the journey to work may make non-working members of the household relatively transport/location disadvantaged. The objective was to identify areas where there is not only transport/location disadvantage, but where public transport is also poor. In these circumstances there should be potential for an improvement in the public transport availability, to reduce transport/location disadvantage for the work trip and create benefits for residual trips through its effect on car availability.*

* Previous Bureau studies on consumer preferences in urban trip making demonstrated the effect of car usage for the work journey on the captivity of the housewife to a relatively limited set of shopping opportunities. See D.A. Hensher (1974) **Consumer Preferences in Urban Trip Making** Unpublished Report 72/68 to the Commonwealth Bureau of Roads: Melbourne.

The approach to the selection of appropriate transport improvement projects involved two key stages – the identification of the residential location of the disadvantaged (the "location identification" stage entailing a ranking of areas on the basis of criteria and decision rules discussed below) and then, given this determined location, the identification of projects to reduce the degree of transport disadvantage (the "project identification" stage). The overall framework is summarised in Figure 2.2.

2.2.1 Development Of Criteria To Measure Transport Disadvantage

To determine the present level of transport service in the context of identifying the transport disadvantaged for the work journey, the basic premise that such a disadvantage is reflected in the present distribution of the private costs of transport usage was adopted in the first instance. The higher such costs, the greater would be the disadvantage.

The incidence of existing work journey generalised cost (summation of money and time costs), however, was not regarded as a satisfactory sole criterion of "need". High transport costs can result from any combination of a number of factors such as poor provision of public transport facilities relative to residential and employment locations or poor distribution of employment opportunities relative to residences. High work journey costs might also reflect households' location preferences, whereby the household is willing to forego accessibility to employment in favour of other location benefits, in particular accessibility to other urban services. For these reasons, income was used as a crucial constraint on household preference. The coincidence of high transport costs and low income was believed to provide a measure of transport/location disadvantage which the household would have difficulty in avoiding by way of either relocation or increased car ownership.

The varying total demand for the work trip (T) in an interzonal comparison of need for improved accessibility to employment was taken into account by defining "need" as an increasing function of transport costs (per work trip per zone) and workforce per zone, and a decreasing function of income (per worker per zone). The relationship between transport cost incidence and the group's ability to pay (or avoid) such costs was described algebraically as:

$$M_i = \frac{C_i}{I_i}$$

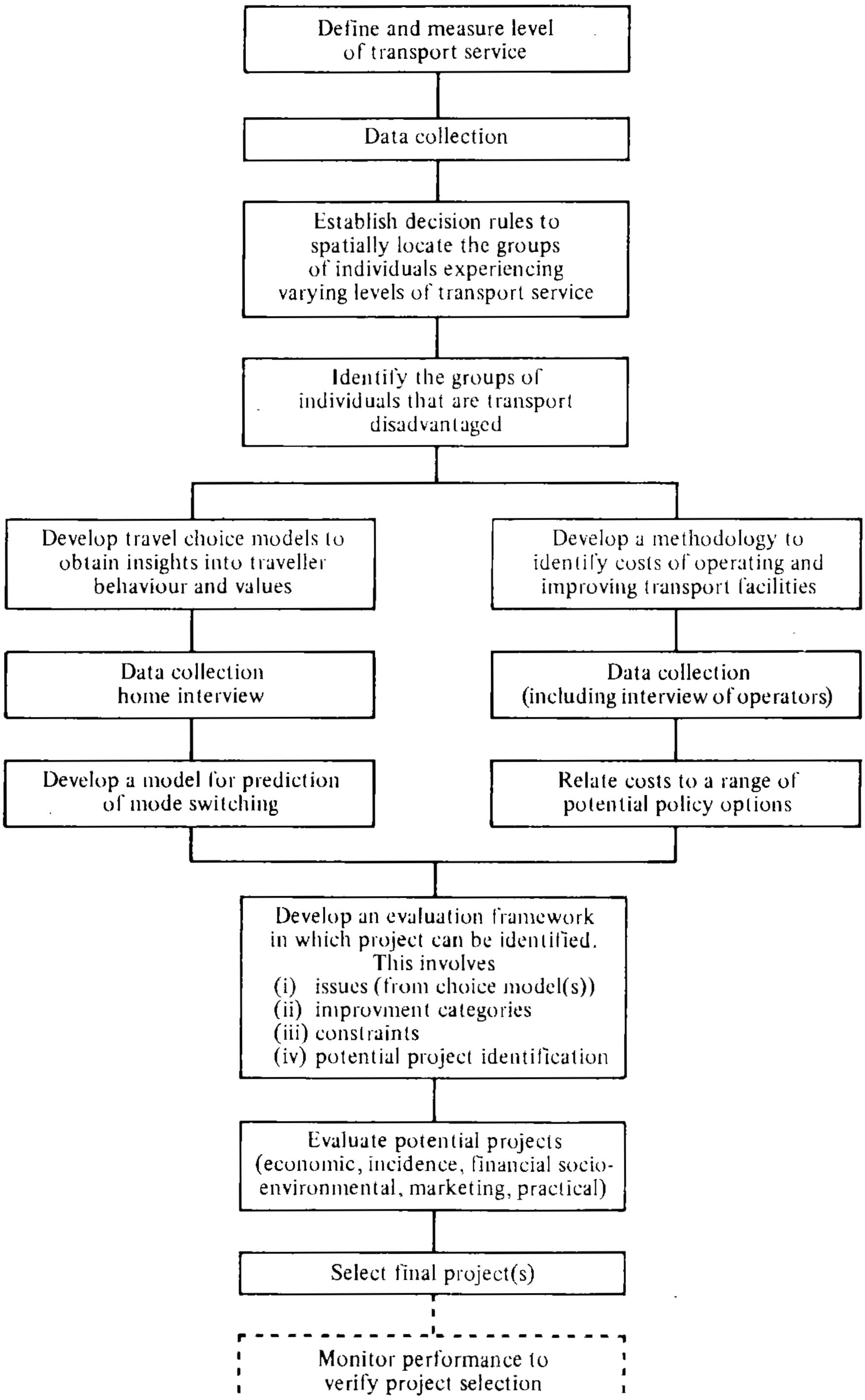
where M_i = incidence of journey-to-work generalised costs on income, zone i.
C_i = mean journey-to-work generalised cost per person, zone i.
I_i = mean gross income employed person, zone i.

Given the additional planning objective of this study of identifying those transport disadvantaged groups who might be assisted by improved public transport, to allow for the difference between total zonal and public transport zonal effects, and to separate the variation in transport cost incidence due to differences in mode characteristics, a "public transport disadvantage" variable (P_i) was defined as the weighted mean deviation of C_{ij} (public transport) from the mean C_{ij} (all modes).

It was in fact difficult to select a variable which would provide an accurate and unambiguous indication of public transport disadvantage. For the purpose of this study the variable P_i as defined below has been used to represent this characteristic. It is not the only nor necessarily even the best possible alternative. Another variable which could have been used to indicate public transport disadvantage is the relative cost of public transport compared with the generalised transport cost over all modes; that is C_{i2}/C_i.

FIGURE 2.2

THE FRAMEWORK FOR IDENTIFICATION OF PROJECTS TO ASSIST THE TRANSPORT – DISADVANTAGED



$$P_i = \frac{\sum_{j=1}^{n} T_{ij2}\ (C_{ij2} - C_{ij})}{T_{i2}}$$

where T_{ij2} = number of trips between i and j by public transport.

C_{ij2} = mean generalised cost of travel between i and j by public transport, per person trip.

C_{ij} = mean generalised cost of travel between i and j by all modes, per person trip.

P_i was used to identify whether work tripmakers from zones identified as being transport/location disadvantaged were also disadvantaged with respect to public transport services. Simplifying the above formulation gives

$$P_i = C_{i2} - C^*_{i2}$$

where C_{i2} = actual public transport cost incidence, zone i.

C^*_{i2} = hypothetical cost incidence if public transport commuters from zone i had only incurred the average cost of all modes.

This variable utilizes the present distribution of land-use and public transport trips, and is only affected by the individual's opportunity cost of public transport usage for that trip distribution.

2.2.2 The Method Of Ranking Areas According To The Criteria Developed

The ranking of spatially-defined groups of travellers, given the three decision variables (M_i, T_i, P_i) was conditioned by a set of pre-determined "rules" and the involvement of value judgements. Since it was naive to assume that there is one necessarily "correct" criterion, and since the final allocation of transport expenditure should ideally stem from the explicit consideration of the properties desirable in a social welfare function, it was necessary to assess the extent of inter-relationship between the three decision variables. This is an important determinant of the sensitivity of the identified rank order of zones, to the form of the decision rule. If the three variables move in close association, and in fact behave as one variable, then the task of identifying and ranking is straight-forward. But as the empirical evidence indicated the contrary, the following decision rules were adopted in location identification. Each rule involves the definition of standard ranks and values, whereby critical levels are established for the variables used, above which a zone was "identified":

Rule 1: The identified zones must simultaneously have relatively high values for M_i and P_i.

Rule 2: The maximum ranks for M_i and P_i should yield the number of zones for which study resources allow further investigation at the project identification stage.

Rule 3: Zones identified according to the above conditions, are grouped into contiguous areas and ranked by the sum of T_i for the grouped zones.*

* The grouping of zones according to their contiguity makes some allowance for external benefits to neighbouring zones. The final ranking, according to total trip production assumes homogeneity according to M and P within a set of identified zones.

2.2.3 Identification And Evaluation Of Projects

Once the transport disadvantaged locations (origin zones) were identified, projects that might provide net benefits to these locations had to be developed and assessed. The emphasis at the outset was given to a knowledge of travellers' behaviour patterns and preferences as a basis for understanding the extent to which the relatively transport disadvantaged might benefit from potential transport improvements. Home-interview data was collected, and disaggregate probabilistic choice models developed to assess the role of a range of characteristics in influencing choice and also the extent to which various combinations of bundles of trip and modal characteristics were associated with positive changes in the level of user benefits.

In order to identify the potential of public transport options, a range of explanatory variables was included in the choice models. These variables were chosen to reflect the service characteristics influencing choice. A taxonomy of potential improvements, and the constraints in the system (institutional, financial, marketing, etc.) were used in addition to arrive at particular supply strategies (see Tables 5.1 and 5.2). A trade-off was made subsequently between the various levels of benefit attainment and costs associated with supply strategies, within the limits of realistic levels of technological progression.

This approach amounts to the identification of the least-cost alternative for a given degree of benefit attainment. The existence of the constraint on the benefit side is an important variation from the traditional approach of constraining the cost side and relates back to the underlying analytical basis of the location identification stage where locations were ranked and selected on the basis of relative levels of generalised cost. The aim of project identification is to determine the type of project and the associated new level of generalised cost (for the particular activity) for residents of the designated urban location. The project when introduced should reduce the level of transport disadvantage of residents in that location.

Evaluation of the selected location-specific supply strategies was based on an assessment of the relatively immediate (up to five years) benefits and costs to the user and non-user. Given the emphasis on relatively certain, low-cost, positive-benefit transport options with short gestation periods designed to complement the more substantial capital-intensive transport investment through providing a flexible and limited-locality service, significant general effects on overall urban activity were not anticipated. That is, an underlying assumption of the study is that implementation of the identified transport improvement projects would not have unexpected and harmful secondary effects. This does not, however, invalidate the conceptual framework for use in the identification and evaluation of high-cost, long-gestation-period projects. The evaluation method is outlined in the later chapters of this report.

Monitoring a project both before and after project implementation provides a basis for assessing the appropriateness of the adopted method of project selection and evaluation. In particular the reliability of prediction derived from the demand model can be tested. The final evaluation must be determined by a monitoring exercise, spread over the early life (say 2 years) of a demonstration project. Extensive monitoring of a wide range of project types in varying situations is necessary in order to finally have confidence in a (modified) version of the present method developed to advise on financial allocation to transport improvements. Real-world empiricism using the supply technology is a real test of the appropriateness of the methodology.

2.3 THE METHODOLOGY APPLIED TO A DIFFERENT ISSUE

2.3.1 The Issue – Improvement Of Road Passenger Movement By Public Transport

In order to indicate the flexibility of the general approach outlined above it is useful to briefly outline the way of using this procedure with another target issue. The exemplary target issue chosen is the improvement of road passenger movements which at present experience "poor" performance. In the context of this issue the emphasis could be on ways of improving public transport facilities in order to improve the relative transport efficiency of consecutive road links, measured in terms of improvements in average speed (for example, via changes in modal and passenger composition on the routes under investigation). The suggested approach follows the same guidelines as for the transport disadvantaged study. The overall framework is summarized in Figure 2.3.

2.3.2 Selection Of Decision Criteria To Measure Efficiency In Road Passenger Movement

The average travel times of all traffic during the peak period (in the direction of maximum traffic flow) could be chosen as the main criterion for ranking "locations". "Locations" are defined here as sets of consecutive road links with similar inefficiencies (low average speeds). Limited availability of data on actual road links (in contrast to zonal information) would not normally permit the adoption of any further criteria, with the exception of the total volume of traffic. This criterion is required to ensure that there is enough traffic to make an improvement potentially worthwhile. Location identification could be restricted to road links on existing bus routes, on the grounds that recommendations for improvements to an existing facility have greater prospects for (early) implementation.

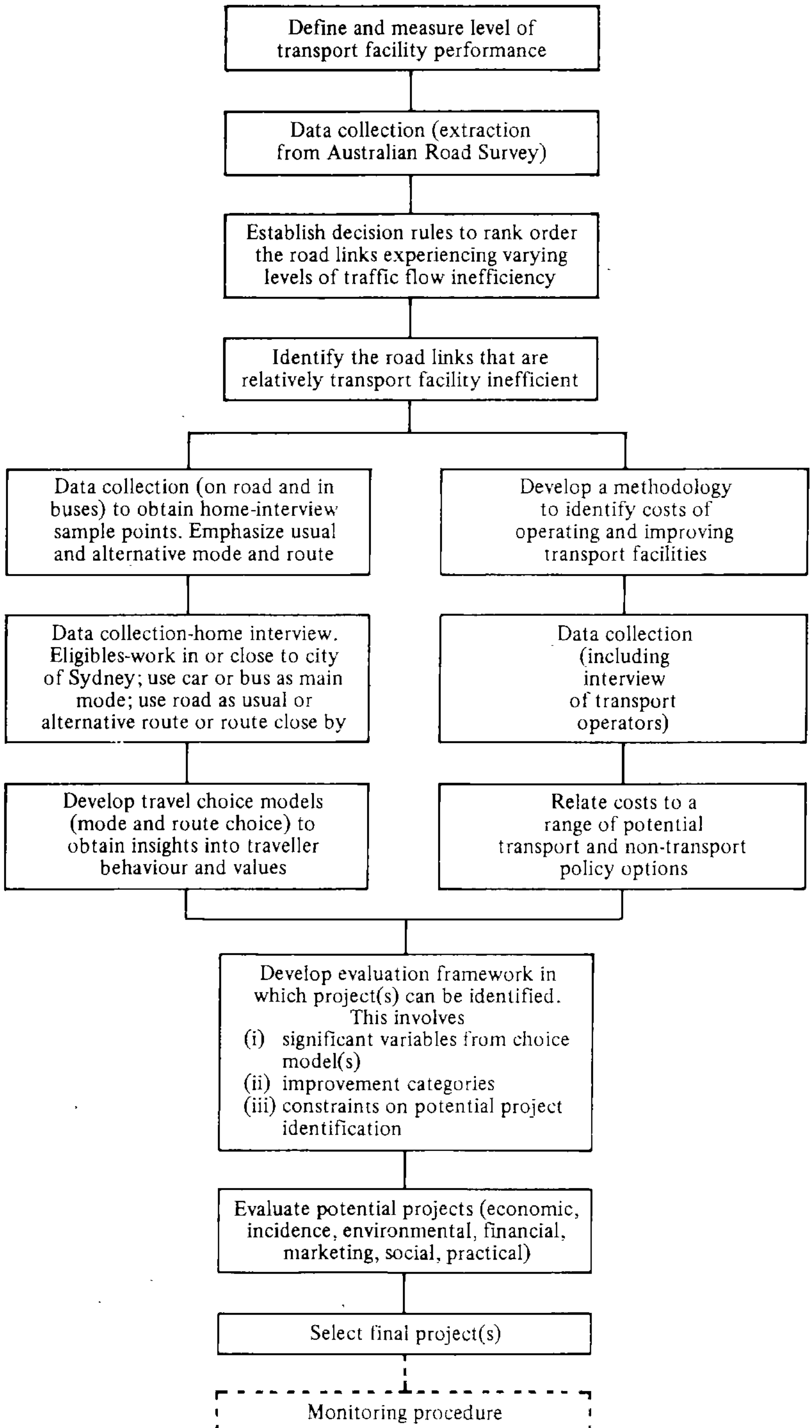
The socio-economic composition of traffic would not be of initial concern. However, the origin-destination profile by mode and route is central to the determination of the potential levels of patronage expected from an improvement. A check of this profile from existing data sources would be required as a basis for identifying the relationship between the total journey length and the proportion of such a journey on the relatively inefficient road links. The effect of improvements on the congested links is clearly dependent on its impact on the overall journey. Once all road links had been ranked on the basis of average travel time, and the contiguous nature of each road link had been considered, given origin-destination profiles (by mode and route), the road links that are relatively inefficient would be selected for further analysis at the project identification stage.

2.3.3 Selection Of Projects

The project identification stage would be very similar in emphasis to that outlined for the transport disadvantaged study, the main difference being in the identification of a sample set for the home-interview. The travel choice set could be simulated by a choice of mode and route along the inefficient set of links and between competitive links (and modes). Area-wide transportation study data would be inadequate for this purpose since the zonal assumption and assignment algorithms would be unable to distinguish within a zone the particular road links. A hand-out-on-site form may need to be developed to seek out the actual and potential users of the road link; who at present either use the road link and travel by bus or car, or do not use the road link (travelling by bus or car) but who might benefit by the link improvement either as a switcher or member of residual non-switchers.

FIGURE 2.3

THE FRAMEWORK FOR IDENTIFICATION OF PROJECTS TO IMPROVE TRANSPORT FACILITY INEFFICIENCY – THE WORK TRIP



Identification of the travellers having particular choices is an often neglected stage in methodologies and can subsequently jeopardise the predictions made. Some individuals, in a binary choice setting, if faced with a change in travel circumstances, would use the same mode of transport but over another route, others would use the same route but another mode, while the rest would use another mode and another route. These groups of travellers would have to be identified and modelled separately since their perceptions of alternatives requires different external structures of variables.

The main initial benefits and disbenefits of a public transport improvement (to be proposed) will usually be: the gain in consumer surplus to existing and new passengers; the loss of consumer surplus to those from another mode and/or route; benefit to passengers on other modes and/or routes who suffer less crowding; benefits in the form of reduced congestion costs to existing road travellers if some people divert from car (although this has to be compared with possible disbenefit to car users on the particular public transport improvement route if fewer lanes are available for car users); and changes in operators' revenue and costs.

The method for the remaining parts of the efficiency study should replicate the transport disadvantage approach. Once the methodology developed in this paper has been set up it should not be a costly procedure to apply on a continuous basis for a variety of issues.

CHAPTER 3

THE SYDNEY CASE STUDY – LOCATION IDENTIFICATION

3.1 INTRODUCTION

This chapter applies the approach outlined in Chapter 2 to identify those residential locations in which persons are considered to be relatively transport disadvantaged in the context of the journey to and from work. The Sydney Metropolitan Area was selected for the study and the basic data of the 1971 Sydney Area Transportation Study (SATS) used to identify groups of people who were relatively transport/location disadvantaged.

3.1.1 An Alternative Procedure

Travel data from the SATS home-interview survey were used to impute time costs and to estimate money costs for each modal trip. The highway network data for car travel distances were also used in the calculation of money costs. An alternative method using highway and public transport network data could also have been used. This method would involve the derivation of generalised cost matrices for minimum cost paths. The costs of travel to all destinations for a given origin (weighted by the corresponding number of trips) would then be summed to obtain the transport cost.

Although the traffic zone was the basic unit of analysis in the ranking of locations, the former approach (based on SATS data) permits more disaggregate analysis at the project identification stage in which the individual trip-maker and household is used as the observation unit. In general the chosen method is likely to produce more accurate generalised cost incidence data as it does not require the usual assumptions on zone centroids, path minimization, travel speeds and modal combinations. In addition, intra-zonal trips are not lost since there is no assumed point of origin and destination for each zone.

3.1.2 Definition Of Key Variables

Details of data definition and functional relationship are summarised in Table 3.1, and summary statistics together with a correlation matrix for the key variables are presented in Table 3.2. In Table 3.2, the "generalised cost by mode" variables are not strongly correlated, due in part to the differing roles of the three modes. Inter-zonal trip tables indicate that public transport is more popular for central business district oriented trips, while private transport is commonly used for local and non-radial trips, reflecting the provision of public transport facilities. The strong positive relationship between P and C_2 suggested that the greater the mean generalised cost by public transport, the greater the difference between this cost and the mean cost for all modes for the same trips. That is, the greater the public transport cost, the higher the opportunity cost of using public transport. This is largely due to the substantially greater average speeds for longer car trips as revealed by the correlation coefficient of 0.68 between mean speed and mean distance.*

* The correlation matrix for every variable in Table 3.1 is given in part 1 of the Working Notes relating to this study, available from Bureau of Roads Library.

TABLE 3.1

FUNCTIONAL FORM OF VARIABLES AND DETAILS OF DATA FOR THE LOCATION IDENTIFICATION STAGE OF THE TRANSPORT DISADVANTAGED STUDY – THE WORK TRIP
578 REVISED TRAFFIC ZONES (RTZ's)

Data Item	Identity	Notation	Comments
generalised cost	$GC_{ijm} = c_{ijm} + t_{ijm}$	i = origin zone j = destination zone m = mode GC = generalised cost (cents per person trip) t = time cost (cents per person trips) c = money cost (cents per person trip) pc = perceived money cost (cents per person trip) 36 = value of in-vehicle travel time savings (per person hour) 60 = value of excess travel time savings (per person hour), as a weighted average of waiting and transfer time values. x = mean car occupancy for home-based work trips invt = in-vehicle time (hours per person trip) acct = minimum time distance of travel by car (hours per person trip) d = distance (kilometres per person trip) C = transport cost incidence (cents per person trip) T = number of home based work trips (per day-one way) 2.5 = perceived car running costs (cents per kilometre per vehicle) M = incidence of journey to work costs on income I = gross annual personal income per employed person P = public transport disadvantaged variable C^*_{i2} = hypothetical cost incidence if public transport commuters from zone i had only incurred the average cost for all modes.	mode definition is SATS definition of resultant modes. m=1 = private vehicle driver or passenger with no transit mode m=2 = public vehicle (ferry, train, bus) including taxi passenger, walk and other mechanical modes as well as private vehicle passenger trips as part of a linked journey subsequent to a transit trip. m=3 = all other combinations not in m=1 and m=2 m=1,2 accounts for 86% of home-based work journeys. Costs have been estimated entirely for the home-based work purpose. 50,233 (33%) of trips sampled by SATS are home-based work trips. Trip costs are estimated on a production zone/attraction zone basis and thus refer to average cost per one-way trip of the round trip. Average RTZ population is 4800. Time values are derived from logit models of mode choice using non SATS data collected in Sydney in 1971. The car running cost-speed relationship is obtained from Bureau of Roads Studies and applied to private cars in private use, after adjustment to 1970-71 prices. Speeds for car travel were estimated by calculating average in-vehicle time for home-based work trips by car from SATS interview data. Distances actually travelled by car users were assumed to be equal to distance for minimum time path between each origin and destination. The fare-time relationship for public transport was estimated from available data on in-vehicle times. In calculating M, 480 trips per employed person year are assumed. Income variable is obtained from SATS home interview data on "annual family total income" and number of employed persons per family (full time and part-time). The choice of income class intervals, selected by SATS is likely to lead to a bias since 30% of sampled families fall into lowest interval of under $4000 per year.
time cost	$t_{ijm} = 36invt_{ijm} + 60acct_{ijm}$		
money cost for car mode	$c_{ij1} = \frac{1}{x_i}(2.75d_{ij} + 30invt_{ij1})$		
perceived money cost for car mode	$pc_{ij1} = 2.5d_{ij}/x_i$; $pGC_{ij1} = c_{ij1} + t_{ij1}$		
money cost (fare) for public transport mode	$c_{ij2} = 5.99 + 43.15invt_{ij2}$		
money cost for mixed mode	$c_{ij3} = 5.99 + 43.15invt_{ij3}$ (transit) $+ (85/x_i)\,invt_{ij3}$ (car)		
transport cost incidence	$C_{im} = \left[\dfrac{\sum_{j=1}^{578} GC_{ijm}T_{ijm}}{T_{im}}\right]$		
incidence of journey to work costs on income	$M_i = \dfrac{C_{im}}{I_i}$		
public transport disadvantage	$P_i = \left[\dfrac{\sum_{j=1}^{n} T_{ij2}(GC_{ij2} - GC_{ij})}{T_{i2}}\right]$ $= C_{i2} - C^*_{i2}$		

TABLE 3.2

SUMMARY INFORMATION OF KEY VARIABLES IN LOCATION IDENTIFICATION (SATS 1971)

Variable			Mean	Standard Deviation	Coefficient of Variation	Simple Correlation Coefficients							
						1	2	3	4	5	6	7	8
1	generalised cost by car mode. (cents per person trip)	C_1	43.8	14.4	0.33	1.0							
2	generalised cost by public transport. (cents per person trip)	C_2	67.7	28.3	0.42	0.12	1.0						
3	generalised cost by mixed mode. (cents per person trip)	C_3	58.7	47.9	0.82	0.11	0.00	1.0					
4	generalised cost by all modes. (cents per person trip)	C	51.1	14.0	0.27	0.81	0.44	0.11	1.0				
5	income per employed person. ($ per year)	I	4,700	1,475	0.31	0.26	–0.08	0.03	0.16	1.0			
6	ratio of C to I (%).	M	5.6	2.1	0.37	0.44	0.38	0.06	0.66	–0.57	1.0		
7	public transport disadvantage. (cents per person trip)	P	3.1	6.3	1.99	–0.02	0.42	–0.08	0.13	–0.04	0.12	1.0	
8	total trip production.	T	3,630	2,360	0.65	–0.05	0.22	0.11	0.04	–0.20	0.15	0.17	1.0

3.2 IDENTIFICATION OF TRANSPORT DISADVANTAGED LOCATIONS

3.2.1 Ranking According To The Value Of M And P Where M And P Are Given Equal Weight

Since there was a weak relationship between the three decision variables (M,P,T), a range of sensitivity tests was undertaken in the selection of locations for further study at the project level. The aim was to identify those zones which had high values of both M and P. Three groups were identified, those which appeared in the top 50 of both (8), zones in the top 75 (17) and the top 100 (21). Equal weighing for M and P was assumed. The results including and excluding the contiguous zone requirement (rule 3 on page 10) are summarised in Table 3.3. The application of the contiguous zone requirement produced the final rankings shown in Figure 3.1.

Many of the zones with high values for M did not have high values for P. For example, RTZ number 409 (the outer urban area of Mt. Druitt) had one of the highest values for M (12.5%) but had a relatively low value for P (4.2 cents). This is partly explained by the close proximity of Mt. Druitt to a relatively efficient radial rail service and a well managed and operated private bus company accessing the rail system. Of the 20 highest zones on M, only 8 were in the highest 100 for P.

3.2.2 Ranking According To The Variable Z = M.P.T

An alternative decision rule involved the construction of a single composite variable (Z = M.P.T) with no explicit regard for the relative importance of the three variables and no account of zonal contiguity, producing the zones indicated in Table 3.4. Two zones (362, 363) in the Green Valley District appeared high on the list in Table 3.4. For the highest ranking it appeared that zone identification was relatively insensitive to this alternative decision rule.

3.2.3 Relationship Between The Decision Variables

Over the metropolitan area as a whole, there was only a weak relationship between "transport/location disadvantage" variable and the "public transport disadvantage" variable as measured in this study (Table 3.2). That is, general inadequacies in public transport appeared to contribute little to overall transport/location disadvantage at the metropolitan level. However, the zones "identified" at the location identification stage for further study were those for which it appeared that public transport improvements would reduce overall transport/location disadvantage.

3.2.4 Description Of Identified Locations

A brief socio-economic profile of the identified disadvantaged zones is given in Table 3.5. Twelve of the thirteen zones are in four rapidly growing Local Government areas of Sydney, namely Blacktown, Liverpool, Penrith and Fairfield, with population growth between the two most recent censuses (1966 and 1971) of 41.1%, 19.5%, 30.0% and 11.7% respectively. The zones all lie in a belt between 22 and 45 kilometres from the Sydney central business district with an income per person per household in all cases below the metropolitan mean. (For the most populous two zones of Green Valley (363) and Mt. Druitt (408), it was less than $1,000 per year in 1971).

There is generally a high concentration of manufacturing workers in the total workforce. While car ownership is below the metropolitan mean, the inaccessibility of the zones seems to have necessitated what is still, in many cases, a relatively high rate of car ownership, taking into account the low level of income. The fixed cost of car ownership would thus account for a large share of income in many of the zones. While increased car owner-

TABLE 3.3

LOCATION IDENTIFICATION RESULTS – TRANSPORT DISADVANTAGED STUDY

Rank Order	Zone Number (RTZ)	Decision Variable M	Decision Variable P	Decision Variable T	Zone Group (see Fig. 3.1)	Location
	(i) excluding contiguous zone group assumption					
	With maximum rank = 50					
1	367	13.1	8.9	814		
2	415	10.7	20.8	3,776		
3	362	10.2	19.7	4,630		
4	336	9.8	8.9	1,073		
5	86	9.5	27.8	816		
6	363	9.5	10.8	7,632		
7	298	8.7	16.1	3,777		
8	387	8.7	9.7	1,989		
	Additional zones using maximum rank = 75					
9	384	12.3	8.6	3,680		
10	403	10.2	7.9	220		
11	375	10.2	7.9	81		
12	423	10.0	7.3	5,462		
13	413	9.6	7.5	2,750		
14	437	9.0	7.4	2,046		
15	385	8.3	7.3	2,079		
16	343	7.8	7.7	4,620		
17	352	7.5	8.4	5,178		
	Additional zones using maximum rank = 100					
18	408	12.9	6.5	5,990		
19	412	10.2	6.3	1,705		
20	462	8.6	6.3	1,837		
21	302	7.4	6.7	480		
	(ii) including contiguous zone group assumption					
1	352	7.5	8.4	17,440	1	"Green Valley"/Lurnea
2	363	9.5	10.8			
3	362	10.2	19.7			
4	408	12.9	6.5	10,395	2	"Mt. Druitt"/ Plumpton/ Doonside
5	412	10.2	6.3			
6	413	9.6	7.5			
7	387	8.7	9.7	7,748	3	Penrith
8	385	8.3	7.3			
9	384	12.3	8.6			
10	423	10.0	7.3	5,462	4	Lalor Park
11	343	7.8	7.7	4,620	5	Fairfield
12	415	10.7	20.8	3,776	6	Blacktown
13	298	8.7	16.1	3,777	7	Panania
14	437	9.0	7.4	2,046	8	South Granville
15	462	3.7	5.6	1,837	9	Berowra
16	336	9.8	8.9	1,073	10	South Graystanes
17	86	9.5	27.8	816	11	Macdonaldtown
18	367	13.1	8.9	814	12	West Hoxton
19	302	7.4	6.7	480	13	Condell Park
20	403	10.2	7.9	220	14	Marsden Park
21	375	10.2	7.9	81	15	Campbelltown/Woronora

FIGURE 3.1

LOCATION IDENTIFICATION IN SYDNEY

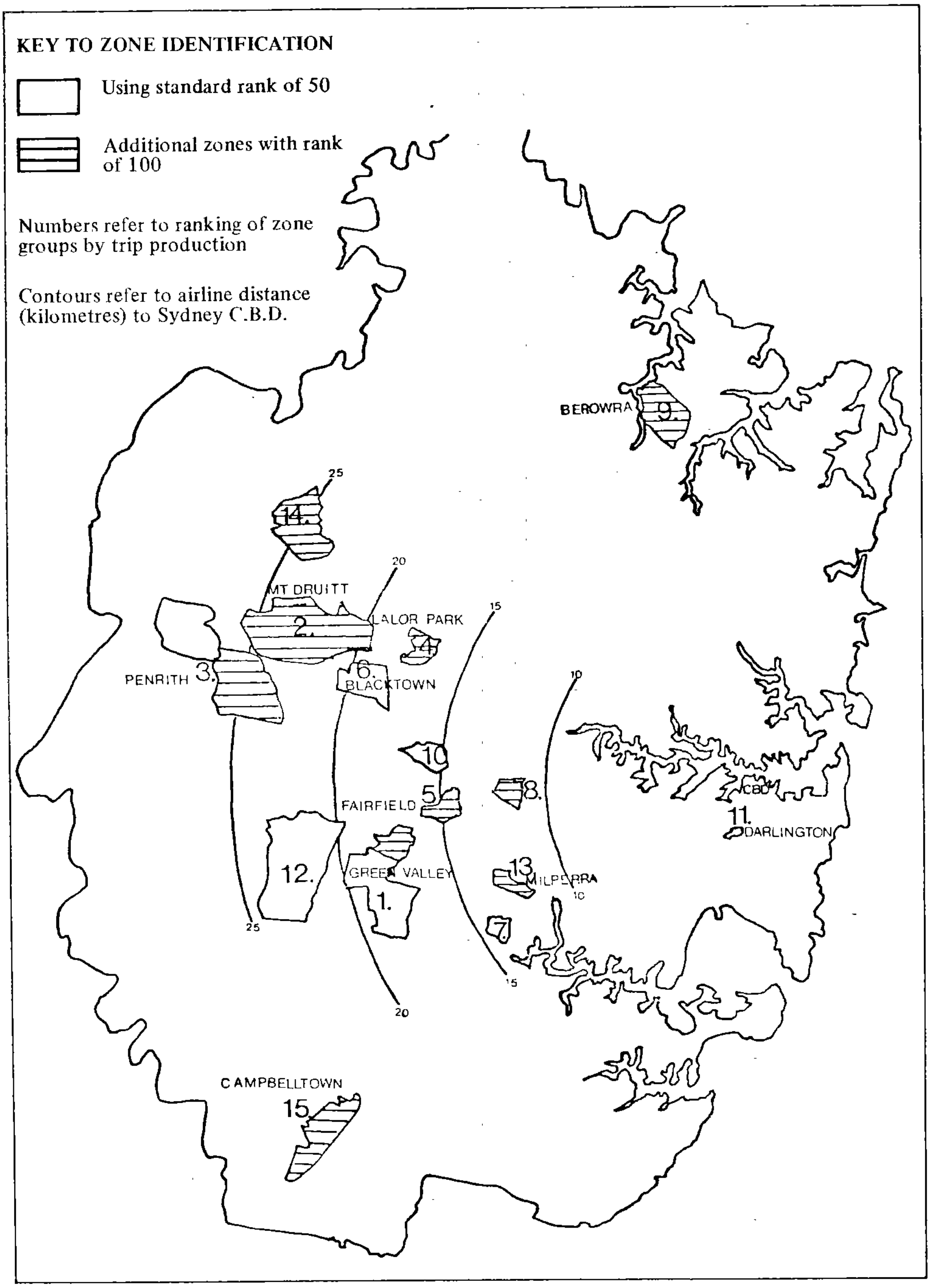


TABLE 3.4

SENSITIVITY OF ZONE IDENTIFICATION TO A RE-FORMULATION OF THE DECISION RULES

Rank Order	Zone Number (RTZ)	Z (= M.P.T/1000)	Rank Order	Zone Number (RTZ)	Z (= M.P.T/1000)
1	362*	927	11	384*	392
2	415*	852	12	285	377
3	363*	785	13	340	369
4	333	557	14	252*	336
5	295	552	15	256	304
6	298*	751	16	280	291
7	408*	496	17	343	275
8	324	457	18	344	258
9	276	417	19	531	243
10	423*	399	20	438	221

Note: The asterisks denote zones common to Tables 3.3 and 3.4.

ship entails a high burden of costs on low-income earners, it is also only a partial remedy to their transport problems, since inaccessibility is still a handicap to other members of the family unable to drive a car or for whom a car is not available during the day.

A relatively high proportion of the workforce in the identified zones was unemployed, a fact which could well have a casual relationship with the high burden of journey to work costs on income. Also, there was a low level of schooling, especially in tertiary education; and there was a relatively low proportion of females in the workforce.

3.2.5 Conclusion

The area of Green Valley/Lurnea/Mt. Pritchard was selected for detailed analysis, since journey costs to and from work were relatively high, average incomes were relatively low, public transport was relatively poor, and there were a substantial number of trips produced daily. In terms of the initial equity criterion, this area must be rated the most transport deprived area of Sydney so far as the work trip is concerned. Other areas for attention if this study is to be repeated at the project identification stage include Mt. Druitt, Penrith, Lalor Park, Fairfield and Blacktown.

TABLE 3.5

SUMMARY SOCIO-ECONOMIC PROFILE OF IDENTIFIED ZONES
SOURCE: SATS "BASIC DATA FILE"

Number of Households (Sampled Households in Brackets)	Zone Group	R.T.Z. Number	Local Government Area	Population	Airline Distance from C.B.D. (kilometre)	Mean Generalised Cost, Journey to Work (cents per person trip)	Gross Income Per Person per Household ($/year) (1971 prices)	Mean Family Size	Manu-facturing Work Force/ Total Work Force (%)	Motor Vehicles Per 100 Persons	Estimated Burden of Fixed Costs of Car Ownership on Income (%)
12795 (320)	1	352	Fairfield	16,721	27	60.9	1,414	4.3	44.7	25	10
		363	Liverpool	28,870	30	68.8	938	5.3	42.7	18	10
		362	Liverpool	15,222	29	68.0	1,163	4.4	42.8	25	12
8585 (215)	2	408	Blacktown	24,931	40	80.4	777	5.0	41.6	23	16
		412	Blacktown	5,746	37	70.9	1,232	4.2	37.6	25	11
		413	Blacktown	9,631	34	70.7	1,323	4.4	40.1	22	9
6567 (164)	3	387	Penrith	6,857	45	65.4	1,380	3.6	38.8	25	10
		385	Penrith	6,153	40	53.7	1,141	3.4	45.4	26	12
		384	Penrith	11,125	40	70.2	1,079	3.9	43.1	25	12
3693 (92)	4	423	Blacktown	16,247	27	66.5	1,216	4.4	39.8	20	9
3448 (86)	5	343	Fairfield	12,069	24	51.4	1,300	3.5	41.2	28	12
2521 (63)	6	415	Blacktown	11,091	32	74.7	1,317	4.4	39.2	26	11
2729 (68)	7	298	Bankstown	9,825	22	69.4	1,507	3.6	36.2	30	11
Sydney Metropolitan Area – Mean Population						51.1	1,852	3.2	32.0	31	9

CHAPTER 4

THE SYDNEY CASE STUDY – PROJECT IDENTIFICATION

4.1 DATA COLLECTION

4.1.1 Introduction

An important feature of the approach outlined in Chapter 2 is the emphasis on consumer preferences in the generation of projects. This chapter outlines the procedures and results of the data phase of project identification in the locations selected in Chapter 3. The main objective of this data phase is the identification of the determinants of mode choice for the journey to work.

4.1.2 Method Of Collecting Data

Since data collected in transportation studies is traditionally intended for utilisation in a strategic planning context, the Sydney Area Transportation Study data was inappropriate at the level of project generation and evaluation. A disaggregated set of data was collected in 1975. A home-interview questionnaire was administered to 300 sampled households in the Green Valley/Mt. Pritchard/Lurnea area (R.T.Z.'s 362, 363, 352), representing a 1.6% sample*. The questionnaire is given in Appendix A.

To obtain the sample points, a square grid overlay was applied to updated 1:9504 planning scheme maps and three rules adopted:

(i) the density of grid points was adjusted to any intra-zonal variation in dwelling density in order to minimise any bias in favour of low density areas;

(ii) all grid points contained in land zoned as "residential" were given a sequential number. Field investigation revealed negligible numbers of occupied dwellings within areas zoned non-residential;

(iii) grid points in residential areas were then randomly sampled to obtain the desired number of sample points for each zone.

Interviewers obtained four household interviews at each sample point according to pre-determined "door-knock" rules. Nine hundred calls were required to obtain 300 interviews. The 600 unsuccessful calls comprised 314 "outs or unavailable", 109 "not eligible for interviewing (i.e. no worktrip), 10 "foreign with no translator for the languages", 11 required a car for their occupation, 9 "other/unreliable, dog, locked gate", and 147 refusals to be interviewed.

4.1.3 Type Of Data Collected And Purpose

The data collected is useful for identifying the types of projects which are likely to produce positive net benefits to existing travellers, and for predicting the likely changes in traveller behaviour as a result of project implementation. Two types of data were obtained as part of the project generation stage. Firstly details on actual and alternative travel behaviour were collected for use in the quantitative assessment of likely influences on choice behaviour. In addition, open-ended questions were asked for the purpose of obtaining information on types of projects (by location) which individuals perceived would benefit them for their journey to work.

The travel attributes in the choice models can be used to assess the present and subsequent benefits associated with a range of transport options. These attributes can thus be direct influences in the initial identification of projects likely to produce positive

* Based on estimated 1975 household populations, generated by up-dating the 1971 census household populations using field investigations and planning scheme maps.

user benefits. A necessary requirement for project implementation is that users will benefit by the investment.

4.2 TRAVEL CHOICE RESULTS

4.2.1 Results Of The General Questions Posed In The Questionnaire

A novel supplement to data collection was the utilisation of a large street map of the entire metropolitan area (see question 16, Appendix A). Interviewees were asked to trace the routes of their usual and alternative modal journeys (i.e. in-vehicle, walk, wait, transfer times). Respondents were also asked to indicate by location, specific transport problems.

A major contribution of this technique is the assistance that a visual procedure gives to the respondent in improving the reliability of his information supplied particularly in relation to the magnitudes of the travel and modal characteristics associated with all stages of the usual and alternative journeys and the preferred location of transport improvements. The project information obtained from the maps is summarised in Table 4.1. Relatively few public transport problems were mentioned due to the existing bias towards private transport.

TABLE 4.1

SUGGESTED LOCATIONS FOR IMPROVEMENT

Problem	Location
Congestion	Liverpool Bridge Corner of Maxwell and Elizabeth Drive Hoxton Park Road Terminus Street, Liverpool Chapel Road South, Bankstown
Traffic Signals	Corner of Maxwell and Elizabeth Drive Corner of Meadows and Elizabeth Drive Corner of Hoxton Park Road and Hume Highway Terminus Street Orange Grove Road Milperra Bridge Intersection
Potholes	Kurrajong Road Hoxton Park Road – Newbridge Road
Narrow Roads	Elizabeth Drive
Slow Completion of Road Works	Liverpool expressway (by-pass)
Traffic Merging	Liverpool Bridge
Bus Routes Inadequate	Liverpool Bankstown
Bridge Needed	Over Georges River at Liverpool
Narrow Bridge	Landsdowne (Hume Highway) and Liverpool Bridge
Railway Stations – Outdated	Liverpool Bridge
Poorly Surfaced Road	Hoxton Park Road

The open-ended responses obtained in the home-interview questionnaire form a consensus of opinion for improvements to the Liverpool Bridge, the corner of Maxwell and Elizabeth Drive, and Hoxton Park Road as part of general congestion reduction. Traffic and street light improvements were suggested for the corner of Maxwell and Elizabeth Drive, corner of Meadows and Elizabeth Drive, Hoxton Park Road, Terminus Street, Liverpool Bridge, Orange Grove Road and Milperra Bridge. A direct bus route from Liverpool to Bankstown was frequently cited together with widening of the Liverpool and Milperra Bridges, and another bridge over the Georges River at Liverpool.

The information derived from the home-interview questionnaire relating to household, commuter travel, and mode characteristics were used in the development of two basic models; a car ownership model and a mode choice model.

4.2.2 The Disaggregate Mode Choice Model And Car Ownership Model

A class of models labelled disaggregate models of travel demand were used in project identification. These models are based on a study of individual choice processes in travel demand rather than aggregate measures of trip-making. For example rather than studying mode choice by looking at inter-zonal flows by each mode and the average times and costs by each mode, the disaggregate approach relates individual mode choice decisions to the times and costs facing particular travellers. Three main advantages are claimed for the disaggregate approach over aggregate models that currently form the basis of most urban transportation planning models. Firstly they focus on individuals and thus provide a consistent theoretical basis for models of travel demand; secondly the models are most flexible and can be applied to situations where aggregate data may be too coarse such as less-densely populated subareas; thirdly as the models are estimated on individual trip records rather than on averages (for all individuals), they are more efficient in their use of statistical information. Ultimately, the test of the disaggregate models must be their predictive capability as compared to models currently in use*.

A car ownership model was estimated using multiple regression and a binary logit transformation used in the estimation of the modal choice model. The latter function was selected because of its efficiency in situations where the criterion variable is binary (1,0), as in the case of a choice between a journey where the car is the main mode and a journey where a form of public transport is the main mode. The logit transformation is outlined in Appendix B.

The binary choice models used 193 observations, representing a situation in which the car and a public transport mode were the main, usual and alternative modes. Other journeys (e.g. walk as usual or alternative main mode, and car as usual and alternative main mode) were excluded. The final models together with the correlation matrix are presented in Table 4.2. Because of the existence of multicollinearity between the many variables a number of models were tested in the search for a statistically significant set of influences on levels of car ownership and mode choice. It is assumed that the choice of mode for the journey to work is partly influenced by the availability of a car and the ownership of a car.

In addition it is assumed that the numbers of cars owned per household and the availability of a car for a particular journey are determined by the socio-economic characteristics of the individual traveller and his household. A series of regressions were developed

* See P.L. Watson (1974) "Comparison of Model Structure and Predictive Power of Aggregate and Disaggregate Models of Intercity Mode Choice", **Transportation Research Record No. 527**, (Transportation Research Board Washington, D.C.).

TABLE 4.2

CAR OWNERSHIP AND MODE CHOICE MODELS – GREEN VALLEY STUDY (1975)

(N = 193)

No. of cars owned per household = 0.364 + 0.327 (no. of workers with current drivers licence) + 0.146 (total no. of non-respondent trips)
[7.88] [5.66]
$R^2 = .315$

$$\text{Choice of Mode} = \underset{[-0.226]}{-0.115} - \underset{[3.268]}{0.042} \left(invt_1^{mn} - invt_2^{mn}\right) \underset{[-2.955]}{-0.147} \left(wt_1^{eg} - wt_2^{eg}\right)$$

$$+ \underset{[2.317]}{2.718} \left(\frac{invt_1^{mn}}{t_1} - \frac{invt_2^{mn}}{t_2}\right) + \underset{[2.979]}{0.199} \text{ (car ownership index)}$$

$-2 \log \lambda = 112.17$

pseudo $R^2 = 0.654$

t - values in brackets [ ]

Variables	$\bar{X}_1$ (car mode)	$\bar{X}_2$ (public transport)	$\overline{X_1 - X_2}$	Correlation Matrix				
				$invt^{mn}$	wt^{eg}	$\frac{invt^{mn}}{t}$	car ownership index	Choice of mode
$invt^{mn}$ (min)	36.9	28.7	+8.2	1.0				
wt^{eg} (min)	5.0	9.0	–4.0	–0.13	1.0			
$\frac{invt^{mn}}{t}$	0.81	0.43	+0.38	–0.23	0.15	1.0		
car ownership index			+1.01	–0.24	0.21	0.27	1.0	
choice* of mode				–0.57	0.11	0.50	0.35	1.0
Total Time (t)	45.5	66.5	–21.0					
Total Cost	131.2	58.0	73.2					

* 79% of the sample are car users for the journey to work.

$invt_i^{mn}$ = invehicle time for main stage of journey for i^{th} modal journey (i = 1 = car, i = 2 = public transport) (minutes)

wt_i^{eg} = waiting time for egress stage of journey for i^{th} modal journey (minutes).

to identify the significant socio-economic determinants of car ownership* and then an index developed to combine the significant influences into a single inclusive variable to represent the likely influence of car ownership in the selection of a mode for the journey to work.

4.2.3 Significant Influences On Mode Choice

The significant influences on choice of commuter mode for the Green Valley residents were found to be in-vehicle time for the main journey stage, waiting time on the egress stage, proportion of total time that is main stage in-vehicle time, and the household car ownership propensity. The large differences between the mean values of the car and public transport variables provided scope for project improvements to produce modal switching.

While the negative signs in the mode choice equation were straightforward, the positive sign for the difference of the ratio of in-vehicle time for the main mode stage to total journey time requires comment. The positive sign indicates that decreasing the difference makes the car relatively less attractive because a greater share of the total journey time is spent in the public transport vehicle (i.e. a reduction in disutility of public transport relative to car). Hence the relationship between in-vehicle time changes and the effect on varying total time is crucial in determining whether the probability of mode switching increases or decreases. Since non-invehicle time (waiting, transfer etc.) has a higher disutility than invehicle time, the redistribution of total time in a manner that increases the proportion of non-invehicle time, will produce the opposite result to that expected. In the context of a bus improvement, if any reduction in invehicle bus time is accompanied by a more than proportional reduction in total bus time, then the commuter may or may not switch to the bus, depending on the relative importance of the other variables.

Since the data is cross-sectional then the extrapolation of values of variables should be restricted to the range of values of the sample. The standard deviation for invehicle time associated with both modes is 24 minutes, while for total time it is 41 minutes for car journeys and 53 minutes for public transport journeys. The particular transport improvements proposed in Chapter 6 produce changes in the underlying factors of magnitudes that are within the range of the data sample.

* Since car availability for the journey to work is highly correlated with car ownership (R = .98), a single model was developed. The socio-economic variables considered were:
Number of people in household
Number of people employed full or part-time
Number of people with current driver's licence who go to work
Number of people with driver's licence
Number of adults
Nett household weekly income
Own (=1) or rent (=2) house
Time lived in present house in months
Number of people in school
Number travelling to work in car
Number of non-respondent trips
Proportion of adults in household
Proportion of employed people in household
Nett personal weekly income/nett household weekly incomes
Respondent holding car licence (Yes = 1; No = 0)

The variable that is expressed as a difference of ratios is one proxy for comfort and convenience factors*. The explanatory modal and trip variables explain individual preferences for the journey-to-work mode for the main and egress stages of the trip. The attributes investigated that relate to the access modes, suggested that the present access situation does not have a significant influence on main mode choice for the sample as a whole. This result might have been expected as the binary choice sample only included work trip-makers who had a car-public transport modal pair for the relatively more complex main trip stages.

4.3 CONCLUSION

The findings outlined in this chapter will be used in the selection of projects and the assessment of likely changes in modal usage as a result of project implementation. The next task is to identify the types of supply options which are likely to produce user benefits that are consistent with the major determinants of mode choice. It seems appropriate to use the significant modal choice factors in identifying project types. The next chapter provides a review of possible policy options and concludes with the identification of project types.

* D.A. Hensher and P.B. McLeod, (1977) "Towards an Integrated Approach to the Identification and Evaluation of the Determinants of Travel Choice", **Transportation Research** (forthcoming).

CHAPTER 5
POTENTIAL IMPROVEMENT OPTIONS

5.1 INTRODUCTION

The next task is to relate the findings on modal demand to a range of transport improvements. This involves selecting improvements which offer changes in transport facilities consistent with the factors influencing an individual's choice of travel mode for the work trip. The following parts of this chapter outline the procedure used to relate the travel demand results to a range of transport facilities and constraints likely to affect the implementation of particular supply options. A lengthy review of the potential improvement options selected for matching of demand and supply that offer potential in reducing transport/location disadvantage is given in Appendix C. The emphasis (as stated in Chapter 1) is on the role of low cost options in making more efficient use of existing transport investment, and in particular in areas where there is relative transport disadvantage.

5.1.1 Low-Cost Options

In the absence of any available Australian evidence, the 1972 U.S.A. National Transportation Report which looked at the extent to which urban planning groups had given serious consideration to the use of low cost alternatives, found that:

> "on a nationwide scale, the following four types were reported in practice in 1971 in more than 10 percent of the urban areas: restricted curbside loading and unloading in congested areas (51 percent); staggered work hours (26 percent); unrestricted entry of taxicabs (22 percent); and increase in CBD day time parking rates (20 percent). While only 8 percent of the urban areas reported use of reserved lanes for buses, 50 percent of those over 1 million and 20 percent of those between 1 and 2 million reported use of reserved bus lanes. Those 'planned for the future' in more than 10 percent of the urban areas were: reserved bus lanes (17 percent); banning private cars from the CBD (11 percent); increase in CBD daytime parking rates (11 percent); and evening delivery by trucks in downtown areas (10 percent)."*

This supports the popular contention that only limited attempts have generally been made to employ non-construction alternatives for improving transport. Given previous investments in urban transport resources, and the existing stock of assets, substantial improvement in transport performance can be obtained with fewer massive capital improvement programs in urban areas.

Of prime importance in project selection is the certainty of low-cost improvement options yielding immediate benefits and making better use of existing facilities, together with the feasibility of immediate implementation. The selected options were assessed in the context of:

(a) improving public transport service
(b) improving road efficiency by
  (i) improving passenger flow in vehicles
  (ii) improving efficiency of passenger vehicles by increasing the number of people carried per vehicle
(c) adjusting the demand for transport services and facilities.

* Hedges, C.A. (1974) "Non-Capital and Low-Capital Measures to Improve Urban Transportation in the U.S.", **Proceedings of the International Conference on Transportation Research**, Bruges, Belgium. (Transportation Research Forum, Chicago). p. 392.

5.2 PROJECT GENERATION

Extensive investigations of potential improvement options should be viewed as part of a prior evaluation which precedes further feasibility studies, user considerations and a broad economic appraisal. The next stage of the "evaluation" is intended to reveal the problems and constraints anticipated in the application of the selected options in urban areas.

5.2.1 Constraints On Improvement Options

The following constraints were considered and their effects summarised in Table 5.1:

1. Existing regulations
2. Coordination amongst institutions
3. The constraints from private and public owners and operators
4. Financial constraints
5. Labour relations
6. Possible objections and protests from the community
7. Resource limitations and environmental obstructions.

The number and severity of constraints for bus options is mainly due to the interaction amongst various authorities in both private and public sectors. It appears that small scale projects involving joint co-operation of public and private operators have inherent difficulties. Alterations to existing privately-operated services alone would involve a larger liaison and coordination effort than any of the other modal alternatives or policy options.

To illustrate the point, an express bus service project would involve obtaining a permit from the Department of Motor Transport for the operator(s) involved, endorsement of the Bus Proprietor's Association, co-operation of the operator(s) and any other proprietors affected, approval by Local Council(s) for additional depots, bus stops and use of residential streets, funding to the private sector if necessary, acceptance by unions, community acceptance of the use of any residential streets and the practical availability of buses, labour and road space. Together with these, a rationalization improvement could be expected to involve compensation payments, assurances of equitable participation by operators, cooperation amongst operators perhaps to the extent of forming new companies. These latter additional constraints suggest mini-rationalization projects are infeasible under present legislations.

5.2.2 Demand-Supply Matching Considerations

The demand-supply matching considerations are an important determinant of any project's success. That is information on demand should influence selection of projects (supply option) just as they will in turn influence demand. The normal generalized cost (disutility) measures have been extended in this study to include comfort and convenience factors and to explain a broad range of attitudes vis-a-vis individuals' behaviour. A matrix has been constructed to show the relationships between potential projects and a range of mode choice variables (see Table 5.2). For any project, a tick (✓) in the matrix represents a direct first order effect of that project on travel behaviour in the direction of increasing public transport patronage as measured via the mode choice variable indicated. An empty row in the matrix implies that the project (if implemented) is incapable of increasing individual preferences towards public transport, although it may well be useful for other purposes outside the scope of this study. The effectiveness of a particular project in influencing demand can be crudely judged by the number of ticks across its row.

Conventional bus service improvements generally influence a large range of mode choice issues. In particular, newly planned bus services have potential to influence most time, cost, comfort and convenience aspects of trip making (by real changes which can be observed). The same applies to express bus improvements.

Promotion is a policy which can influence psychological response by firstly increasing the level of knowledge available and secondly, arousing public awareness, thereby influencing individual's perception of the subject. As such, it is nearly always a suitable improvement option where transport provisions have been developed according to consumer requirements. The influence of promotion on mode choice behaviour occurs through changes in the perception of individuals, not observable physical alterations. As such it is difficult to predict how much should be spent on promotion to achieve any desired amount of mode switching without the benefit of past experiences. No studies have monitored this effect of this policy to date, so we cannot be confident of the benefits likely to be produced by its introduction.

The reserve lane options and road and flow improvements mainly influence in-vehicle time and convenience measures, with little effect on out-of-vehicle aspects of the trip. There are few options that are capable of reducing costs (or perceived costs) to the user, particularly of a small-scale, low-cost nature. Most projects would produce a desirable reduction in travel time of public transport.

5.3 SUMMARY OF CRITERIA FOR SELECTING IMPROVEMENT OPTIONS

Six criteria were used to select potentially viable road-based public transport improvements for Sydney:

1. availability of proven technologies;
2. requirements of low-cost, potential benefits and a short gestation period;
3. confidence of successful application in the light of past experience;
4. level-of-service (system performance) attributes;
5. ease of overcoming institutional constraints attached to options; and
6. supply-demand matching considerations.

On the basis of these criteria, several improvement options were eliminated from further investigation. These "unsuitable" options were small-scale rationalization of bus operations, vehicle changes, promotion, passenger fares and road use pricing. The remaining feasible options were finally tested in another demand-supply interaction matrix containing the significant mode choice variables (Chapter 4) for Green Valley residents for their journey to work (see Table 5.3).

The final projects were identified from this matrix. New conventional bus services and express bus services hold the greatest public transport potential for alleviation of the transport/location disadvantage of Green Valley residents (despite some institutional constraints discussed in Section 5.2.1). The costs and benefits of two alternative bus service projects are assessed in Chapter 7 in relation to the location factors of Chapter 6.

TABLE 5.1

CRITICAL FACTORS LIKELY TO CONSTRAIN THE IMPLEMENTATION OF IMPROVEMENT OPTIONS

Some Improvement Options	Projects	Critical Factors Likely to Constrain Implementation
Bus Services (Routes & Timetables)	Extended Routes Redesign route, bus stops Express service Managerial Improvements Increased frequency Increased speed Increased hours of service New service	Permits, licences, regulatory changes required Cooperation of bus associations and regulating authorities Cooperation of local government, ordinances Cooperation amongst operators, government and private No existing avenues for finance from governments. Unions acceptances of conditions associated with proposal Use of residential streets Community acceptance of minimum level of service Availability of buses, labour and depots
Small-Scale Rationalization of Bus Operations	Merged private services Integrate private timetables Integrate private and public timetables Merging arrangement private-private Private takeover of public Public takeover of private Public service overlap private	Permits, licences, regulatory changes required Cooperation of bus associations and regulatory authorities Cooperation of local government Cooperation amongst operators, government and private No existing avenues of finance from governments Compensation
Reserve Lanes	Bus and pooled-car lane Bus lane Lanes for specialized vehicles, trucks, bikes	Consistency with regulations governing enforcement of correct road use (and signalisation) Operators and drivers to approve Objection to increased congestion in other lanes and delays Shortage of suitable existing road space
Minor Road Construction	Upgraded roads and bridges Upgraded intersections New roads, bus streets Bus bays Road exit/entry lanes	Coordination of Local and State Government institutions Temporary closure of roads Shortage of land
Flow Improvements	Signal actuation Signal synchronization Signs, signals, road markings Parking restrictions Turning bans Limited access/egress roads	Consistency with regulations governing road/use (and signalisation) Enforcement of correct use Labour requirements for maintenance/operation Objections by road users Hazards to community safety Noise and pollution due to increased traffic

Parking and Interchange Facilities	Car parks for park and bus ride Car parks for park and train ride Terminus (bus-bus) Interchange (bus-train) Stopping bays for kiss and ride	Local Government ordinances Cooperation of bus associations and regulating authorities Conflict in conditions/interests of public and private operators Community objection to use of open space and visual disturbances Availability of land
Vehicular Changes	Vehicle design changes, ticketing Bus size	Limitations of design codes Approval of public transport operators No means of financing operators for vehicle investment Different union requirements for public and privately operated buses Community objections to large vehicles
Public Transport User Facilities	Shelters, seats Pedestrian crossings/overpasses Access paths	Installation and maintenance by local government Community objections to facilities in residential streets
Promotion	Advertising, public relations Information services	Institutional coordination to achieve comprehensive multi-modal promotion Cooperation of bus operators No existing means of finance Community participation
Passenger Fares	Concession fares Free ride Zone fare Combined bus-bus, bus-train tickets	Licensing, regulatory changes required Cooperation of bus associations and regulating authorities Objection by operators No existing compensation for passenger concessions other than school and pensioner Implications for retrenchment, unions
Road Use Pricing	Congestion pricing Parking charges Car-bus-truck discrimination	Local government ordinance Enforcement of correct use Use of charges collected Delay imposed on traffic Availability of off-street parking

TABLE 5.2

POTENTIAL OF PROJECTS TO INFLUENCE TRAVEL BEHAVIOUR

Options	Projects	Examples of Mode Choice Variables													
		Total journey time	In vehicle time	Waiting time	Walking time	Moving time - in vehicle	Stop time – in vehicle	Out-of-pocket cost	Stop time/in vehicle time	No. of stops	Waiting cross roads/walk time	Ease of transfers	Time exposed to weather	Crowding	No. of vacant seats
Conventional bus service improvements	Extended routes				✓						✓				
	Redesign of routes, bus stops	✓	✓		✓	✓	✓		✓	✓					
	Express service	✓	✓			✓	✓		✓	✓		✓	✓		
	Managerial improvements							✓							
	Increased frequency	✓		✓									✓	✓	✓
	Increased speed	✓	✓			✓									
	Increased hours of service														
	New services	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Small-scale rationalization of bus operations	Merged private services	✓					✓		✓			✓	✓		
	Integrate private timetables	✓		✓					✓			✓	✓		
	Integrate private and public timetables	✓		✓					✓			✓	✓		
	Amalgamate private operators							✓							
	Public takeover of private							✓							
	Public service overlap private							✓							
Reserve lanes	Bus and pooled car lane	✓	✓			✓	✓		✓	✓					
	Bus lane	✓	✓			✓	✓		✓	✓					
	Truck ban lane	✓	✓			✓	✓		✓	✓					
Road improvements	Upgraded roads and bridges	✓	✓			✓	✓								
	Upgraded intersections	✓	✓			✓	✓		✓		✓				
	New roads, road surfacing	✓	✓			✓									
	Bus bays														
	Road exit/entry lanes	✓	✓				✓		✓	✓					
Flow improvements	Signal actuation	✓	✓			✓	✓		✓	✓					
	Signal synchronization	✓	✓			✓	✓		✓	✓					
	Signs, priority signals	✓	✓			✓	✓		✓	✓					
	Parking restrictions	✓	✓			✓									
	Turning bus	✓	✓				✓		✓	✓					
	Limited access/egress roads	✓	✓			✓									
Inter-modal facilities	Car parks for park and bus ride				✓							✓			
	Car parks for park and train ride				✓							✓			
	Terminus (bus-bus)	✓		✓	✓						✓	✓	✓		
	Interchange (bus-train)	✓		✓	✓						✓	✓	✓		
	Stopping bays for kiss and ride	✓			✓						✓	✓	✓		
Vehicle changes	Vehicle design changes, ticketing						✓		✓					✓	✓
	Bus size						✓		✓					✓	✓
Public transport user facilities	Shelters, seats												✓		
	Pedestrian crossing/overpasses				✓						✓	✓			
	Access paths				✓						✓				
Promotion	Advertising, public relations	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Information services	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Passenger fares	Concession fares							✓							
	Free ride							✓							
	Zone fare							✓							
	Combined bus-bus, bus-train tickets							✓							
Road use pricing	Congestion pricing	✓	✓			✓		✓							
	Parking charges	✓	✓			✓		✓							
	Car-bus-truck discrimination	✓	✓			✓		✓							

Note: The ticks (✓) indicate which projects are capable of influencing mode choice, via desirable changes to time, cost, convenience and comfort factors in favour of public transport.

TABLE 5.3

POTENTIAL OF PROJECTS TO INFLUENCE MODE CHOICE OF GREEN VALLEY RESIDENTS

Improvement Options	Projects \ Green Valley Mode Choice Variables	In-vehicle time Main Stage	In-vehicle time Main Stage/total time	Waiting time Egress
Conventional bus service improvements	Extended routes		✓	✓
	Redesign of routes, bus stops		✓	✓
	Express services	✓	✓	✓
	Managerial improvements			
	Increased frequency		✓	✓
	Increased speed	✓	✓	
	Increased hours of service			
	New services	✓	✓	✓
Reserve Lanes	Bus and pooled car lane	✓	✓	
	Bus priority lanes	✓	✓	
	Truck ban lane	✓	✓	
Road improvements	Upgraded roads and bridges	✓	✓	
	Upgraded intersections	✓	✓	
	New roads	✓	✓	
	Bus bays			
	Road exit/entry lanes	✓	✓	
Flow improvements	Signal actuation	✓	✓	
	Signal synchronization	✓	✓	
	Signs, priority signals	✓	✓	
	Parking restrictions	✓	✓	
	Turning bans	✓	✓	
	Limited access/egress roads	✓	✓	
Inter-modal facilities	Car parks for park and bus ride		✓	
	Car parks for park and train ride		✓	
	Terminus (bus-bus)		✓	
	Interchange (bus-train)		✓	
	Stopping bays for kiss and ride			
Public transport user facilities	Shelters, seats			
	Pedestrian crossing/overpasses	✓		
	Access paths	✓		

CHAPTER 6
THE GREEN VALLEY – BANKSTOWN CORRIDOR

6.1 INTRODUCTION

This chapter summarises the identification and specification of a major travel corridor from Green Valley in which improvement options could be initially concentrated. Existing public transport alternatives to the car journey, together with the travel demand by time of day and socio-economic characteristics of the workforce were examined. These factors, combined with local surveys of bus operations and traffic performance, formed the basis of the proposal for four projects in the corridor.

6.2 CORRIDOR IDENTIFICATION

The first stage of project identification involved the determination of journey destinations of the study area residents for which the disadvantage of public transport usage was relatively high. In other words, it was necessary to identify specific "problem travel corridors" which contributed to the relative transport disadvantage of Green Valley residents. The difference between average time of public transport and private transport journeys between the origin zone and each destination zone, together with the number of trips, was used to identify those corridors which were likely to accommodate improvements in public transport.

Using the 1975 Home Interview Survey data (Chapter 4), time and money cost differences between public transport and private transport were obtained for all journey to work destinations. The time difference was found to be strongly correlated with the cost differences and, hence both gave almost identical results. Figure 6.1 shows the destinations travelled to by at least 5 sampled commuters for whom the time differences were found to be exceptionally high. Although many of these only involve small numbers of sampled trips, it was expected that there would be little variation in time differences for travel at approximately the same time of day and for the same destination and, hence, the sample values were regarded as fairly reliable estimates of the true values.

The disadvantaged destination zones and corresponding travel corridors shown in Figure 6.1 were widely dispersed within the middle to outer western suburbs of Sydney. However, taking into account the contiguity of destination zones, three fairly distinct groups of destinations emerged:

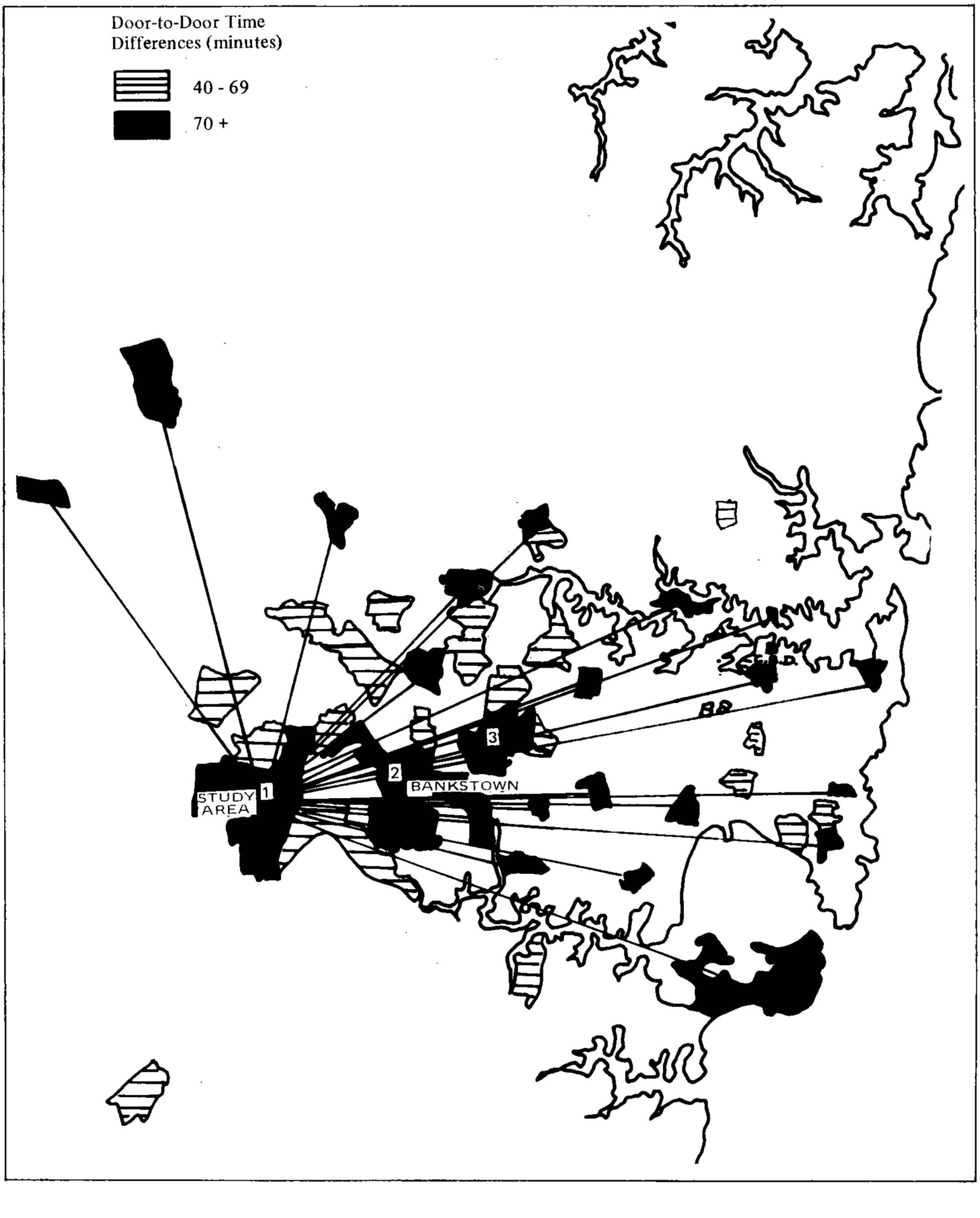
Group 1 – within the study area itself and in close proximity to it – the Green Valley – Liverpool corridor (zones 353, 361, 362, 363 – group 1, Figure 6.1);

Group 2 – to the south western areas of Bankstown Municipality (zones 295, 299, 300, 301, 303, 313, 356 – group 2, Figure 6.1);

Group 3 – to the northern area of Bankstown (zones 305, 307, 308, 310 – group 3, Figure 6.1).

FIGURE 6.1

TIME DIFFERENCES BETWEEN PUBLIC TRANSPORT AND PRIVATE TRANSPORT FOR JOURNEY TO WORK FROM GREEN VALLEY



From the point of view of planning public transport services spatially, 5 additional destination zones were included in the evaluation of projects (zones 296 – 298, 302, 304); and 5 removed (zones 307, 308, 310, 313, 356). The resultant clusters of origin and destinations defined, the Green Valley – Bankstown Corridor. The projects identified and evaluated in this study have therefore been aimed directly at reducing the relative disadvantage of transport usage within this Corridor (defined by origin zones 352, 353, 361, 362, 363 and destination zones 295 to 305 inclusive (see Figure 6.2)), through improvement of public transport services. This corridor contained approximately 6.3% of all work trips from the Green Valley Area. Other corridors from Green Valley could also have been identified for some subsequent improvements. Newbridge Road is the only direct road across this corridor.

6.3 TRAVEL PREFERENCES IN THE GREEN VALLEY – BANKSTOWN CORRIDOR

6.3.1 Demand For Corridor Travel

Figure 6.3 shows the number of work trips across the corridor by time of departure. The morning peak is between the hours of 6 a.m. and 9 a.m. with the greatest number of workers commencing their trips between 7 a.m. and 8 a.m.

6.3.2 Mode Split And Mode Mix

Table 6.1 shows the number of trips across the Corridor for work purposes in peak hours and the corresponding mode split after applying the SATS trip expansion factor to the sample trips. The private vehicle usual mode (car driver, car passenger, motor bike) accounted for about 87.6% of the trips. The relative disadvantage of public transport for travel between Green Valley district and Bankstown is directly reflected in aggregate mode choice. For private vehicle trips along this Corridor, the alternative public transport trip, as perceived by respondents, frequently involved a combination of train and bus segments. On the basis of the 1975 Home Interview Survey, it was found that, of the private vehicle trips from Green Valley to Bankstown, 27% had their alternative trip comprised of a walk (W) – bus (B) – train (T) – bus (B) – walk (W) modal mix, 36% had W-B-W, 18% had W-B-B-W, 14% had W-B-T-W, and 5% had W-T-W.

Seven possible public transport alternatives currently exist (1975) for travel across the corridor:

(i) Bus access to Liverpool station, rail to Bankstown, bus egress (WBTBW); In some cases a transfer between trains is necessary;
(ii) Bus access to Liverpool station, rail to Bankstown station (WBTW);
(iii) Train from Liverpool station to Bankstown station (WTW);
(iv) Bus access to Liverpool station, bus to Milperra, bus egress from Milperra (WBBBW);
(v) Bus access to Liverpool, express bus from Liverpool (WBBW);
(vi) Express bus from Green Valley (WBW); and
(vii) Taxi.

Such public transport trips usually involved substantial waiting and transfer times in both access and egress, as well as high in-vehicle times.

FIGURE 6.2

GREEN VALLEY BANKSTOWN CORRIDOR ORIGIN AND DESTINATION ZONES

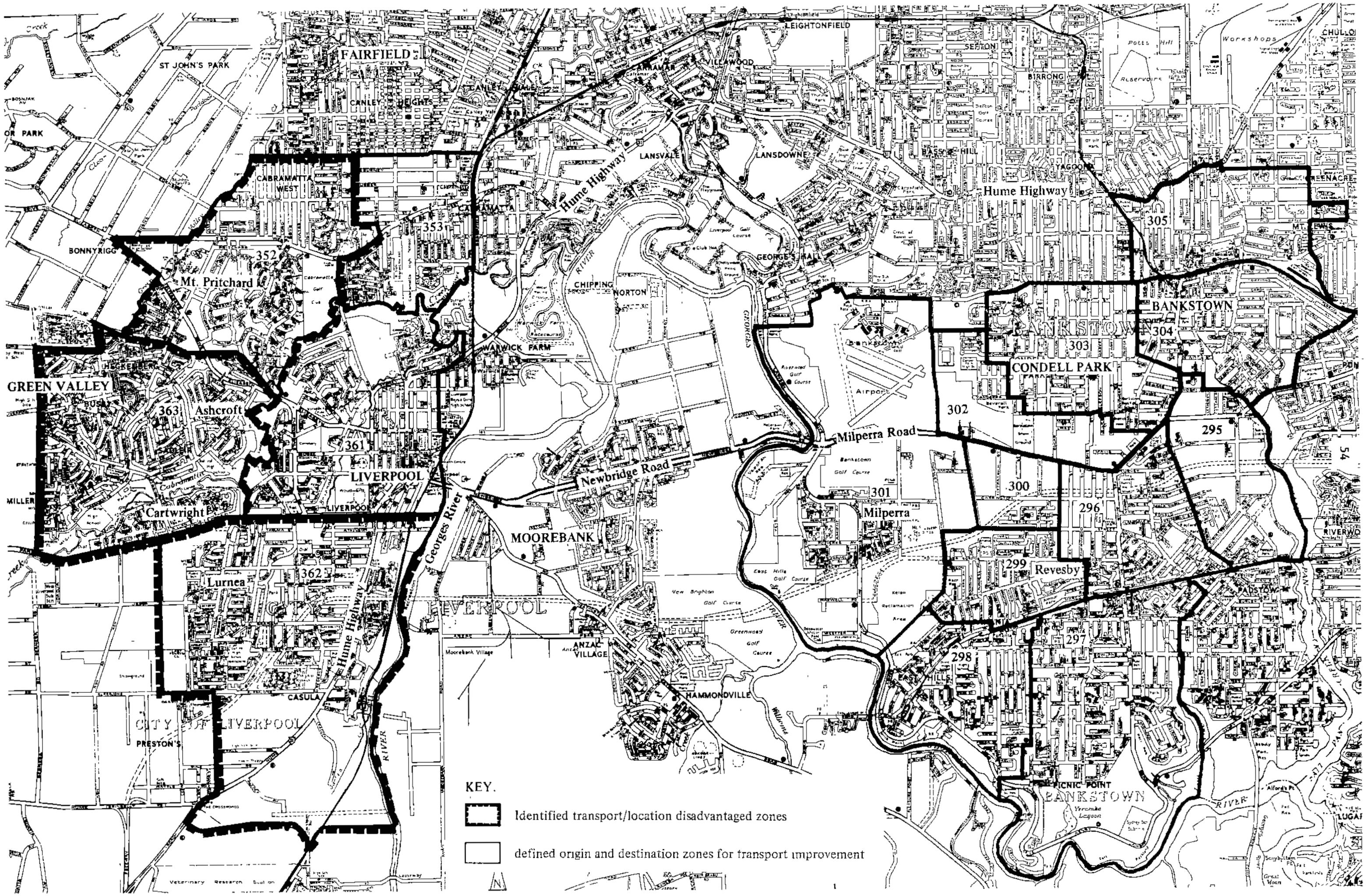
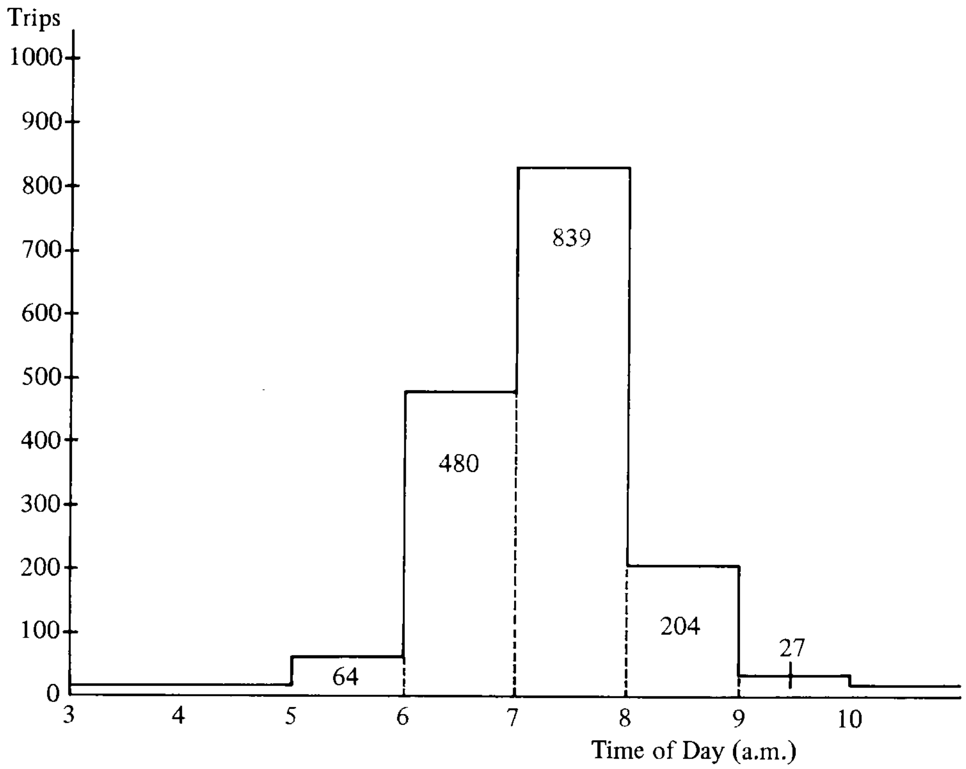


FIGURE 6.3

WORK TRIPS FROM GREEN VALLEY TO BANKSTOWN
BY TIME OF DEPARTURE (A.M.)



Source: Sydney Area Transportation Study data (1971).

TABLE 6.1

1975 TOTAL TRIP PRODUCTION: ONE WAY (A.M.)
HOME-BASED WORK TRIPS ACROSS THE GREEN VALLEY – BANKSTOWN
CORRIDOR, BY MODE

Mode	Private Car	Public Transport			Total
		Bus	Train	Total	
Trips from 6 a.m. to 9 a.m.	1334*	118**	71	189	1523*
Market Share	87.6%	7.7%	4.7%	12.4%	100%

* based on SATS (1971) data assuming no change of market shares.
** observed bus patronage levels, June 1975.

6.4 LOCAL BUS SERVICES

6.4.1 Local Bus Services Currently Serving Green Valley

Regular route services in the Green Valley – Bankstown Corridor are provided by 17 private bus operators. The routes are shown in Figure 6.4. There are no government operated bus services. Most routes provide feeder services to and from railway stations at Liverpool, Cabramatta, Canley Vale, Fairfield, Carramar, Villawood, Chester Hill, Sefton, Birrong, Yagoona and Bankstown. Weekday services usually offer regular headways of 22 minutes in peak hours and 37 minutes throughout the off-peak spreading between the hours of 5 a.m. and 11 p.m. The mean all-day number of passengers per bus kilometre is 2.7 (Table 6.2) although buses are usually full in peak hours in the direction of peak flow. Most operators run commercially efficient services within their franchised areas and are well equipped to provide additional services to meet any increase in demand. Fleet capacity is essentially a function of peak-hour demand. The mean fleet size is 21 buses compared with a Sydney metropolitan mean of 13 buses (Table 6.2). Approximately 80% of all fleets are utilized in peak hours whilst the remainder of buses are either undergoing maintenance or are kept as spares for emergency use. In general, there is no usable excess capacity, consequently any transport proposals for regular services in peak hours would necessitate the acquisition of new buses.

TABLE 6.2

BUS OPERATORS SERVING GREEN VALLEY AND ADJACENT AREAS

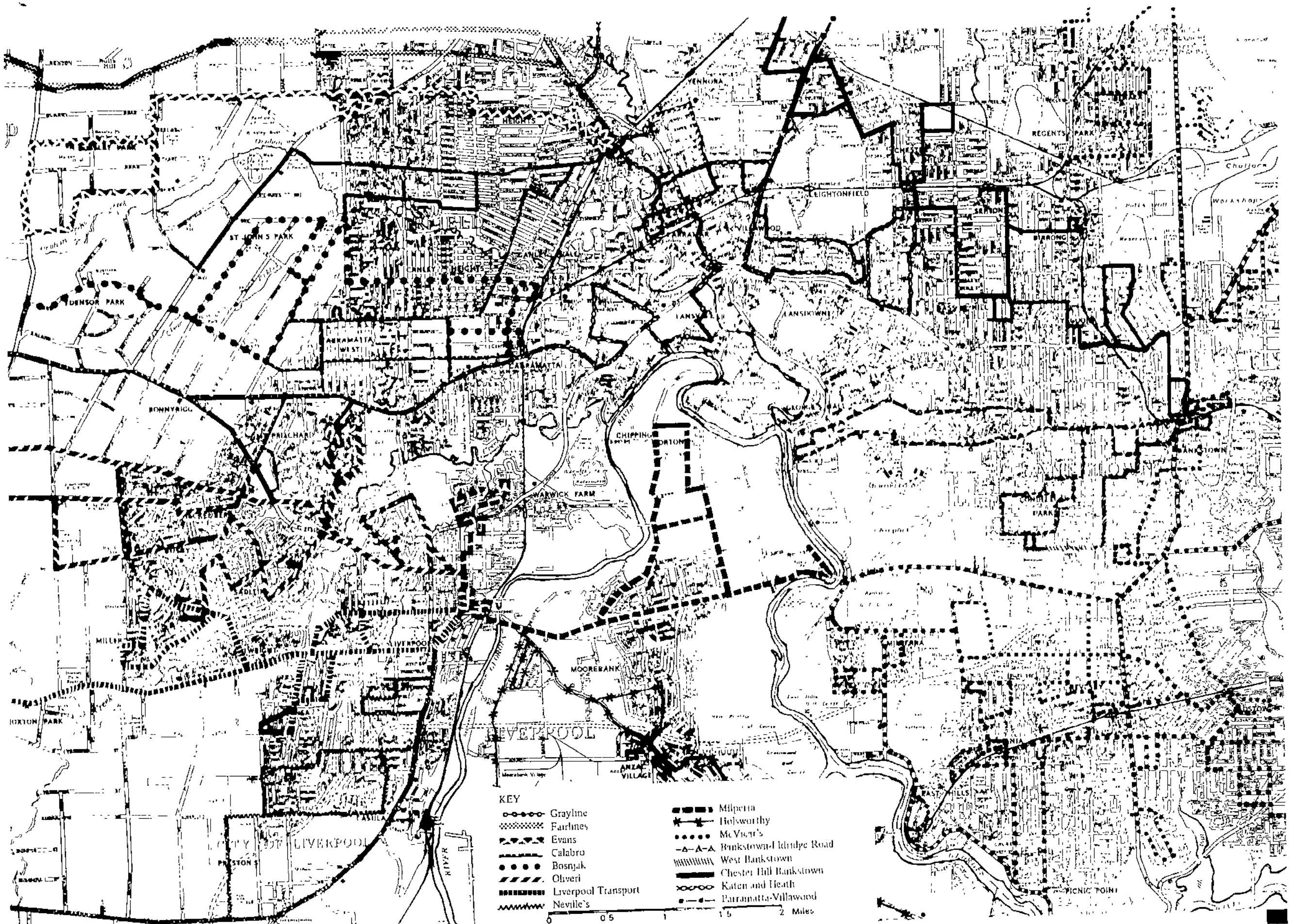
Operator	Route Licence Numbers	Fleet Size (Buses)	Passengers per Bus Kilometre
Grayline	190,170,171	19	3.06
Fairlines	80	13	2.76
Evans	78	8	1.72
Calabro	40,76,77	35	3.55
Bosnjak	45	22	N.A.
Oliveri	41,102	31	N.A.
Liverpool Transport	57	21	1.43
Neville's	58,94	28	N.A.
Milperra	69	6	2.15
Holdsworthy	42	10	N.A.
McVicar's	12,22-24,27, 38, 123,125,137	57	4.73
Bankstown – Eldridge Road	20	5	N.A.
West Bankstown	25	19	N.A.
Chester Hill – Bankstown	73,84	26	3.33
Katen and Heath	81,83	21	N.A.
Parramatta – Villawood	97,186	21	1.97
Muscat	176	8	N.A.
		Mean = 21	Mean* = 2.7

Note: Statistics apply to 1973-74 financial year.

* This figure is based on bus operators who were able to indicate the number of passengers per bus kilometre, and is simply the sum of the figures in the column divided by number of operators.

FIGURE 6.4

BUS ROUTES SERVING GREEN VALLEY AND ADJACENT AREAS



Two express services already operate on a limited scale between Green Valley district and Bankstown (Figure 6.5). One, from Liverpool, is operated on a permit by Milperra Bus Service. Because Newbridge Road is within Milperra's licensed area, the bus is permitted to stop, and is thus not strictly providing an express service. The service extends outside Milperra's licence area into McVicar's area and there is only one departure in each peak. The other "express" bus service is operated in the morning and afternoon peak by Oliveri Transport Service. Oliveri has a permit to pick up passengers between Miller and Liverpool and then to operate non-stop along Newbridge Road to Milperra and beyond. Competition between the two operators is avoided as, in the morning peak, they can pick up passengers only in the areas of their own service licence. However, both operators have common destination points in the area of McVicar's service licence. Conversely in the afternoon peak each operator is only permitted to set down passengers in his own service licence area. Regulations do not make provision for compensation to McVicar's Bus Services although these other express services are duplicating parts of its routes.

6.4.2 Bus Services Required For The Green Valley – Bankstown Work Trip

The origin-destination desire lines obtained in the 1975 survey suggested that direct services originating from the Lurnea/Cartwright/West Liverpool area (in the centre of the Green Valley district) would service local travel needs and reduce the generalised costs of existing public transport alternatives. Improvements to existing local route services in the corridor, such as increased frequences, interconnected routes and timetables, were unlikely to offer much advantage to corridor travellers since large transfer times (and hence large total time) would still be encountered. Furthermore, existing regular route services (as shown in Figure 6.4) are too indirect for Corridor travel. New direct express services are favoured to supplement existing express services and offer an extended range of alternative origins, routes, departure times and destinations.

6.5 SPECIFIC ILLUSTRATIVE TRANSPORT IMPROVEMENT PROPOSALS

6.5.1 Selection Of Spot Improvement Projects

In addition to the identification of major projects across the corridor, it is also desirable to consider spot improvements. Average morning and afternoon peak-hour bus frequences were determined for all major road links in the Corridor. This information was supplemented with Australian Road Survey data on average peak-hour speeds and street characteristics to assist with the identification of links over which flow improvement options might be applicable.

Average delay times (by location) caused to buses, bus passenger loadings, and the physical suitability lead to selection of two locations for spot improvements:

(1) Chapel Road South, immediately north of Canterbury Road in Bankstown;

(2) Junction of Heathcote Road and Speed Street at Liverpool Station.

These are evaluated in Chapter 8.

6.5.2 Projects Proposed For The Green Valley – Bankstown Corridor

Following extensive investigations in the Corridor, a selection was made of four projects from Table 5.3 for detailed design and evaluation. These were:

(1) a small peak-hour express bus service (2 buses);

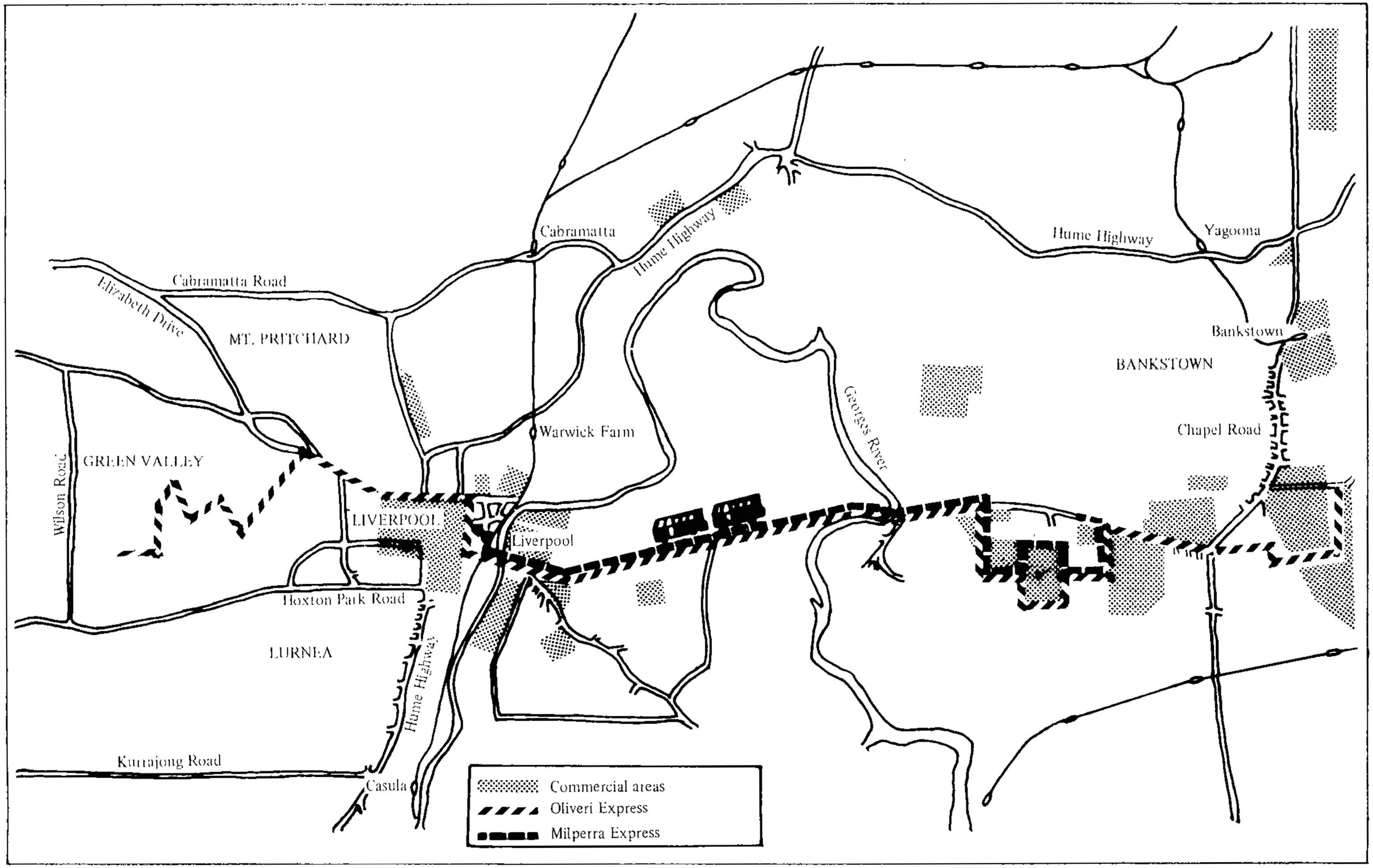
(2) a large peak-hour express bus service (6 buses);

(3) an exclusive peak hour bus lane in Chapel Road South; and

(4) bus priority signals at the Speed Street Intersection at Liverpool.

FIGURE 6.5

EXISTING EXPRESS BUS SERVICES:– GREEN VALLEY TO BANKSTOWN



The first two proposals were of a fundamentally different nature from the second two. The main benefactors from additional supply of bus services were likely to be those who switched from another mode, whereas the benefits from the improved operating efficiency of established bus services would accrue to existing public transport users. This required the use of a mode switching model and different techniques for the evaluation of the two express bus alternatives. For this reason the evaluation of the express bus projects is reported separately (in Chapter 7) from the flow improvement projects (in Chapter 8).

CHAPTER 7

EVALUATION OF NEW EXPRESS BUS SERVICE PROPOSALS

7.1 INTRODUCTION

This chapter outlines the empirical study undertaken to design and evaluate two alternative express bus service projects to operate between Green Valley district and Bankstown during peak hours. Route maps for the two alternative proposals are shown in Figures 7.1 and 7.2.

7.2 PROPOSED EXPRESS BUS SERVICE DESIGNS

7.2.1 Proposal 1

Proposal 1 is designed to double the capacity of the existing two express services in the Corridor. It would involve two extra buses each making a single departure from Green Valley district in the morning peak hour. The afternoon service would cover the same route in the opposite direction from Bankstown to Green Valley. No backloading is anticipated in either case.

Liverpool Transport and McVicars were suggested as the operators most suitable to provide the new service. There are several reasons for this. Firstly, origins and destinations of the proposed routes are in the franchised areas of these two operators. Secondly, as there are only four operators in the Corridor; Oliveri, Milperra, Liverpool Transport and McVicars of which the former two currently provide express services; it appears that the most equitable arrangement would be for the former two to also share the market for corridor travel. The Department of Motor Transport regulations do not allow operators to compete for passengers along the same route. Duplication of routes is only a problem when competition arises.

In this proposal all operators would use Newbridge Road but competition would be avoided by allowing only Milperra to drop or pick up passengers along this road in its own franchised area. All other services would have to be express (i.e. non-stopping) along this route. It would probably simplify the institutional procedures for obtaining the appropriate permits if the four operators were to reach agreement on routes and timetables and gain support from the Bus Proprietors' Association (N.S.W.) before submitting applications to the regulating authority. Should Liverpool Transport or McVicars not wish to undertake the proposal, any other operator could do so and the estimated operating costs would not be disimilar. Timetables have been suggested for demonstration purposes based on a knowledge of operating speeds and performance characteristics (Table 7.1). Average bus speeds in the corridor were taken as 30 km/h for non-stop operation and 21 km/h for local street operation with allowance for peak hour congestion delays. Timetables would be integrated with existing express services so that buses would leave Liverpool at regular intervals. It is assumed that the timetable for proposal 1 caters for corridor demand between 6.45 a.m. and 8.15 a.m. which covers approximately 73 per cent of the 6 a.m. to 9 a.m. demand.

7.2.2 Proposal 2

Proposal 2 is a large express bus service which is three times the scale of Proposal 1. It uses the same bus routes but with six departures from the Green Valley district which would quadruple the existing express bus capacity and cater for the total peak demand between 6 a.m. and 9 a.m. All four operators of the corridor could participate equally in this express bus market using the same rationale as in the design of Proposal

FIGURE 7.1
EXPRESS BUS ROUTES, PROPOSAL 1

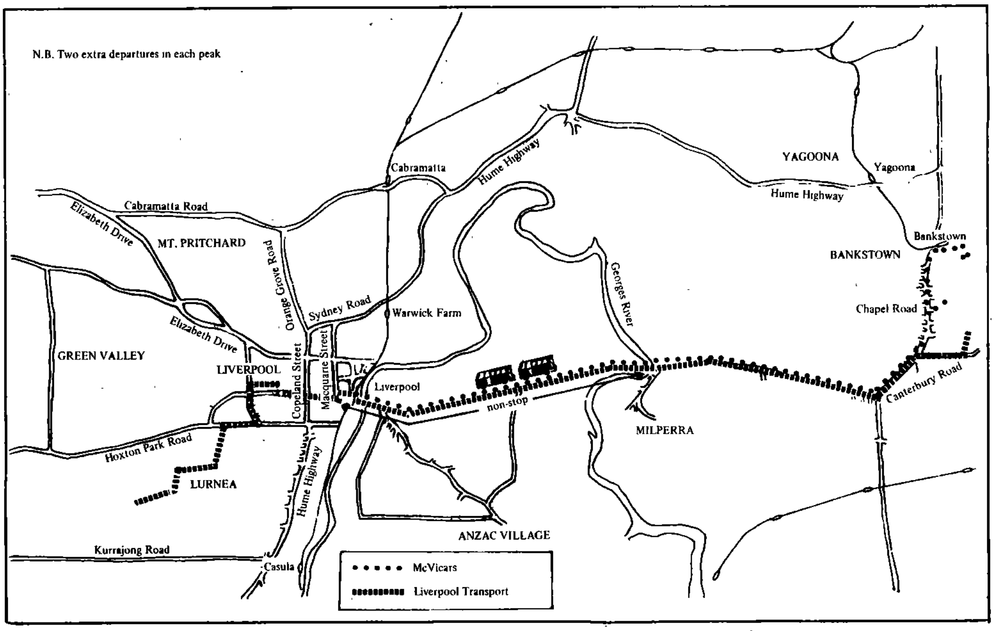


FIGURE 7.2
EXPRESS BUS ROUTES, PROPOSAL 2

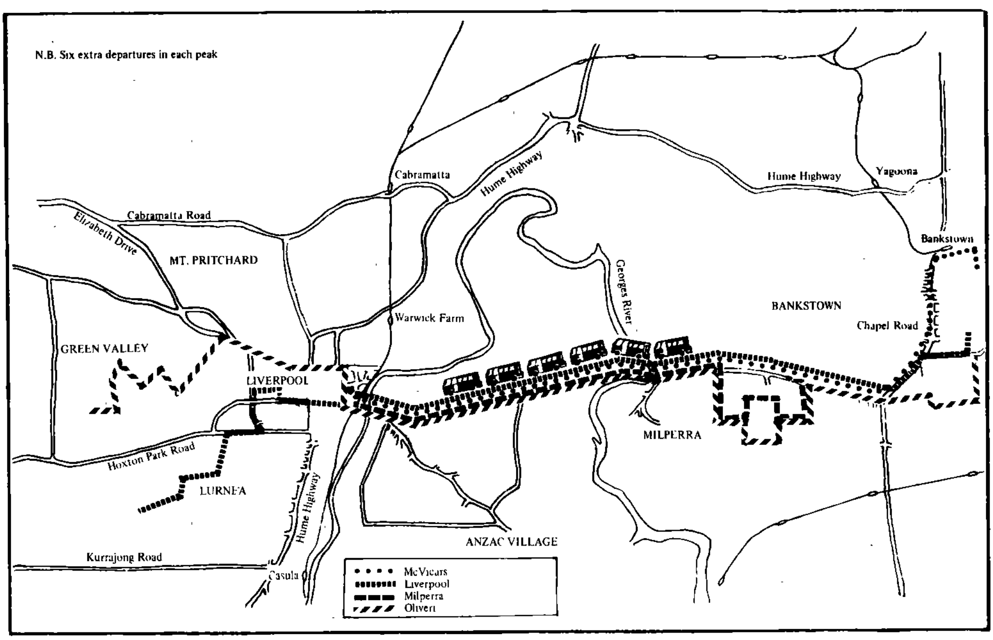


TABLE 7.1

TIMETABLES FOR PROPOSALS 1 AND 2 (INTEGRATED WITH EXISTING TWO EXPRESS BUSES) WEEKDAY A.M. ONLY*

PROPOSAL 1

Small Express Bus Service between Green Valley and Bankstown	Bus stops at						
Suggested Operator	Miller	Lurnea	Liverpool Station	Milperra Bridge	Violet and Carrington Streets	Canterbury and Clements Streets	Bankstown Station
Liverpool Transport		7.00	7.15	7.26		7.42	
McVicar			7.45	7.56			8.16

PROPOSAL 2

Large Express Bus Service between Green Valley and Bankstown	Bus stops at						
Suggested Operator	Miller	Lurnea Stops	Liverpool Station	Milperra Bridge	Violet and Carrington Streets	Canterbury and Clements Streets	Bankstown Station
Oliveri**	8.00		8.20	8.32	8.45	8.55	
Liverpool Transport (Express from Lurnea)		6.15 7.15	6.30 7.30	6.41 7.41		6.57 7.57	
Milperra**			7.50	8.02	8.15		
McVicar (Express to Bankstown)			6.45 7.45	6.56 7.56			7.16 8.16

* The proposed afternoon timetable is assumed to be the reverse.
** Proposals for these operators are to supplement their existing express services.

1. Proposal 2 would then involve a doubling of frequencies by the existing two express bus operators (i.e. Milperra and Oliveri) plus four new departures provided by Liverpool Transport and McVicar, both operating two new departures.

One additional bus would be required for Liverpool Transport and McVicars as in Proposal 1, although different amounts of bus-mileage and labour are required for the different routes. It was expected that Milperra and Oliveri could use their existing express buses to provide the extra service. The annual mileage and hours of payable labour for each operator have been estimated for costing purposes (see Table 7.8).

7.3 CHANGES IN THE LEVELS OF TRAVEL ATTRIBUTES ASSOCIATED WITH THE NEW EXPRESS BUS SERVICES

7.3.1 Modelling Assumptions

In order to determine the travel attributes associated with the new bus services, identification of the present magnitudes of the factors influencing choice of travel mode for the journey to work in the Green Valley – Bankstown corridor was necessary. The significant variables identified from the logit model in Chapter 4 were assumed to apply to the identified corridor even though the choice model was calibrated on a sample of commuters travelling in all directions from the entire Green Valley area. The mean values for the corridor were obtained from those travellers in the sample of Green Valley residents who were currently using the corridor for travel to work. The mean values are thus reported perceived values in contrast to manufactured estimates. The former measures are deemed more appropriate for analysis of likely modal switching, although it has been assumed in subsequent economic evaluation that perceived and actual values are the same. At present there is little evidence to support different quantitative values.

7.3.2 New Levels Of Travel Attributes

The average levels of the travel attributes associated with the different public transport networks are given in Table 7.2, and are derived from the mean reported perceived levels of existing modal journeys and manufactured levels for proposed journeys as given in Table 7.3. Despite the utilisation of disaggregate choice models in which the basic unit of analysis is the individual traveller, the characteristics of alternative modal journeys are expressed as averages across the sample. For a linear preference function the average is an unbiased representation of all individual observations, although it is itself a piece of aggregate information. Hence in this sense the models are not disaggregate.

Trips on the express bus service would take 52 minutes on average (40 in bus, 12 in access and egress). For public transport patrons switching to the new express bus service, there would be average time savings amounting to 33 minutes for the total journey, comprising 5 minutes main stage in-vehicle time, and for access and egress stages 9 minutes walk/transfer time, 9 minutes waiting time and 10 minutes in-vehicle time. The express bus fare would be set according to the average price of existing fare structures equal to 56 cents per one-way person trip.

TABLE 7.2

ESTIMATED CHANGES TO THE MAGNITUDES OF TRAVEL ATTRIBUTES DUE TO CORRIDOR EXPRESS SERVICES

Variables for corridor destinations only	Existing Car Journey	Existing Public Transport Journey	$\bar{X}_1 - \bar{X}_2$ before	Proposed* Express Bus Journey	New** Public Transport Journey	$\bar{X}_1 - \bar{X}_2$ after
Main Stage In-vehicle Time (mins)	29.0	42.0	−13.0	37.0	39.7	−10.7
Waiting Time Egress Stage (mins)	0	3.0	− 3.0	0	1.6	− 1.6
Ratio of In-vehicle Time Main Stage to Total Journey Time***	0.81	0.49	0.31	0.71	0.59	0.21
Car Ownership Index (= 1.18)	–	–	–	–	–	–

* Manufactured estimates of effects of express bus services.

** Based on 8.6% of existing car users switching to express bus and 30% of existing train users switching to express bus. Calculation is based on 54.4% of the existing level of public transport attributes plus 45.6% of the new level of express bus attributes to give the weighted average level of an attribute associated with all public transport users after the improvement.

*** Rounded to two decimal places.

TABLE 7.3

MEAN VALUE OF ATTRIBUTES OF NEW AND EXISTING MODAL JOURNEYS

(a) Travel Time (minutes)

Journey Stage	Existing Modal Journeys								New Modal Journey			
	Car				Public Transport (Train and Bus)				Express Bus			
	invehicle	wait	transfer walk	total time	invehicle	wait	transfer walk	total time	invehicle	wait	transfer walk	total time
Access	0	0	6	6	9	9	6	24	3	3	3	9
Main Mode	29	0	0	29	42	0	0	42	37	0	0	37
Egress	0	0	1	1	4	3	12	19	0	0	6	6
All Stages	29	0	7	36	55	12	18	85	40	3	9	52

(b) Monetary Travel Cost (cents)
(car running costs and public transport fares)

	Existing Modes		New Mode
	Car	Public Transport (Train and Bus)	Express Bus
Total Money Cost	64	66	56

7.3.3 Estimation Of Extent Of Mode Switching Due To New Express Bus Services

Although public transport overall reduced its relative unattractiveness because of the improved magnitude of attributes, the generalised cost of public transport (at the mean) still remained higher than that of the car (at the mean). The mean was derived from a distribution of attribute levels across the sample. The improved attributes of the public transport service would cause new patrons to switch from car to public transport in accordance with the mode choice model. In order to obtain the likely modal switchers from our choice model which is calibrated on a car – public transport choice, the savings to express bus users have to be distributed over all public transport users. The number of modal commuter journeys in the corridor before and the estimated number after the improvement are given in Table 7.4.

TABLE 7.4

NEW TRIP DISTRIBUTION OWING TO EXPRESS BUS IMPROVEMENTS IN THE GREEN VALLEY – BANKSTOWN CORRIDOR

	Time of Departure	Main Mode of Travel to Work			
		Car	Bus	Train	Total
Existing trips	6.45 a.m. – 8.15 a.m.	967	86*	51	1104
Trips after proposal 1	6.45 a.m. – 8.15 a.m.	884	186	34	1104
Existing trips	6.00 a.m. – 9.00 a.m.	1334	118*	71	1523
Trips after proposal 2	6.00 a.m. – 9.00 a.m.	1219	257	47	1523

* These are express bus users presently travelling across the corridor.

The likely switch in mode was calculated by substituting the estimated magnitude of change in quantity of the travel attributes into the mode choice equation (Chapter 4). This procedure indicated that 8.6% of existing car users would switch to public bus transport; and 33% of existing train users would switch to the express bus. The result assumes no lag in mode switching response following the improvements to the bus service. Although private transport time costs are still on average less than public transport time costs, some switching occurs from car to the new bus service because of variation around the mean. Hence the car switchers obtain a reduced generalised cost in using the bus service. The new modal allocation is given in Table 7.4*. The expansion of the sample indicates that 83 car users and 17 train users are likely to switch to the bus as a result of proposal 1, and 115 car users and 24 train users for proposal 2. Express Bus Proposal 1 would adequately cater for the 100 people switching. The patronage probably would be too low for proposal 2 to be financially viable.

* Individuals would also tend to switch for reasons not explicit in the choice model, such as increasing car availability for housewife.

7.4 PROJECT EVALUATION

A cost-benefit analysis was undertaken to provide a basis for comparisons of the suggested projects on the grounds of economic efficiency. In addition a capital-budgeting analysis was used to assess the likely financial viability of the projects for the operators. In evaluating the proposals a narrow economic calculation was considered sufficient since the small-scale impacts are not likely to cause any harmful effects to the community and environment. Further, as the proposals are not likely to affect the speed-flow characteristics overall, the calculation of user benefits was straightforward.

The range of constraints and the supply-demand matching requirements of the study methodology ensured that only a small number of alternative transport options reached the social cost-benefit analysis stage of evaluation. This is not considered a limitation of the study but rather an assurance of the thoroughness of project selection from the many options considered. Projects generated from the corridor studies tend to be small in scale. This permits some simplification of the evaluation procedure without any loss of accuracy.

7.5 PROJECT APPRAISAL

7.5.1 Assumptions Underlying The Project Appraisal

The economic appraisal of express bus proposals was initially made within a social framework. The costs represent the real cost to the community of additional resources consumed by the projects. The increase in the level of transport service, valued in money terms, represents the increase in benefits to society. All transfer payments were excluded from the calculations.

The resource cost includes both the capital cost of additional vehicles, and the increased costs of operation. Promotion is an integral part of the total marketing strategy for some projects such as new bus services and its cost will vary according to the project. The cost function can be written as:

$$C_R = C_C - C_S + C_{OP} + C_{PR}$$

where
C_R = real resource cost to society
C_C = capital resource costs
$-C_S$ = resale value of assets at termination of project
C_{OP} = operating resource costs
C_{PR} = promotion cost

The benefit function can be written as:–

$$\Delta B_S = \Delta B_U + \Delta B_{GEN} + \Delta B_{ORU} + \Delta B_{OTH} - \Delta C_E$$

where
ΔB_S = additional benefits to society
ΔB_U = additional benefits to existing and switched public transport users
ΔB_{GEN} = additional benefits from latent demand and future growth in demand (more than five years after introduction)
ΔB_{ORU} = additional benefits to other road users
ΔB_{OTH} = other social benefits
$-\Delta C_E$ = real resource cost savings for existing operations.

The criteria for inclusion and valuation of specific benefits in the benefit function are summarised in Table 7.5. Two assumptions were employed in the forecasting and evaluation. Firstly, it was assumed that all costs and benefits would accrue from the first day of the first year of operation of the new bus service. No allowance was made for "preparatory costs" to be paid before the first day. Preparatory costs refer to costs of promotion, vehicle construction, etc. which in practice would be needed before the project began its operation. These were assumed to be paid on or after the first day. Secondly, it was assumed that all costs and benefits were expressed in June 1975 dollars and would not be affected to different degrees by inflation. All costs were discounted to June 1975, the "base year". The social discount rate used for the public sector was 10% as recommended by the Commonwealth Bureau of Roads. For the private sector (bus operators) a discount rate of 10% was also used, but with different rationale. This was considered an average estimate of the opportunity cost of capital for investment in new private bus services.

As the effects of latent demand and growth in demand are assumed negligible the term ΔB_{GEN} can be omitted from the benefit function. Any benefits or disbenefits to other road users (ΔB_{ORU}) and others (ΔB_{OTH}) are zero by the assumptions in Table 7.5. The final benefit function thus consists of benefits to users of the improved service (ΔB_U) and cost savings from reduction in the use of resources in existing travel modes ($-\Delta C_E$). It can be written algebraically as

$$\Delta B_S = \Delta B_U - \Delta C_E$$

7.6 COSTING OF PROPOSALS

7.6.1 Costing Procedure Used

The normal procedure for cost-benefit analysis is to include costs as and when they occur and apply one of the discounted cash flow procedures. The "present value" method was used in this study. An appraisal of bus costing procedures was undertaken and a marginal costing methodology developed. This includes a forecasting procedure used to update historical cost information collected from operators and is described in Appendix D.

7.6.2 Capital Costs

Capital costs constitute those costs of owning and using the buses which can be measured by the purchase price minus the selling price at the end of the project. There were no costs of bus shelters, buildings or land involved in the express bus proposals. New and used bus costs were derived from market prices. The Bedford Vam 70 buses were chosen as most suitable for the proposed services. Their purchase price new was $26,700 (at June 1975) of which $1,262 were transfer payments and were excluded from the resource cost, $25,438.

The decline in value of buses due to ageing, obsolescence and usage was determined from estimates of the resale value of buses. The rate of devaluation of buses was assumed to equal the past rate of devaluation. Market prices for second-hand Bedford Vam 70 buses indicate that over the first 5 years of the bus life, the resale value as a proportion of the new price declines at a rate of 11 per cent per annum in constant prices. The discounted resale values expressed in June 1975 dollars and in resource and financial terms are shown in Table 7.6 for 1, 2 and 5-year periods. The capital cost of buying and owning a bus is the initial purchase price less the resale price at the end of the project. It is assumed that buses are financed by private operators.

TABLE 7.5

VALUATION OF BENEFITS

Benefits	Value	Comments and Value Judgements
ΔB_U	$(GC)_{\text{before-after}}$	Saving in generalised cost of travel in study corridor.
ΔB_{GEN}		
latent demand	zero	The study did not aim to increase the number of passenger trips but to effect mode switching in peak hours. In any case the latent demand for peak hour travel in the corridor is expected to be low. Backloading is assumed to be negligible.
growth in demand	zero	The short-term success of projects and their ability to bring about immediate benefits is of interest. Although long-term effects are relevant, in this situation, they are difficult to identify. Since the area is one of the fastest growing in Sydney, then the projects are likely to have benefits at least as high as those identified in the 5-year cost-benefit analysis.
ΔB_{ORU}	zero	Reduction in congestion and operating cost savings may have resulted from traffic improvement projects but in this case of a small-scale bus project, the effect was negligible.
ΔB_{OTH}		
(pedestrians and non-tripmakers)	zero	Time savings and other reductions in generalised travel cost were considered negligible for small-scale projects.
environmental	zero	The net changes in noise, pollution, visual disturbance, etc. due to a small number of additional buses and reduction in number of cars were considered negligible.
accidents	zero	Small-scale projects were assumed to have no effect on accident statistics.
institutional	zero	Reduction in social subsidy (by government) to rail, bus and car may result from a change towards an optimal mix of transport modes. This benefit was neglected for small-scale projects.
$-\Delta C_E$		
public transport	zero	Real resource cost savings to existing operations due to increased efficiency (i.e. level of service/existing investment). This was negligible for small-scale additions to operations.
car	Marginal variable operating costs	Resource cost savings from reduction in vehicle usage.

TABLE 7.6

RESALE VALUES OF A SINGLE BUS AT END OF PROJECT LIFE

(a) Financial Prices	Project Life (Years)		
	1	2	5
Resale Value (in June 1975 dollars)*	$23,763	$20,826	$12,015
Resale Value (present value)** C_{FS}	$21,603	$17,212	$ 7,460

(b) Resource Costs	Project Life (Years)		
	1	2	5
Resale Value (in June 1975 dollars)***	$22,640	$19,842	$11,447
Resale Value (present value)** C_S	$20,582	$16,398	$ 7,108

* Second hand bus prices reflect an 11% flat decline in constant prices from initial purchase price, $26,700.

** Social and private discount rates are 10% p.a.

*** Resource resale values exclude the same proportion of transfer payments from financial values at any point of time. See Section 7.9.

7.6.3 Operating Costs

The operating costs of providing an increment of service have been calculated with reference to existing fleetsize, management, staff and facilities. The marginal bus costing framework (Appendix D) was used to calculate the financial costs to operators who might provide one of the proposed services. Information about operators' annual accounts and their corresponding performance records was collected using the business-interview questionnaire shown in Appendix E. Table 7.7 summarises unit costs for the 73/74 financial year. The costs to existing private operators of one additional bus were developed from this data after conversion to 1975 prices.

For an increment to service involving one new bus, the marginal cost of fuel at an average operating speed of 21 km/h was the same as the average cost (3.0 ¢/km), assuming fuel consumption was the same as average. However, during express running at an average speed of 30 km/h a 23% fuel saving* would be achieved so that marginal unit cost of fuel would become 2.3 ¢/km (Table 7.7). The marginal cost of tyres and maintenance was assumed to equal the average costs, as the conditions affecting these costs for additional buses were similar to those for existing buses.

The registration cost per additional bus was calculated directly using information from the Department of Motor Transport. An average service licence fee of $25 per bus was added. The marginal cost of insurance per bus was assumed equal to the average cost. Depreciation and hire and lease charges were excluded from operating costs and included in the capital charge for bus (Section 7.6.2). The marginal costs of office supplies, mechanics, and administrative staff were estimated on the advice of operators. There were no marginal rates or rent for the proposed increments to operations.

* See Appendix D.

TABLE 7.7

MARGINAL OPERATING FINANCIAL COSTS USED IN DERIVATION OF MARGINAL OPERATING RESOURCE COSTS

Cost Items	Average Financial Costs 1973/74[1]	Indices used To Update 1973/74 Costs[2]	Updated Unit Financial Costs June 1975	Marginal Financial Costs June 1975	Proportion of Tax removed to give resource Costs
Per-kilometre Costs	(¢/km)		(¢/km)	(¢/km)	
Fuel and oil (21 km/h)	2.5	20%	3.0	3.0	46%
(30 km/h)	–	–	–	2.3[4]	46%
Tyres and tubes	0.9	22%	1.1	1.1	13%
Maintenance (parts)	2.3	22%	2.9	2.9	5%
Per-bus Costs	($/bus)		($/bus)	($/bus)	
Registration and licence	432	DMT formula	626	626	100%
Insurance	218	38%	301	301	0%
Office and Miscellaneous	482	28%	619	12	0%
Mechanics	1,346	27%	1,704	164	5%
Administration	1,180	38%	1,629	31	5%
Rates and Rent	286	21%	348	0	0%
Time-Based Costs	($/h)		($/h)	($/h)	
Drivers[3] (all-day service)	2.77	56%	4.33	–	–
(peak)	–	–	–	4.48	5%

Notes: 1. Average costs 1973/74 are for private bus operators in the south-western suburbs of Sydney and reflect the operating costs of the firms involved in the proposals.
2. Indices based on time series data are used to update/extrapolate costs over 18 months from 1973/74 financial year to June 1975. The percentages in this table indicate the increases in the economic indicators used. Refer to source for further details.
3. Drivers' wages include payroll tax and contingencies.
4. Fuel consumption for express running at 30 km/h is 77% of normal fuel costs (21 km/h). See Appendix D.

Source: R.A. Smith (1976) **Evaluation of Small-Scale Urban Bus Improvements: A Case Study in Sydney**. Unpublished M.Eng.Sc. Thesis, University of Melbourne.

The unit costs of employing drivers in peak hours exceeded the unit costs associated with normal all-day rosters due to penalty clauses of the Motor Omnibus Drivers' Award. The additional drivers required could be hired on broken shifts which spread over morning and afternoon peak periods with a break of at least 2 hours between. This would normally involve a penalty rate of 16 per cent over the basic award. The peak-hour wage calculated at $4.48 per hour was used to estimate labour costs on an hourly basis.

The set of marginal costs for small-scale additions to four selected operators are given in the fourth column of Table 7.7. The amount of tax as a proportion of the marginal costs is shown in the fifth column. These proportions were removed as transfer payments to derive resources costs. Table 7.8 shows the marginal unit costs of all components aggregated into subtotals proportional to mileage, buses and hours of drivers' labour. These were used to calculate the annual financial costs of projects and the annual resource costs of projects. Total annual operating resource costs are $8,639 for proposal 1 and $23,520 for proposal 2.

7.6.4 Total Resource Costs Of Proposed Express Bus Projects

The total resource costs of the 2 alternative express bus projects are presented in Table 7.9 for 1, 2 and 5-year operating periods. All costs are expressed in June 1975 dollars discounted (at 10% p.a.) to June 1975*. Promotional costs were assumed to amount to 5% of the marginal operating costs. Over each of the time periods the resource costs can be compared with social benefits in cost benefit analysis.

7.7 BENEFITS

7.7.1 General

Travel decisions may be described as producing benefits to the traveller at the cost of certain disbenefits incurred in making journeys. The disbenefits are the weighted sum of various "costs" such as travel time and money cost. The benefit variables included in this analysis are those which are found empirically to be related to travel decisions and which also influence behaviour directly, rather than those (such as population density) which exert their influence indirectly via effects on travel time and travel cost. In the context of cost-benefit analysis, benefits have to be assessed in the same units as the costs; with the non-quantifiable benefits being stated explicitly and taken into account in the final assessment. A major benefit is travel time savings which requires a dollar-equivalent value to enable it to be expressed as dollars of time saved.

Values of commuter travel time have traditionally been derived from observing and measuring the times and costs of alternative modes and then assuming a relationship between time, cost and the choice of mode. Since these values of time are based on individuals' travel behaviour, they are not strictly resource values of time. In the absence of a direct method of deriving resource time values, the equity (resource) value of travel time savings has to be derived from the behavioural value of travel time savings. The next section discusses the application of behavioural and equity values of travel time savings for the assessment, respectively, of the benefits actually perceived by travellers, and the money value of resources which it would be socially worthwhile to allocate to transport facilities in order to make a unit saving in travel time.

* The end of the 1974/75 financial year was taken as the base date.

TABLE 7.8

INCREMENTAL OPERATING FINANCIAL AND RESOURCE COSTS OF PROJECTS 1 & 2

Specification of Proposed Project					Accounting Costs ($ p.a.)						Resource Costs ($ p.a.)					
					Marginal Costs in Peak Hours				Promotion Cost	Incremental Financial Cost of Improvement	Marginal Costs in Peak Hours				Promotion Cost	Incremental Resource Cost of Improvement
Operator	Annual kilometres at 21 km/h	Annual kilometres at 30 km/h	Extra buses	Hours of drivers' labour per year	Per kilometre at 21 km/h	Per kilometre at 30 km/h	Per bus	Per hour			Per kilometre at 21 km/h	Per kilometre at 30 km/h	Per bus	Per hour		
PROJECT 1																
Liverpool	5,398	13,298	1	767	377	840	1,134	3,436	289	6,076	288	184	497	3,260	289	4,994
McVicars	3,451	9,083	1	540	241	574	1,134	2,419	218	4,586	660	451	497	2,295	218	3,645
										Financial Operating Cost 10,662						Resource Operating Cost 8,639
PROJECT 2																
Oliveri	7,313	10,989	1	875	511	694	1,134	3,920	313	6,572	390	546	497	3,719	313	5,465
Liverpool	10,796	24,055	1	1,267	755	1,519	1,134	5,676	454	9,538	576	1,195	497	5,385	454	8,107
Milperra	5,109	5,672	1	500	357	358	1,134	2,240	204	4,293	272	282	497	2,125	204	3,380
McVicars	6,903	18,166	1	1,042	483	1,147	1,134	4,668	372	7,804	368	902	497	4,429	372	6,568
										Financial Operating Cost 28,207						Resource Operating Cost 23,520

TABLE 7.9

PRESENT VALUES OF TOTAL PROJECT FINANCIAL AND RESOURCE COSTS FOR ALL OPERATORS

Proposal 1: Two Express Bus Departures

Financial Cost		First year	For 2 years	For 5 years
Capital	C_{FC}	\$53,400	\$53,400	\$53,400
Operating	C_{FOP}	\$9,682	\$18,485	\$40,374
Promotion	C_{FPR}	\$483	\$923	\$2,016
Resale	C_{FS}	–\$43,206	–\$34,424	–\$14,920

Resource Costs		First year	For 2 years	For 5 years
Capital	C_C	\$50,876	\$50,876	\$50,876
Operating	C_{OP}	\$7,754	\$14,802	\$32,331
Promotion	C_{PR}	\$483	\$923	\$2,016
Resale	C_S	–\$41,164	–\$32,796	–\$14,216

Proposal 2: Six Express Bus Departures

Financial Costs		First year	For 2 years	For 5 years
Capital	C_{FC}	\$53,400	\$53,400	\$53,400
Operating	C_{FOP}	\$25,614	\$48,899	\$106,806
Promotion	C_{FPR}	\$1,280	\$2,445	\$5,340
Resale	C_{FS}	–\$43,206	–\$34,424	–\$14,920

Resource Costs		First year	For 2 years	For 5 years
Capital	C_C	\$50,876	\$50,876	\$50,876
Operating	C_{OP}	\$21,145	\$40,368	\$88,172
Promotion	C_{PR}	\$1,280	\$2,445	\$5,340
Resale	C_S	–\$41,164	–\$32,796	–\$14,216

7.7.2 User Benefits

The behavioural values of travel time savings expressed as a percentage of average personal gross income were obtained from a study in Sydney (Table 7.10)*. It was assumed that the percentages applied throughout the entire metropolitan area. The Green Valley District average gross weekly personal income for 1975 of $129.5 obtained from the home-interview survey (Appendix A, question 20) was related to the (constant) percentages of the average wage rate from the 1971 study. The values of travel time savings are presented in Table 7.10 (assuming a 40-hour working week).

TABLE 7.10

BEHAVIOURAL VALUES OF COMMUTER TIME SAVINGS

Nature of Time	Value of Travel Time Savings	
	1975	
	cents per person hour	% average wage rate
in-vehicle	43.6	13.4
waiting	84.3	26
transfer	66.1	20
Total (door to door)	64.8	20

An earlier Bureau study** suggested that persons who indicate time savings as the most important factor influencing travel choice have a different value of time to persons who indicate cost savings as the most important factor influencing travel choice. The generation of separate behavioural values of travel time savings for the two groups may be more appropriate in the determination of total perceived benefits to users than the utilisation of a single (averaged) value across both groups. These alternative values of time savings are shown in Table 7.11.

TABLE 7.11

1975 BEHAVIOURAL VALUES OF COMMUTER TRAVEL TIME SAVINGS

Nature of Time	Time Savers	Cost Savers	All Travellers
in-vehicle	51.8	12.7	43.6
waiting	100.2	24.6	84.3
transfer	78.6	19.3	66.1
total (door-to-door)	77.0	18.9	64.8

* Hensher, D.A. (1972) **The Consumer's Choice Function: A Study of Traveller Behaviour and Values**, unpublished Ph.D Thesis, School of Economics, University of New South Wales.

** Hensher, D.A. and Delofski, E.F. (1973) **Route Choice and Value of Travel Time Savings: Analysis of Newcastle-Sydney Tollway Study**, unpublished report, Commonwealth Bureau of Roads.

7.7.3 Time And Cost Savers

The allocation of car and train switchers to the time savers and cost savers groups is difficult given the absence of any direct evidence. However, if it is assumed that the relationship between cost difference and time difference was an appropriate criterion, then the proportion of car and train switchers who were cost and time savers could be identified. For the train switchers we assume that the "all travellers" values are appropriate, while for the car switchers it is assumed that nearly all belonged to the cost savers category. This seemed consistent with the empirical situation, since the bus improvement would not offer any time benefits, only cost and other benefits. Hence present car users who placed a higher value on cost savings than time savings would be expected to switch to the bus.

7.7.4 Total Benefits To Travellers

The changes in attribute levels associated with modal switching are summarised in Table 7.12.

TABLE 7.12

CHANGE OF ATTRIBUTE VALUES BETWEEN NEW AND OLD MODAL JOURNEYS FOR MODE SWITCHERS

(a)	Ex-car Users Switched to Express Bus				
trip stage	time savings*			total time (min)	cost savings (cents)
	invt (min)	wt (min)	tt (min)		
Access	–3	–3	+3	–3	–
Main Mode	–8	0	0	–8	–
Egress	0	0	–5	–5	–
All Stages	–11	–3	–2	–16	8

* **Note:** Negative sign indicates time lost.

(b)	Ex-train Users Switched to Express Bus				
trip stage	time savings			total time (min)	cost savings (cents)
	invt (min)	wt (min)	tt (min)		
Access	+6	+6	+3	+15	–
Main Mode	+5	+0	+0	+15	–
Egress	+4	+3	–3	+13	–
All Stages	+15	+9	+9	+33	10

The benefits of time and cost savings to the users who switch to express bus were given by the change in behavioural generalised cost:

$$\text{Change in Benefits } (\Delta B_{FU}) = \text{no. of switchers} \left\{ \begin{bmatrix} \text{value of} \\ \text{in-vehicle} \\ \text{time} \end{bmatrix} \times \begin{bmatrix} \text{in-vehicle} \\ \text{time} \\ \text{savings} \end{bmatrix} + \begin{bmatrix} \text{value of} \\ \text{waiting} \\ \text{time} \end{bmatrix} \times \begin{bmatrix} \text{waiting} \\ \text{time} \\ \text{savings} \end{bmatrix} + \begin{bmatrix} \text{value of} \\ \text{transfer} \\ \text{time} \end{bmatrix} \times \begin{bmatrix} \text{savings in} \\ \text{transfer} \\ \text{time} \end{bmatrix} + \begin{bmatrix} \text{savings in} \\ \text{money cost} \end{bmatrix} \right\}$$

As a result of proposal 1, the behavioural user benefits are given as follows:

$$\begin{aligned} \text{For ex-car users, } \Delta B_{FU} &= 83 \left\{ 12.7 \left(\frac{-11}{60}\right) + 24.6 \left(\frac{-3}{60}\right) + 19.3 \left(\frac{-2}{60}\right) + 8 \right\} \\ &= 83\ (3.80) \\ &= 315\ ¢/\text{peak period} \\ &= \$1{,}576/\text{year} \end{aligned}$$

$$\begin{aligned} \text{For ex-train users, } \Delta B_{FU} &= 17 \left\{ 43.6 \left(\frac{15}{60}\right) + 84.3 \left(\frac{9}{60}\right) + 66.1 \left(\frac{9}{60}\right) + 10 \right\} \\ &= 17\ (43.46) \\ &= 739\ ¢/\text{peak period} \\ &= \$3{,}694/\text{year} \end{aligned}$$

The total user benefits as perceived by all travellers affected by Proposal 1 amounted to \$5,270 per annum; similarly the total user benefits as perceived by the 139 individuals affected by proposal 2 amounted to \$7,400 per annum.

7.7.5 Resource Benefits Calculated Using An 'Equity Value Of Time'

The values of travel time savings used in the generation of benefits perceived by the travellers are not equity values. They are behavioural values related to the incomes of the particular travellers directly affected by the project, since it was explicitly assumed that different individuals place different values on saving travel time for a number of very legitimate reasons (for example, marginal utility of income differences, varying preferences, etc.). However, in a cost-benefit analysis concerned with changes in aggregate social welfare, it is not appropriate to apply local behavioural values of time. Individuals with higher values of time savings may also have greater ability to pay. It is inequitable that the ability to pay should influence the desirability or otherwise of a particular project and thus an equity value of time has been applied.

The equity value is assumed equal to the average resource value of time for the total urban population (assumed equal to the behavioural value of time savings). Income in the Green Valley area were 12.1% less than the metropolitan average. The individual's willingness-to-pay was converted into what he would be willing-to-pay if he had the metropolitan average income level and if he still devoted the same proportion of his income to each good. The empirical value of this weight was 1.121. The equity values of travel time savings are given in Table 7.13. All other user weights (e.g. car mileage costs) are assumed to be the same as these for the community as a whole.

TABLE 7.13

EQUITY VALUES OF COMMUTER TRAVEL TIME SAVINGS

Nature of Time	cents per person hour (1975)	% average gross wage rate
in-vehicle	48.9	13.4
waiting	94.6	26.0
transfer	71.1	20.0
door-to-door total	72.7	20.0

For the cost-benefit analysis (as distinct from the assessment of net behavioural benefits to the user) the benefits consist of net gain in user and producer surpluses in which the public transport fare payments and savings cancel with producer fare revenue gains and losses (see Table 7.14).

For proposal 1, $\Delta B_S = 83\left[48.9\left(\frac{-11}{60}\right) + 94.6\left(\frac{-3}{60}\right) + 71.1\left(\frac{-2}{60}\right) + 64\right]$
(100 switchers)

$$+ 17\left[48.9\left(\frac{15}{60}\right) + 94.6\left(\frac{9}{60}\right) + 71.1\left(\frac{9}{60}\right)\right]$$

$$= 83\,[47.94] + 17\,[37.08]$$

$$= 4{,}609\ \text{¢/peak period}$$

$$= \$23{,}045/\text{year}$$

For proposal 2, $\Delta B_S = 115\left[48.9\left(\frac{-11}{60}\right) + 94.6\left(\frac{-3}{60}\right) + 71.1\left(\frac{-2}{60}\right) + 64\right]$
(139 switchers)

$$+ 24\left[48.9\left(\frac{15}{60}\right) + 94.6\left(\frac{9}{60}\right) + 71.1\left(\frac{9}{60}\right)\right]$$

$$= 115\,[47.9] + 24\,[37.08]$$

$$= 6{,}402\ \text{¢/peak period}$$

$$= \$32{,}012/\text{year}$$

7.8 COST-BENEFIT ANALYSIS RESULTS

The final calculations of the net benefit of the alternative bus proposals are given in Table 7.15. The results suggested that proposal one (small express bus project) was acceptable on economic grounds but that the alternative proposal was unacceptable to the community as a whole. Releasing the car for non-work trips is likely to constitute additional significant benefits and may be a basis for accepting proposal 2, together with a subsidy to the bus operator. This is consistent with the objective of the study (see Section 2.2), although at this stage it has not been possible to quantify these benefits.

TABLE 7.14

CONSUMER AND PRODUCER SURPLUS

		gains per trip per person or organisation	losses per trip per person or organisation	gains-loss per trip per person or organisation
Ex rail users (1.6%)	time	85 minutes	52 minutes	Net Consumer Surplus
	money	66 cents	56 cents	
Ex car users (7.6%)	time	36 minutes	52 minutes	
	money	64 cents	56 cents	
Railways (1.6% switch lost)	money	—	66 cents (train fare)	Net Producer Surplus
Bus Companies (9.1% switch gain)	money (ex rail) users	56 cents (express bus fare)	—	

* To calculate total consumer and producer surplus, 500 trips per year are assumed to occur for each traveller.

TABLE 7.15

SOCIAL COST BENEFIT ANALYSIS RESULTS

Small Express Bus Project 1	Life of Project (Years) 1	2	5
Resource Costs $C_C + C_{OP} + C_{PR} - C_S$ ($ present value)	17,949	33,805	71,007
Benefits ΔB_U ($ present value)	21,972	41,948	91,623
NPV ($)	4,023	8,143	20,616

Large Express Bus Project 2	Life of Project (Years) 1	2	5
Resource Costs $C_C + C_{OP} + C_{PR} - C_S$ ($ present value)	32,137	60,892	130,171
Benefits ΔB_U ($ present value)	30,522	58,270	127,275
NPV ($)	–1,615	–2,622	–2,896

Note: The capital outlay is the same for both projects, since the same number of new buses were required for both proposals.

7.9 CAPITAL BUDGETING FOR PRIVATE BUS OPERATORS

A commercial analysis of cash inflows and outflows for the individual operators was undertaken. The cost function for operators is:

$$C_F = C_{FC} + C_{FOP} + C_{FPR} - C_{FS} - \Delta C_{EF}$$

where C_F = total financial cost (including transfer payments)
C_{FC} = financial cost of capital investment
$-C_{FS}$ = resale value at the end of the project life
C_{FOP} = financial marginal operating costs
C_{FPR} = financial promotion costs
ΔC_{EF} = operating cost reductions (existing operations)

and the benefit function is:

$$B_F = B_{FR}$$

where B_F = total monetary benefit to the operator
B_{FR} = fare revenue.

Normal accounting practice was applied to aggregate the costs and revenues. The net present value for the additional service and the total operations could then be assessed and used as a basis for negotiation with the operator.

Over each of the evaluation periods the financial costs can be compared with fare revenues to determine operators gross profits (expressed in present values). The financial costs used as a basis for calculation of the resource costs are given in Table 7.6(a). Total annual operating financial costs are S10,662 for proposal 1 and $28,207 for proposal 2 (Table 7.8).

It was assumed that operators would pay all operating and capital costs (including promotion cost). The capital budgeting exercise was undertaken for all operators collectively (i.e. 2 operators for the first proposal and 4 operators for the second). A rate of return of 10% was assumed for the discounting of cost and revenue time streams (see Section 7.4). The results in Table 7.16 show that from the operator's point of view only proposal one is a viable proposition.

TABLE 7.16

PRESENT VALUES OF PRIVATE BUS OPERATOR CASH FLOWS
(BOTH OPERATORS COMBINED)

Small Express Bus Proposal 1			
Present Value at June 1975	Life of Project (Years)		
	1	2	3
Total outflow** $C_{FC} + C_{FOP} + C_{FPR} + C_{FS}$	20,360	38,384	80,870
Total inflow* B_{FR}	26,697	50,967	111,323
Profit before Tax	6,337	12,583	30,453

Large Express Bus Proposal 2			
Present Value at June 1975	Life of Project (Years)		
	1	2	3
Total outflow $C_{FC} + C_{FOP} + C_{FPR} + C_{FS}$	37,088	70,320	150,626
Total inflow B_{FR}	37,109	70,844	154,739
Profit before Tax	21	524	4,113

* Based on average fare of 56¢.
** inflows = revenue
outflows = initial capital outlay + marginal operating costs – salvage value.

7.10 CONCLUSIONS

The social cost-benefit analysis, including the equity assumptions made at various stages in the evaluation (i.e. location identification and project benefit weights), and the incidence analysis for private operators, demonstrate clearly the desirability of a small express bus service between Green Valley and Bankstown. The stated aim of the project provision was to reduce the relative level of transport disadvantage of persons living in locations of high transport costs relative to incomes and where a major contributing factor to this situation was high public transport generalised costs. Although only 17% of the modal switchers were originally public transport users, 70% of the perceived benefits would accrue to these switchers. Of the switchers the 83% who were previously car users, received 30% of the perceived benefits.

The recommended project will reduce the mean generalised cost for the work journey for all residents of Green Valley from 66.2 cents per person trip to 65.9 cents per person trip. This reduction is not likely to affect the relative ranking of Green Valley on the transport/location disadvantage criteria. For the particular corridor studied, however, the overall generalised cost will decrease by 3%, whereas for all public transport users (including switchers) it will decrease by 15%. A single project relevant to a particular group (Green Valley – Bankstown Corridor travellers) would not itself be expected to have a significant effect on the ranking unless it affected a significant proportion of the residents of the disadvantage area. Even if more transport projects of an equivalent size were considered across the Green Valley population, the percentage increase in user benefits to all commuters is not likely to increase by more than 10%, however, more substantial projects may achieve a more significant impact.

What has been achieved, however, is a demonstration of the usefulness of the procedures outlined above, by identifying and evaluating a realistic option. Any changes over time in the ranking of locations according to transport disadvantage criteria however are not likely to be significant unless complementary non-transport solutions are considered, such as relocation of employment facilities to assist in transport cost reduction. In the proposals investigated full attention was given to the real-world implications of the illustrative proposals. It is suggested that the relevant authorities consider utilising this approach for other proposals in the study area.

CHAPTER 8
EVALUATION OF OTHER TRANSPORT IMPROVEMENT PROPOSALS

8.1 INTRODUCTION

This chapter summarises an assessment of the impact of two traffic-flow improvements designed to overcome major transport deficiencies which Green Valley residents identified. Although the Green Valley residents would obtain a degree of benefit from these improvements, their location would also provide benefit to non-Green Valley residents. Hence, these projects were seen as primarily associated with the transport facility inefficiency issue (see Chapter 2.3).

8.2 CHAPEL ROAD SOUTH BUS LANE

8.2.1 Description Of The Proposal

This proposal involves reservation of the existing kerbside lane along Chapel Road South approaching Canterbury Road at Bankstown for exclusive use by buses. This lane would extend for 690 metres and would terminate 55 metres prior to the intersection of Chapel Road South and Canterbury Road (Figure 8.1). It would be demarcated exlusively for buses only by means of a wide painted line and an appropriate nomenclature and sign-posting. The "bus-only" restriction would operate during the hours of 6.45 a.m. to 7.45 a.m. and 4.30 p.m. to 5.30 p.m. each weekday.

Field tests showed that the problem existing in Chapel Road South is that buses suffer 5-minute delays in long queues forming because of saturation flows during the peak at Canterbury Road intersection. There is little opportunity for signalling improvements as settings are optimal. The proposal is designed to enable buses to bypass the queue and gain priority to the intersection on the first signal green time. Termination of the bus lane 55 metres before the intersection allows admission of other traffic to the kerbside lane to preserve normal left-turn movements. Intersection capacity would not theoretically be altered by the proposal.

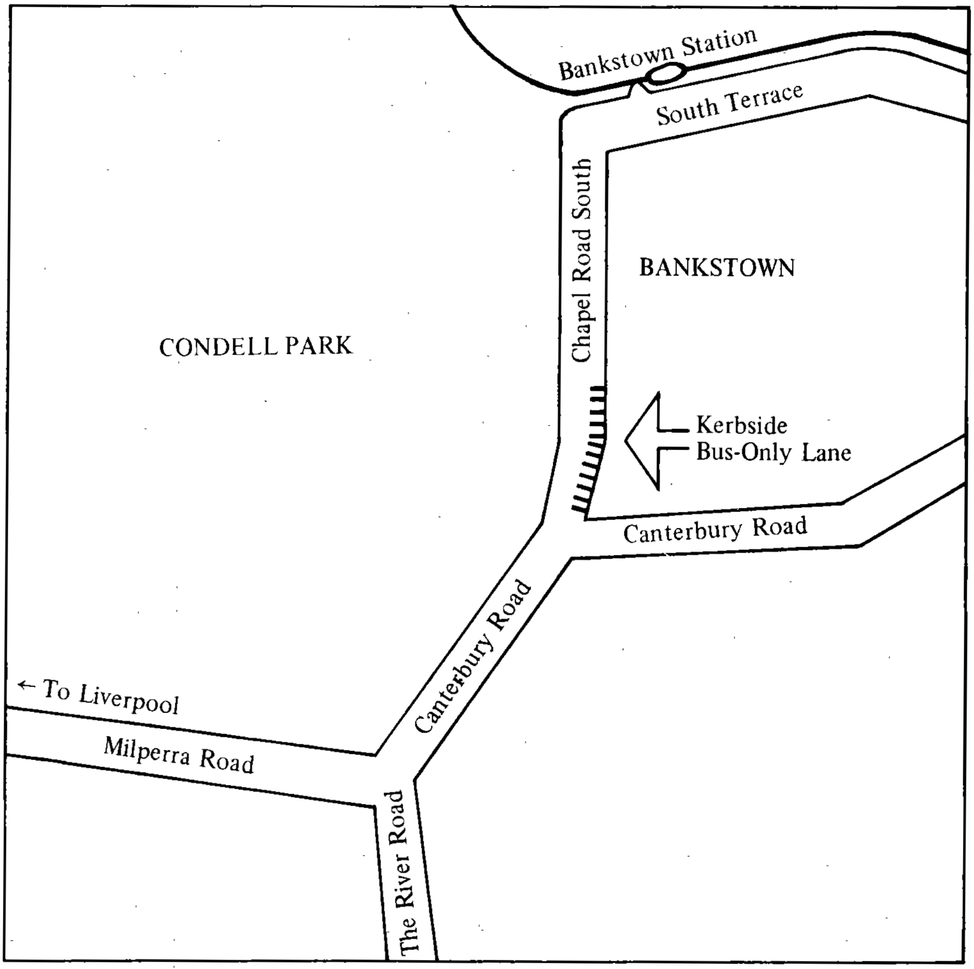
8.2.2 Benefits From The Chapel Road South Bus Lane

The net benefits from the proposal would relate essentially to travel time savings to bus users, disbenefits to other road users and the cost of implementation. In determining the potential bus passenger savings, it was assumed that the average speed of buses in the bus lane equals the average free-flow traffic speed 18 km/h. Benefits would occur over the second 345 metres of bus lane only. The benefits associated with the proposed bus lane are given in Table 8.1. Valuing in-vehicle time savings at 48.9 cents per person hour, the annual time savings benefits to existing bus users was \$3,602 in the morning peak and \$3,990 in the afternoon peak.

The number of trip-makers who would switch to the bus service as a result of the improvement was assumed to be zero, as the improvement involves a non-significant proportion of average trip length for all non-bus journeys. The benefit to public transport users due to reduced travel times is \$7,592 per year. Although there will be some reduction in the variability in bus travel times, and hence improved reliability in maintaining schedules and reduced waiting times, this second-order effect has been difficult to gauge and should be noted in subsequent monitoring.

FIGURE 8.1

SCHEMATIC DIAGRAM OF THE PROPOSED CHAPEL ROAD SOUTH BUS-ONLY LANE IN BANKSTOWN



8.2.3 Disbenefits Of The Chapel Road South Bus Lane

The delay to other traffic due to a longer queue alongside the bus lane was calculated from queuing theory as approximately 25 seconds per vehicle in both morning and afternoon peaks (Table 8.2). This amounted to lost time worth $2,588 per year to other road users assuming an average car occupancy of 1.2 and the value of in-vehicle time savings as 48.9 cents per person hour.

TABLE 8.1

BENEFITS TO BUS PATRONS FROM THE CHAPEL ROAD SOUTH BUS LANE

Nature of Benefit		Morning Peak (6.45 a.m. – 7.45 a.m.)	Afternoon Peak (4.30 p.m. – 5.30 p.m.)
Average bus running time before and after the bus lane (min)	Before	6.53	6.53
	After	3.13	3.13
Vehicle time savings (min)		3.40	3.40
Number of annual passenger trips		130,000	144,000
Annual passenger time savings (S)		3,602	3,990

TABLE 8.2

DISBENEFITS TO OTHER TRAFFIC FROM THE CHAPEL ROAD SOUTH BUS LANE

Nature of Disbenefit		Morning Peak (6.45 a.m. – 7.45 a.m.)	Afternoon Peak (4.30 p.m. – 5.30 p.m.)
Average traffic time before and after the bus lane (min)	Before	6.53	6.53
	After	6.95	6.95
Vehicle time losses (min)		0.42	0.42
Traffic Volume (excluding buses) (vehicles/peak hour)		1,260	1,260
Number of Annual Passenger Trips		378,000	378,000
Annual passenger time losses ($)		1,294	1,294

The adjacent land use is manufacturing and wholesale while there are some residences and a small shopping strip opposite. No increase in traffic was expected and it was not expected that this project would generate any further undesirable side-effects than presently exist. Vehicles turning into the business establishments on the eastern side of the road would be allowed to use the bus lane. Enforcement of the ban on private car usage in the kerbside lane would require the co-operation of the New South Wales Police Department.

8.2.4 Costs Of The Chapel Road South Bus Lane

The costs involved would be those associated with initial painting of the road, which would involve 8 man-hours at $3.20 per hour. This would be repeated annually. In addition, signs would have to be erected at the commencement and end of the lane at an estimated cost of $650. The marginal cost of Police involvement as a result of this project was considered to be negligible.

8.2.5 Conclusion

This assessment of the impact suggested that significant net benefits over 1, 2 and 5-year operating periods would be likely as shown in Table 8.3. This traffic management proposal is an illustration of a measure incurring low cost with positive net benefit.

TABLE 8.3

NET BENEFITS, CHAPEL ROAD SOUTH BUS LANE

	Period of Operation		
	For 1 year	For 2 years	For 5 years
Net present value ($)	4,127	8,442	19,173

It may prove worthwhile to allow high-occupancy vehicles (e.g. carpools) to use the bus lane. These vehicles might not impose any delays on the buses using the land whilst generating additional time savings to passengers travelling in groups. The prospect of this should be investigated along with the effects of consecutive reserved lane improvements along congested arterial roads as distinct from the effects of an isolated bus lane.

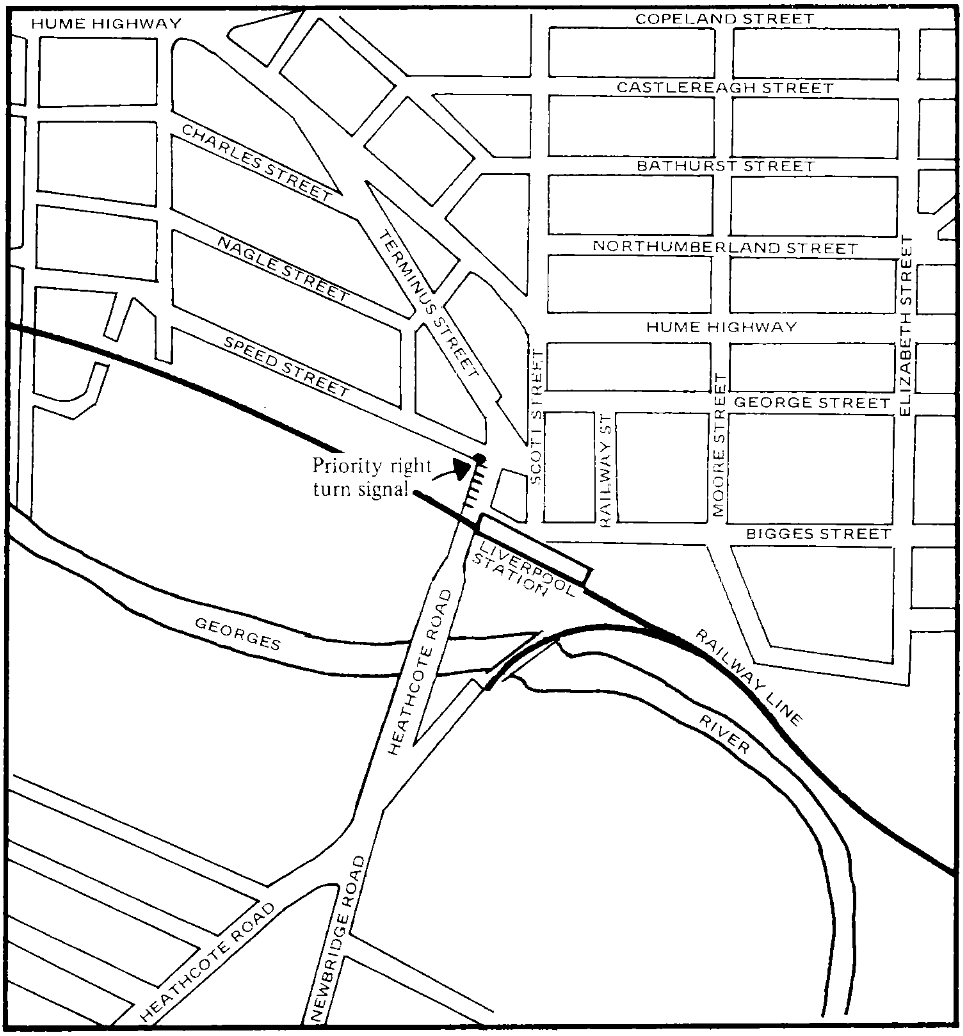
8.3 BUS PRIORITY SIGNAL AT LIVERPOOL FOR EVENING PEAK

8.3.1 Description Of The Proposal

This project involves the installation of a power unit in the set of traffic lights at the intersection of Speed Street, Terminus Street, Scott Street and Heathcote (Figure 8.2). This would enable buses to reduce long delays. Buses would be fitted with portable transmitters to delay the right turn signal if green, or pre-empt the green if currently red. At present the arrival rates during the peak period in the vicinity of the intersection exceed the service rates, with queueing delays that often extend back over the Georges River Bridge along Heathcote Road. The priority signallisation would be operative between 4.30 p.m. and 5.30 p.m. on weekdays. The signal design criteria is to maximise intersection through-put whilst at the same time limiting maximum individual delay.

FIGURE 8.2

BUS PRIORITY SIGNAL AT LIVERPOOL



8.3.2 Benefits Of The Right-Turn Signal

Existing average delay times for buses before the intersection were calculated as 5 minutes. The priority signallisation is assumed to reduce these delays. Although the priority signallisation is designed to minimise delays, it is not feasible for green time to be extended or pre-empted to reduce the average delay to zero. Elimination of the average queue would require in excess of 2 cycles. Given this limitation, a 20% reduction in bus delay time is the most likely outcome. The alternative not considered in this illustrative proposal, is a complete replanning of the intersection complex. Benefits to bus users in excess of a 20% reduction in bus delays would probably be outweighted by costs to other road users through increases in the average delay per vehicle. No desirable or undesirable social or environmental effects are anticipated. The number of bus users per hour in the evening peak is estimated to be 228, being carried in 6 buses. Using a value of time of 48.9 cents per person hour, and 250 workdays per year, these time savings represented an evening peak benefit of $465 annually.

8.3.3 Cost Of The Right-Turn Signal

With the existing bus frequencies the capital costs were estimated as $1,200 for the total cost of transmitters for each bus, assuming 6 buses in use in the peak, and $4,500 for a fixed signal unit. The total cost is $5,700.

The annual discounted net benefits over five year period using a 10% discount rate are given in Table 8.4 together with the calculated net present value of minus $3,588.

TABLE 8.4

NET BENEFITS, BUS PRIORITY SIGNAL – LIVERPOOL

	Period of Operation		
	For 1 year	For 2 years	For 5 years
Net present value ($)	–4,991	–4,588	–3,588

If the smaller of the two express bus projects were implemented (Chapter 7), however, two additional buses would carry an extra 118 passengers. These would also experience 5-minute delays in the absence of priority signallisation. Additional (evening-peak) time savings of $240 annually should therefore be considered. Extra costs of $400 would be incurred in purchasing additional portable transmitters in the two extra buses. The new net present value would be minus $3, 013.

The proposed bus priority signal for right turning from the Georges River bridge approach to Speed Street at Liverpool is not justified on economic grounds. Given the high average delays at this intersection, a detailed traffic management study is warranted.

8.4 CONCLUSION

The method outlined in Chapters 2 to 4 has been used to identify both corridor and spot-improvement projects. In the present chapter two spot-improvement projects suggested by the study (Table 4.1) were assessed and one justified on economic grounds: i.e. the with-flow kerbside bus lane on the eastern side of Chapel Road South at the approach to Canterbury Road. The lane would be 690 metres long and terminate 55 metres from the "stop line" at Canterbury Road.

CHAPTER 9

SUMMARY – CONCLUSIONS AND SUGGESTIONS

9.1 INTRODUCTION

This study proposed that transport improvements are one way of improving the social welfare of urban residents. The study in toto* is a demonstration (in Sydney) of a different approach to the planning of urban transport improvements. It was not assumed that transport improvements were necessarily a "best" solution, but that if transport improvements have a contribution, there should be some systematic procedure for identifying the types of desirable improvements.

This study can be assessed in terms of its contribution to a number of areas:

- (a) issue identification
- (b) planning approaches
- (c) methodological framework
- (d) appropriateness of low-cost, easy-to-implement, "software" options
- (e) role of the conventional bus
- (f) planning within the existing private bus industry.

While it is desirable to have a mechanism by which 'relevant' issues can be presented, and to arrive at a target issue for investigation: in the present study the target issue was assumed within the context of the goals to which road transport policies might be directed (Roads in Australia 1975, 1.16). This target issue was assistance through transport improvements to groups of people who are relatively transport disadvantaged.

In order to pursue an issue in accordance with broad goals, a planning approach must be developed. This study proposed an incremental approach in which the emphasis was on systematic identification of transport improvements with due consideration to their certainty of success, level of capital intensity, flexibility, and period for implementation. That is, the orientation was that of taking the present state of transport provision and modifying the system in accordance with notions of flexibility, certainty, low cost, and positive benefits, so as to make better use of existing transport infrastructure, while at the same time improving the relative distribution of transport between advantaged and disadvantaged groups of people. The approach emphasises demand related policy responses and may be thought of in terms of one to five year planning and implementation time horizons. However, we believe the approach has more general relevance over longer time horizons.

* Other documents related to parts or all of this study are

1. Hensher, D.A. and McLeod P.B. "Towards an Integrated Approach to Identification and Evaluation of Transport Determinants of Travel Choice", **Transportation Research**, (forthcoming).
2. Hensher, D.A., Hooper, P.G. and Ravallion, J.M. "An Approach to Planning for Urban Transport Improvements", **Metropolitan Transport Planning – The Way Ahead**, Proceedings of a Conference, Institution of Engineers (Australia), Melbourne, November 1975.
3. Hooper, P.G. "Investment Options for Urban Passenger Transport", **Australian Transport Research Forum**, Sydney, April 1975.
4. Smith, R.A. **Evaluation of Small-Scale Urban Bus Improvements: A Case Study in Sydney**. Unpublished M.Eng.Sc. Thesis, University of Melbourne, 1976.
5. McLeod, P.B. **Demand for Urban Travel**. Unpublished Ph. D. Thesis, Department of Economics, University of Adelaide, 1976.
6. Hensher, D.A. (1976) "Use and Application of Market Segmentation", in Stopher, P.R. and Meyburg, A.H. (eds.) **Behavioural Travel Demand Estimation** (D.C. Heath, Lexington).
7. Unpublished Working notes, prepared during the course of the study. (Available as a single (7-part) consolidated document in the Commonwealth Bureau of Roads Library, 1976).

Within an incremental planning context groups of people residing in urban locations were ranked with respect to the issue of concern, in accordance with a number of criteria. Decision rules were postulated to combine criteria as a basis for selecting those groups of persons who were at the low end of the transport/location disadvantage ranking. The particular empirical study emphasised the relative transport disadvantage of persons in the context of the journey to and from work. Within a selected location, types of proposals for transport improvements were identified by a systematic procedure using a combination of disaggregate travel choice models and direct user participation. Potential projects were initially selected from demand considerations, in contrast to the more orthodox supply approach used for larger capital investment projects. A short list of proposals was generated from a range of potential transport improvement types, taking into consideration the significant factors influencing travel choice, direct user participation, and difficulties of implementation (institutional, labour, financial). The particular corridor or site location for possible project implementation within the preidentified zonal location was determined according to present origin-destination patterns and the relationship between volume and capacity of particular links in the transport system. Project evaluation was then undertaken in terms of cost-benefit analysis, incidence analysis and financial analysis. This systematic approach concluded with recommendations for project implementation.

The importance of the approach adopted is that it systematically identifies and ranks localities of residents considered in need of an improvement in welfare and then generates appropriate transport projects that assist the desired redistribution through improvement to personal mobility. This differs from the traditional approach which considers a much wider range of technologies and recommends their application at locations in which they would achieve some improvement in efficiency, irrespective of which areas are disadvantaged. The traditional approach has its role but should not receive any more emphasis than the approach developed in this report.

The philosophy of the approach does not mean that large-scale revamping of the present transport system (e.g. institutional rearrangement or replanning of all bus routes) is not a desirable alternative, but rather that there is a need to continually improve on the distribution of resources within the existing transport structure, regardless of the appropriateness of that structure in meeting longer-term aspirations.

9.2 THE SYDNEY CASE STUDY

The new approach has been applied in Sydney and, in the location identification phase, the Green Valley district was identified as most "disadvantaged" according to a criterion of "greatest burden of transport costs relative to income of residents for the journey to and from work". This and other criteria were discussed in relation to non-work journeys. The project identification phase generated feasible projects such as express bus services, exclusive bus lanes and bus priority signals. Disaggregate behavioural mode choice models were used to estimate public transport patronage levels and a broad evaluation framework was employed for project appraisal.

The categories of transport options considered for the Green Valley District were (See Chapter 5, Table 5.1 Appendix C):

1. conventional bus services
2. mini-rationalization of bus operations
3. reserve lanes
4. road improvements
5. flow improvements
6. inter-modal facilities
7. vehicle design/size changes
8. public transport user facilities
9. promotion
10. passenger fare changes.

The regulatory, legal and other constraints pertaining to each option were investigated to assess feasibility of successful and immediate implementation. Potential of options to induce modal switching from private modes to public transport through improvements in public transport attributes was also checked. It was concluded from these initial considerations that conventional bus service improvements and promotional activities have some potential for reducing transport location deficiencies in the Green Valley area. In the longer term, new tertiary employment located closer to the Green Valley Area may be required, so as to provide increased opportunities for employment to both men and women.

A survey of economic characteristics and legal restrictions of the private and government bus industries in Sydney indicated the suitability of private operators for undertaking small-scale bus service projects in metropolitan areas. This is despite the general need for rationalization of private services as part of any strategic plan in the medium or long term.

Responses from citizens and bus operators assisted in identifying the particular deficiencies in existing public transport services and their possible causes. The Green Valley – Bankstown transport corridor was found in need of improvement. Information about existing trip distributions and the time distribution of demand was supplemented with performance data for road networks and established bus and train services. Public transport journeys usually involved long waiting and transfer times. The average door-to-door time of 85 minutes by public transport makes it an unattractive alternative to the car (36 minutes). Accordingly the mode split was 87.6% car and 12.4% public transport, of which 7.7% was private bus and 4.7% train.

Behavioural modelling techniques based on the individual preferences of Green Valley residents for their journey to and from work suggested that improvements to certain attributes of public transport would have a significant effect on increasing preference for public transport. The attributes found to be statistically significant were in-vehicle time on the main mode, egress waiting time and the proportion of total journey time spent in-vehicle on the main mode.

The express bus services proposed for operation by the private bus operators whose franchised service areas were part of the corridor were investigated. Each would involve some morning departures from Green Valley to Milperra and some from Liverpool to Bankstown with express running along the common route between Liverpool and Milperra, and conversely in the afternoon peak. One project was small involving 2 departures across the corridor, and one large, involving 6 departures. Although novel in Sydney, suburban express bus services operating along routes which are licensed for different operators need not contravene any existing regulations. However, a liberal interpretation of the regulations may be necessary. This would seem consistent with the rationalization ideas of the Department of Motor Transport (N.S.W.). Agreement amongst private operators and the Bus Proprietors Association (N.S.W.) would be necessary and should not be difficult to achieve.

Of the options available, distinction must be made between those which aim to improve the efficiency of existing public transport but not specifically to induce some switching (Type I), and those which increase the performance of public transport such that additional supply or capacity will be needed to cater for mode switching (Type II). An example of a Type I project is a bus lane which results in time savings and increased reliability for present users (Chapter 8). The express bus proposal is a Type II example since the main benefactors will be those who switch to the new service regardless of whether they are bus or non-bus users at present (Chapter 7). In this case, accurate mode switching predictions are important for ensuring a design of adequate capacity for the level of benefits attainable. In this regard, existing mode choice models are adequate only when there is no threshold to be overcome before car users begin switching to public transport. The small and large projects would both cater for the expected 9% modal switching although the larger project would have low load factors, making it highly unlikely from the operators' viewpoint.

A broad evaluation framework comprising 3 parts was used for project appraisal; a cost-benefit analysis, financial analysis and an incidence analysis.

For the small express bus service the cost-benefit analyses yield positive net present value surpluses over 1, 2 and 5-year operating periods. For the first 5 years the net present value is $20,616. In contrast, the large express bus service with a net present value of minus $2,896 is not justified on economic grounds. There is no doubt that some Green Valley residents would benefit to some degree by an additional public transport service. However the cost of promotion and initial outlay for buses may require government sponsorship. The express bus project should be viewed as a useful demonstration project.

As a demonstration project it would be necessary to monitor operational performance and user and non-user attitudes to the new service. The long-term benefits to public transport could be substantial.

The Green Valley to Bankstown Corridor contains less than 6.3% of the total number of peak-hour work trips from Green Valley so the reduction in generalized cost of public transport for the Green Valley workforce as a whole resulting from one such small improvement in this single corridor will be infinitesimal. The "disadvantage ranking" of Green Valley area with respect to other districts will not change because of the corridor express bus service. However, the new planning methodology has been illustrated in both the location identification and project identification phases. The generation of sufficient numbers of transport projects in all corridors from Green Valley district would undoubtedly improve its ranking. So long as the partial analysis assumption is acceptable, improvements in the transport sector may be a valid approach to improving social welfare in urban areas. However the longer-term effects on residents, both owners and tenants, resulting from transport improvements still needs to be studied.

Two other projects in the Green Valley to Bankstown Corridor were identified and evaluated. The first of these was a bus-only lane in Bankstown of buses taking workers from the Bankstown Station to employment centres. This would improve the egress part of the work trip from Green Valley for those people who travel by train to Bankstown Station and then bus. The other project, not justified on economic grounds, is a priority turn signal which would enable buses to avoid long waiting times at the intersection of Speed and Terminus Streets at Liverpool when returning from Bankstown in the evening peak. The net present values for the two projects were calculated to be respectively

$19,173 and minus $3,588. If the smaller express bus project were implemented, the net present value of the bus priority signal project would increase to minus $3,013. The net benefits and losses over the 5 years reflect the small-scale nature of the projects. The locations of the two recommended projects are shown in Figure 9.1.

The proposals evaluated in Chapters 7 and 8 were suggested from earlier stages of the methodology and developed within an incremental planning framework. The evaluation of actual projects is an appropriate way of giving the approach some empirical realism. Realism, however, should not be associated solely with recommendations for project implementation but also with the accumulation of knowledge and understanding appropriate for recommendation of policy directions. While policies should not be the simple summation of projects, the latter are fundamental inputs in any detailed planning arising out of the formulation of policy.

9.3 FEATURES OF THE OVERALL STUDY

The research and investigations effort of this study have contributed to transport planning and policy formulation in a number of directions.

1. The Value Of Location Identification Approach

There is much to be gained from an approach that systematically seeks out the location of groups who are considered to be in need of transport improvements. This study has demonstrated the practicability of this approach.

2. Project Identification

Having identified the locations of groups needing transport improvements, project planning may proceed on a number of levels. The range of investment options may take on varying levels of capital intensity, periods to implementation, and degrees of certainty of predicted benefits.

3. Short Implementation Period, Low-Capital Investment

The potentials of this type of investment have not yet been fully exploited. For little capital outlay, these investments may return significant benefits within short time periods. The point is not that other types of investment (high capital intensity, etc.) should be ignored, but that relatively more emphasis should be placed on short-implementation period, low-capital investment options than has been the case in the past.

4. Options

Much research and development has occurred in recent years with the types of options discussed in the previous section. It is felt that some of the more "exotic" options are not suitable at present. In particular, dial-a-bus seems only suited for limited application under Australian conditions. Car pooling promises great benefits for minimal outlay but the prospects of it becoming a widely-accepted practice are not great. More faith is given to improvements of established conventional technologies such as upgrading existing bus services. The bus represents a basic technology most suitable for meeting many needs of urban areas. Much can be done to improve bus services by development of bus design, bus priority measures including bus lanes and queue-jumping lanes, and integration with other public transport services (Table 9.2).

FIGURE 9.1
RECOMMENDED PROJECTS

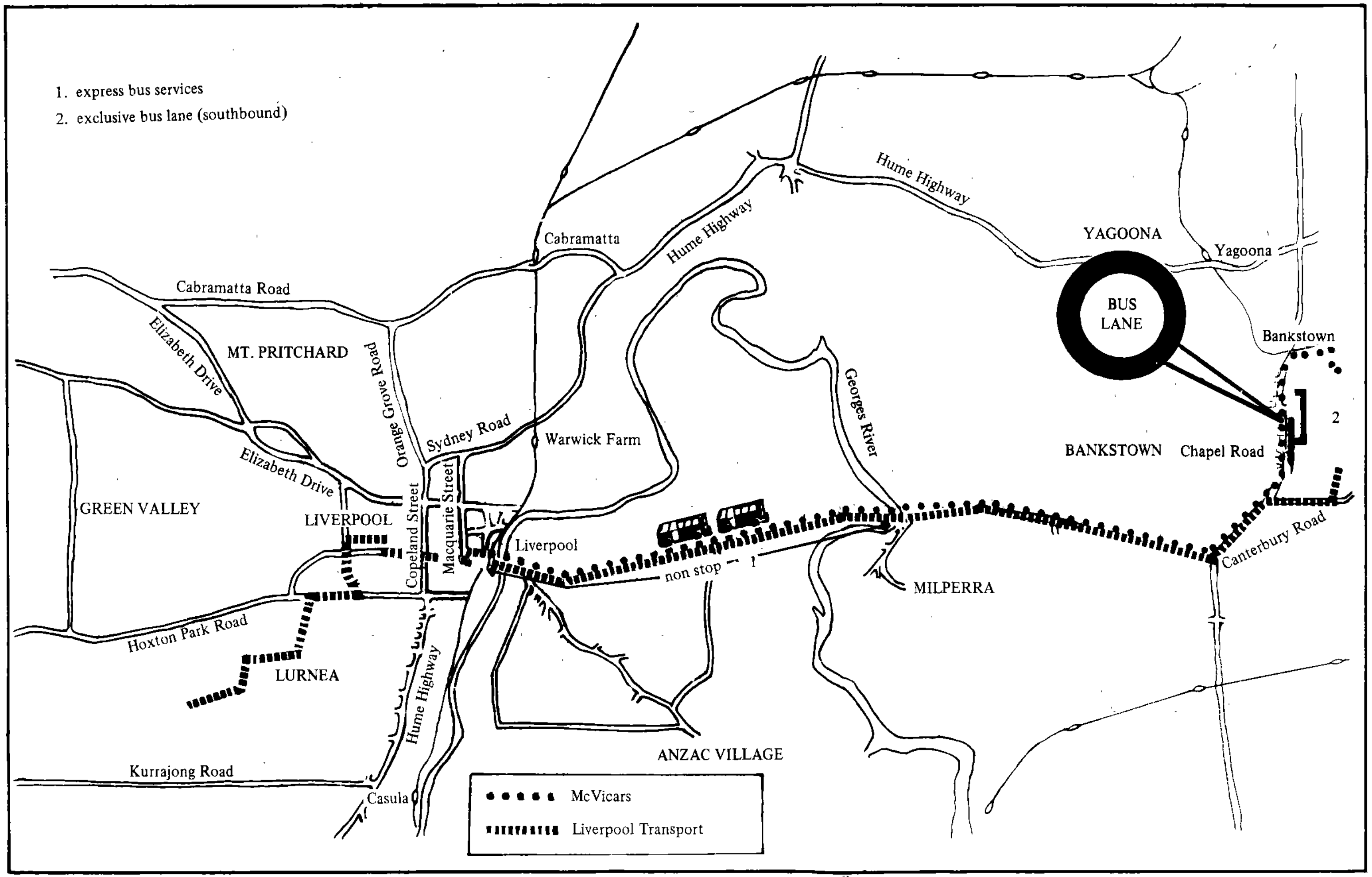


TABLE 9.2

OPTIONS WORTHY OF FURTHER DETAILED INVESTIGATION

Option	Criteria	Situation	Comments
Bus Pool	Encouraging less use of private car for work journey.	Medium/high density residential location; persons with relatively regular and unchanged work journey patterns; centrally orientated travel.	Includes subscription bus services. Bus can be owned either by private or public organisation, or a firm or private syndicate, and operated by either. Pool organised by local community group or bus company or firm.
Exclusive Bus Lanes	Encouraging less use of private car for work journey.	Where the greater proportion of journey is by the bus. At least 6 kilometres in length.	
Express Bus	Providing an alternative to stage bus for existing bus users, and more direct access to opportunities than rail, in addition to assisting rail movement of people.	Middle to outer suburban areas where a significant proportion of residences commute to the central business district or to a major industrial area.	
Traditional Bus Services	(1) Through improved marketing and promotion to encourage use of existing bus services during peak hours. (2) Within mode efficiency.	All bus services serving rail stations.	This is primarily an efficiency exercise to make better use of existing bus services, and perhaps also an attempt to improve bus reliability.
24 hour clearways	To make most efficient use of existing roads in accordance with major aim of providing such facilities.	All arterial and major roads in urban areas.	Many main roads which presently only have clearway signs for peak hours also display high levels of congestion during off-peak. This policy can assist in reducing the requirement for further investment in road infrastructure.
Parking Limitations	To discourage use of car for journeys in peak towards the central area (not necessarily to the central area).	Radial Journeys terminating within 4 miles from the CBD.	Infinite pricing (or restrictions) of parking on main streets seems desirable given the prime requirement for road space.
Road Management (includes interchange redesign, signal coordination, actuation of signals by priority modes, bus lanes, new rules regarding overtaking (lanes, etc.).	To improve the flow of traffic.	Any congested spot in the road network – spots or links.	This is primarily designed to produce benefits to present users of facilities (both car and/or bus users) including reduced operating costs of vehicles.

5. Inadequacy Of Present Planning Methods

The transport plans that have been prepared for urban areas are not capable of giving due consideration to the types of options discussed, nor are they designed to carry out the type of location identification analysis suggested.

6. Marginal Costing Preferred To Average Costing

In the usual long-term evaluations, the analyst is justified in using average costs. For short-term evaluation, and for small incremental projects, this is inadequate because the short-term marginal cost can be as low as 25% of the short-run average cost for incremental bus projects. Marginal analysis is essential.

7. Travel Choice Modelling

If analytical models are to be used, then predictions of patronage for these types of special-context improvements can only be adequately treated with disaggregate probabilistic modelling procedures based on behavioural relationships. Furthermore, these types of models assist in identifying relative levels of importance of certain policy variables which are then taken into consideration in planning improvements. Thus, it is necessary that the explanatory variables in the choice models be capable of responding to the characteristics of the policy options. This study indicates that it is possible to identify key comfort and convenience variables, as well as traditional time and cost variables, which users perceive to be important in their travel choice decisions. Small group search sessions may be as useful in the generation of projects. However, it is not felt that the prediction role can be adequately handled by other than disaggregate choice models. Simpler choice models are needed when prediction of modal usage etc. and not generation of projects is the concern of the choice models.

8. Demonstration Projects

Government-sponsored transport demonstration projects have been used extensively in the United States. The concept has been valuable because many potentially worthwhile improvements would not otherwise have been tested. There is considerable reluctance in the transport agencies to experiment and strong central government motivation and assistance is needed to realise, through variations, the full potential of traditional technologies. Urban road-based public transport projects of the type discussed would be particularly amenable to demonstration exercises over periods of 1 to 5 years. Some reasons for this are:

(i) comparatively low capital investment with the likelihood of benefits exceeding costs when options are carefully selected, designed and implemented.

(ii) short implementation periods before stable operations are achieved so that performance can be assessed as well as public relations, industrial relations and other human aspects.

(iii) suitability to scientific monitoring so that the results can be generalized to predict performance in other locations.

(iv) flexibility to change parameters of the system to achieve the desired effects.

(v) low termination costs at the end of the experiment if (and when) it should be discontinued.

The need for demonstration projects influenced the Bureau in its recommendation of an amount of $25 million for improvements to road based public transport (para. 7.173, Roads in Australia 1975).

9. The Value Of Marketing

Marketing should be integral to the process of transport planning.* Our studies have revealed the lack of public knowledge of public transport operating times, routes, speed and cost. It is not always realised that public transport could be a real alternative to the car for some journey purposes. This is partly a fault of the passive advertising of bus and train services and the lack of co-ordinated promotion. It would seem that an active promotion campaign would be a valuable demonstration project and an essential part of any new transport projects.

10. Lack Of Public Awareness Of Issues

Increasing public awareness of urban transport problems has focused more attention by some (rather vocal) groups on the role of public transport. Often, however, too much is expected of public transport too soon. Given the complex mobility needs in urban areas, improving public transport services to cause large shifts of car drivers into public modes is not an easy nor necessarily a desirable matter. It is unrealistic in the short-term. This does not mean that nothing is to be gained from efforts directed at improving public transport: the point is that there are many widely held expectations which are unlikely to be realised for some time.

11. Regulation And The Need For Rationalization

Where studied, existing regulations over private bus operations are restrictive within unplanned licenced areas. Operations outside of franchised areas are prohibited, often ruling out the possibilities of express and line-haul services. Many uneconomic services are maintained in order to eliminate competition from other operators in franchised areas. The regulations are antiquated and are a likely cause of inefficiency within the system. This had led to the need for rationalization of routes, timetables and fleets to achieve a co-ordinated urban bus program.

12. Impending Disaster Of The Sydney Bus Industries

The overall trend for public and private bus industries can be represented as a circle of "declining patronage, and reduced services" caused by the factors indicated (Figure C.1, Appendix C). Planning improvements should seek to break the vicious circle. Financial assistance alone is only prolonging the otherwise "ultimate fate".

13. Labour Relations

Although our studies have done little to cast any light on this issue, it is not an issue that ought to be sidestepped, being one of the most sensitive areas in labour-intensive public transport operations. Excessive demands for improved awards and conditions along with strike action (often in order to gain the former) by unions have imposed heavy costs on government transport operations and the taxpayer.

14. Land Use-Transport Interaction

Preliminary results of our work suggest that transport costs for the work journey exert a strong influence on land values.** However, very little is known about the process whereby transport improvements have a dynamic impact on changing land values and in time, occupancy and land use. This has implications for the ultimate incidence of costs and benefits associated with transport improvements for different groups in urban

* See P.C. Weiglin, (1975) "Marketing and the Management Attitude", **Transit Journal**, 1(2).

** See Part I of the associated working notes, available in Bureau of Roads Library.

areas. While road based public transport projects provide an effective short-run means of improving accessibility to employment opportunities, in the long term employment relocation will occur and will have an impact on access to employment. There is a pressing need for greater co-ordination of transport planning and land use planning.

15. Financial Assistance

When financial assistance is needed for operators of public transport demonstration projects, the basis for funding should be related to types of costs incurred e.g. operating costs, capital costs for vehicles and establishment costs. Current Commonwealth Government assistance to the States for transport takes the form of capital grants, with the exception of MITORS. State Government (as distinct from privately-sponsored) programmes only are eligible. In some States private operators receive no assistance to cover operating deficits. Any organisation that provides a transport service should be considered for assistance, if such assistance can be shown to be warranted. Bus services in inner and middle-distance suburbs in Sydney are government-operated and subsidised by tax-payers generally, but in outer areas they are not. The result is to aggravate further the regressive effect of outer area access cost. The correction should be to finance all transport on the same basis. Levels of transport subsidy in many parts of the world have been increasing over the years, and are often more than a quarter of the total operating costs. The provision of operating subsidies should be carefully considered to ensure that it does not lead to over-provision of services, over-manning or inefficient use of both human and material resources, and over-payment of staff.

Although as a general principle we would argue that the users of transport facilities should pay the real cost of their travel, the application of this general principle should be limited in certain situations because of low ability to pay and/or special personal circumstances.

Overall, the study has shown the feasibility of both identifying groups in the community who have poor access to particular opportunities and of developing effective proposals of a type that can reduce that access disadvantage. We recommend the extension of such studies both in Sydney and to other urban areas in Australia (See Report of Roads 1975, para. 7.139). Funding should be made available by the Commonwealth Government for demonstration projects to enable development, implementation and monitoring of projects such as those discussed in this report. The Bureau has formalised this into the following recommendation in its Report on Roads 1975.

> ". . . . we RECOMMEND an amount of $25 million for road based public transport services to be expended on capital and operational improvements involving the road vehicle and vehicle use providing benefits to the community and the road user generally and including a provision for feasibility studies and demonstration projects." (para. 7.173).

9.4 SUMMARY OF THE CONTRIBUTIONS OF THE STUDY

This study can be concluded with a summary of the main contributions to transport planning.

1. Identification of ways of using existing road and transport infrastructure more effectively through low-cost short-term transport improvements.
2. Identification of urban residential locations where transport disadvantaged might be assisted by the provision of road-based public transport. This study begins systematically at the level of the wellbeing of individuals

(a distributive justice orientation) rather than adopting the pure efficiency approach. The study has equity and efficiency implications. The basic unit of account is the individual, in contrast to the road link.

3. Evidence and demonstration of a procedure for systematically assessing the relevance of transport management and low-cost (short-term) transport options. The method is intended for general application to all forms of transport improvement.
4. The encouragement of the implementation of projects to test a planning approach and a systematic methodological framework.
5. Identification of a broader set of factors influencing various travel choices. This is the first study to follow through the logic of identifying an extended set of relevant influences on choice as measured in policy sensitive units, with the use of attitudinal and behavioural theories of traveller behaviour. Quantitative measures of travel comfort and convenience were developed.
6. Assessment of the role and structure of the private and public bus industries in an urban area, and indication of likely areas of improvements in the efficiency of the industry as a provider of transport services.
7. Identification of the extent of likely relevance of a range of road based public transport improvements in the context of modal switching effect and/or within-mode efficiency. There is an important distinction between operational improvements to the existing road system with negligible (or zero) modal switching, and transport improvements designed to adjust the modal mix.
8. A major criterion for success of any short-term low-cost option which has the objective of modal switching associated with it is that the improvement should represent a significant proportion of the total journey time. That is, total-journey type projects have greatest success especially in context of modal switching or journey generation. Small-scale improvements (e.g. interchange improvements, bus priority signals etc.) are primarily relevant in achieving increased benefits to existing users and reductions in operating costs, but negligible in influence on modal switching.
9. The idea of marketing of urban transport as a consumer orientated process in contrast to a supply approach. This study has suggested a framework within which consumers' preferences can be considered in the generation and evaluation of projects.
10. An awareness of the need for further research and investigation along the general lines of this study with the objective of determining a procedure that permits effective (competitive) allocation of funds between road infrastructure, road operations, and road based public transport.
11. The notion that road (bus) – rail competition is being used to the detriment of travellers and operators of both rail and bus services. The study has indirectly suggested that bus improvements should not be considered for the single purpose of encouraging car users to switch mode, but also as a desirable method for complementing the existing rail system, not only as traditional feeder services but more particular to assist the movement of persons who prefer to travel by public transport. In this way, buses can assist in reducing the need for increased rail investment and contribute towards an improved quality of public transport service for all concerned.

12. The methodology used has the advantage of short-cutting itself, by suggesting a less-costly procedure. The major area of cost reduction is in project generation, using direct participation to identify project types (by location) and hence reducing the quantity of data required (by home-interview) for the demand model. Many aspects of the method began as basic research. An important lesson from this study is the selection of sequence in which investigations occur. Since project evaluation appears to be primarily concerned with a transport corridor (or series of transport corridors), it seems more appropriate to initially identify transport corridors (e.g. Green Valley – Bankstown) within the context of particular predetermined locations, (e.g. Green Valley Area) and then select the home-interview sample that is appropriate for the corridor rather than the area as a whole. This will result in less home-interviewing (hence reduced costs) and a more representative sample for the corridor evaluation. There is also a real danger in collecting excessive amounts of data (see Appendix A), which can result in the useful identification of a broader set of factors influencing mode choice, but which also increases the modal specificity of variables, and hence reduces the ability of the estimated choice model in assessing the real impact of a new modal option on modal split.

APPENDIX A

HOME INTERVIEW QUESTIONNAIRE FOR GREEN VALLEY AREA SURVEY

MARCH 1975

Hello. Can I please speak to the main income earner? (Interviewer: Sex of respondent M( ) F( )).

Identification No: ______________________________

Home Address: No: ______ Street ________________ Suburb ______________

Work Address: No: ______ Street ________________ Suburb ______________

Do you have a telephone? Yes ( ) No ( ). If Yes: What is the number __________

SECTION ONE

1. Step by step, how do you get to work in the mornings? e.g. bus-walk; car driver-train-walk. (Interviewer: Use notation at bottom of this page*.)

   ____

2. If you were unable to get to work the usual way, how would you get there? e.g. car passenger-train-walk, bus-walk.

   ____

3. Do you have a car available for getting to work if you want to use it?

   Yes – as car driver ( )
   Yes – as car passenger – family car ( )
   Yes – as car passenger – car belonging to non-family member ( )
   No – ( )

NOTE * For these questions, please use the following symbols.

W = walk
T = train
B = bus
CP = car passenger
CD = car driver
M = motor bike

Date completed form is received at PRC ______________________
Edit check ( ).

4. If Yes to question 3, then ask: How many days a week would a car usually be available for getting to work?

________________ days per week.

5. Do you hold a current driver's licence? Yes (   ) No (   )

6. How many cars and motorbikes are available for use by members of your household?

____________ cars, ____________ motorbikes

7. Do you personally own one of these cars? Yes (   ) No (   )

8. What is your normal occupation? ______________________________

9, 10, 11. ASK ALL RESPONDENTS
(Answer whether or not you use bus)

9. How far away is the nearest bus stop which you could use for getting to work?

   (a) Time ____________ minutes

   (b) Distance ____________ miles ____________ yards.

10. How often does a bus arrive at your bus stop during the

   (a) morning peak hours? Every __________ minutes. Do not know (   )

   (b) after 9 a.m. Every __________ minutes. Do not know (   )

11. If the bus is not on time, how late does it come? __________ minutes

12. In the past fortnight, how many times have you been delayed on your way to work by fifteen minutes or more?

________________ times.

13. When does the delay occur? ______________________________

14. What time do you usually:

Leave home to go to work ______________ a.m.

Arrive at work ______________ a.m.

Officially start work ______________ a.m.

15. If you had to use your alternative means of transport indicated earlier, what time would you leave home to arrive at work at the usual time?

________________ a.m.

SECTION TWO

16. Interviewer will now show the map to the respondent and after indicating the respondents home and workplace location will ask him/her to trace (with a biro) the route he usually takes (according to the answer in question 1) to work and the route by the alternative mode that was also indicated in question 2. Ask respondent to mark with a cross (X) where he completes a stage of the journey (e.g. home ______________ X ______________ X where the first 'X' refers to completion of walking to bus stop, and second 'X' refers to completion of bus journey). Also ask respondent to indicate above the 'X' the nature of the completed journey stage, using our notation given on the bottom of the front page of this questionnaire, e.g. 'W' is walk stage completed.

MAKE SURE THE MAP IS COMPLETED FOR BOTH THE **USUAL** AND **ALTERNATIVE** JOURNEYS TO WORK THAT ARE DESCRIBED IN SECTION TWO OF THIS QUESTIONNAIRE.

SECTION THREE

Interviewer to select the appropriate page for USUAL journey to work (given in Question 1 of section one) and the ALTERNATIVE journey to work (given in Question 2 of section one). The appropriate page is identified by the combination of symbols in the top left hand corner, which should line up with symbols used in questions 1 and 2 of section one. Indicate with a tick whether the selected page relates to the USUAL journey or the ALTERNATIVE journey to work. Commence to complete the page by systematically working through **column by column**, not row by row.

17. How many people live in this house? ______________

    How many are:

    Employed (part or full time) ______________

    Hold a current driver's licence and go to work? ______________

    Hold a current driver's licence and **DO NOT** go to work? ______________

    Are presently seeking employment? ______________

    Are on a pension? ______________ (specify pension) ______________

18. At what age did you leave school? ______________

19. How many people in your household are:

Adults	(over 30 years old)	______________
Adults	(18-30 years old)	______________
Young people	(14-17 years old)	______________
Children	(3-13 years old)	______________
Infants	(under 3 years old)	______________

QUESTIONS 20, 21 and 22 ARE ALL VERY IMPORTANT TO OUR RESEARCH. THEY ARE PERSONAL QUESTIONS, BUT ALL INFORMATION WILL BE STRICTLY CONFIDENTIAL.

20. We would like some indication of your personal income **and** the total household income, as this is important information for the research, given our concern with **the proportion of a person's and household's income spent on transport.** If you are willing to give this information please indicate on the card provided what:

(a)	your net household weekly income is	(tick on card)
(b)	your net personal weekly income is	(tick on card)
(c)	your gross household weekly income is	(tick on card)
(d)	your gross personal weekly income is	(tick on card)

INTERVIEWER TO SHOW THE RESPONDENT THE CARD

21. Do you own or rent this house? Own ( ) Rent ( )

    State Housing Authority? Yes ( ) No ( )

22. Could you please indicate:
    Your weekly repayments $ ____________
    OR
    Your weekly rental $ ____________

23. How long have you lived in this house? ____________

24. Where did you live before this? Street ____________

    Suburb ____________

25. Before this, where had you lived for the longest time? (If Sydney, state Suburb)

    ____________ For how long? ____________

26. If you have any children below school age, do you have child care arrangements?

    Yes – Institutions ( ) Days per week ( )

    Yes – Other friends etc. ( ) Days per week ( )

    No –

27. How many people in the household go to: High School ____________

    Primary & Infants ____________ Other ____________ (specify) ____________

28. I will now ask a series of questions related to the various journeys undertaken **TODAY/FRIDAY** by other persons in your household between the hours when you go to work and arrive home.

	H	W	S/D	O	No. of trips per day	Main Address (Name (if school), no., street, suburb)	Usual Transport			Usual Transport			Is a car available (YorN)	Does person have a licence?	If by car, no. of persons travelling together
							Means	Cost	Time	Means	Cost	Time			
Work															
School															
Shops															
Other															

NOTE: H = Head, W = Wife, S = Son, D = Daughter, O = Other.

SECTION FIVE

29. What would you like to see carried out to improve your travel to work? (Could you point out on the map where improvements could be made.)

____

____

30. What is wrong with the present local bus service?

____

____

31. What is wrong with the present train service?

____

____

32. What is wrong with the present roads?

____

____

33. How about the parking near your workplace?

____

____

34. Are there any further comments you would like to add?

____

____

THANK YOU FOR YOUR CO-OPERATION

SECTION THREE

Identification No. ______ Usual trip ( ) Alternative trip ( ) W - B - T - B - W (walk-bus-train-bus-walk)	TIME mins. secs.	COST cents	Distance miles yds.	% or amount of time passing through industrial areas	% or amount of walking time exposed to weather	% of amount of waiting time exposed to weather	Number of roads crossed	Number of stops due to signals, stop and giveway signs	 rail stations, bus stops	 rail and road con-gestion delays	How long are you in the vehicle before there are 35 people standing (for train or 20 people standing (for bus)?	% of vacant seats in carriage or bus when you get on vehicle	% or amount of time vehicle is stationary	Type of vehicle (bus or train carriage) i.e. single decker (SD) or double decker (DD)
1. Walk from home to bus stop along, a) main roads														
b) other roads, lanes etc.														
2. Waiting to cross roads while walking from house to bus stop.														
3. Wait for bus.														
4. Travel by bus to station.														
5. Walk from bus to station.														
6. Waiting for train.														
7. Train journey.														
8. Walking from platform to bus stop.														
9. Wait for bus.														
10. Bus journey.														
11. Walking from bus stop to workplace along, a) main roads														
b) other roads, lanes etc.														
12. Waiting to cross roads while walking from bus stop to workplace.														

SECTION THREE

Identification No. ______ Usual trip ( ) Alternative trip ( ) CD - W (car driver-walk)	TIME mins. secs.	COST cents	Distance miles yds.	% or amount of time passing through industrial areas	% or amount of walking time exposed to weather	% or amount of waiting time exposed to weather	Number of roads crossed	Number of stops due to signals, stop and giveway signs	Number of stops due to road congestion delays	% or amount of time the vehicle is stationary	Number of persons travelling in car (including yourself)
1. Travel by car.											
2. Looking for place to park car and park car.											
3. Walking from parked car to workplace along, a) main roads											
b) other roads, lanes etc.											
4. Waiting to cross roads while walking from car to workplace.											

APPENDIX B
THE LOGIT TRANSFORMATION

In order to explain the logit method as it is used in the choice of travel modes for the journey to work, consider that the objective is to construct a model to find the probability, P, that a person will choose one mode (say, the car) in preference to another mode. This probability of choice can be explained in terms of combinations of explanatory variables.

These explanatory variables are assumed to act additively to influence choices between modes. However, the effects of changes in the explanatory variables on probabilities of given choices depend on the initial choice probabilities. Logit analysis operates so that given changes in the explanatory variables have less and less effect on the probabilities of given choices as the tails of the distributions are approached. Thus, in choosing between a car and a train for the work journey, the effect of a given change in the cost differential between the two modes will change the chance of the car (or reciprocally the train) being actually used, much less if the original probability was near 0% or 100%, than if the original probability was nearer the 50-50% point.

The resultant probability function, almost identical to the cumulative normal curve, is a symmetrical sigmoid curve diverging from the normal curve at the extremes only. Let us develop the model when the dependent variable is dichotomous, taking on the values 1 (for car use) and 0 (for other mode use). A qualitative dependent variable, such as the binary choice of mode, imposes an automatic restriction on the range of variation of its conditional distribution, constraining the probability of choice to take values between 1 and 0. The logit function for a binary choice is expressed as

$$\log\left(\frac{P}{1-P}\right) = a_0 + a_1x_1 + a_2x_2 + a_mx_m$$

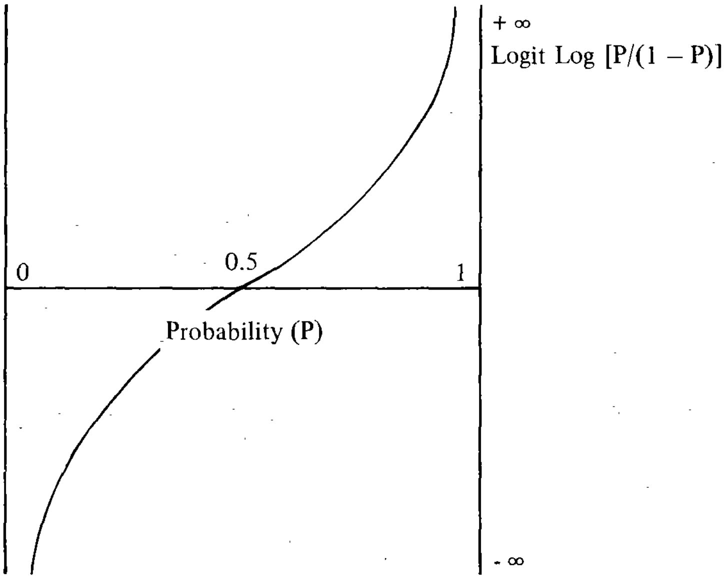
As P approaches zero, $\log\left(\frac{P}{1-P}\right)$ approaches minus infinity, and as P approaches unity, $\log\left(\frac{P}{1-P}\right)$ approaches plus infinity.

$$\text{i.e.}\quad \lim_{P\to 0} \frac{P}{1-P} \to 0 \text{ and } \lim_{P\to 1} \frac{P}{1-P} \to +\infty$$

This gives a transformation of the probability which can take values from $-\infty$ to $+\infty$, while restricting the probability itself to values in the range 0 to 1. $\log(P/(1-P))$ is referred to as the "LOGIT", and is plotted as a sigmoid curve (Figure B.1).

FIGURE B.1

THE LOGIT AS A FUNCTION OF THE PROBABILITY



Let $\log (P/(1 - P)) = G(\underline{X}, \underline{a})$

where $\underline{X}$ is $X_0, X_1, \ldots, X_m$, with $X_0 = 1$

$\underline{a}$ is vector of coefficients of function $G(\underline{X})$

Rearranging,

$$\frac{P}{1 - P} = e^{G(\underline{X}, \underline{a})}$$

Thus,

$$P = \frac{e^{G(\underline{X}, \underline{a})}}{1 + e^{G(\underline{X}, \underline{a})}}$$

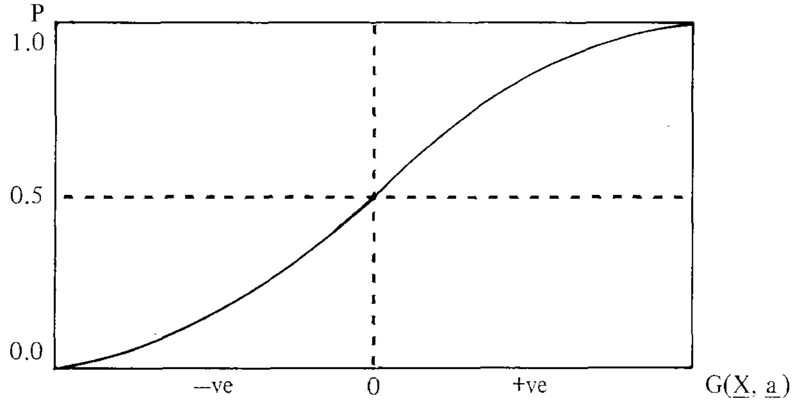
A plot of the relationship between P and $G(\underline{X}, \underline{a})$ yields a sigmoid function (Figure B.2). This is calibrated using the maximum likelihood method:

$$\Lambda = \prod_{j=1}^{N_1} \left(\frac{e^{G(\underline{X})}}{1 + e^{G(\underline{X})}} \right) \prod_{j=N_1+1}^{N} \left(\frac{1}{1 + e^{G(\underline{X})}} \right) \quad \begin{array}{l} j = 1, \ldots, N_1 \text{ mode 1 users} \\ j = N_1 + 1, \ldots, N \text{ mode 2 users} \end{array}$$

The test for goodness of fit is the generalised likelihood ratio test, distributed as chi-square at $-2 \log \lambda$*.

FIGURE B.2

THE LOGISTIC CURVE



* This test works by proposing a null hypothesis that the probability, P_1, of an individual choosing mode 1 is independent of the value of the parameters of the $G(\underline{X})$ function. If this were true, the coefficients would be zero. The value of the log likelihood function evaluated for maximum likelihood, $L^x (a^1_o, 0, 0,....0)$, is determined. Next the alternative hypothesis is set up so that the probability of an individual choosing mode 1 is not independent of the value of the parameters in the $G(\underline{X})$ function. The value of the log of its likelihood, $L^x (a_o, a_1, a_2,....., a_m)$ is determined. It can be shown that if $\log \lambda$ is set equal to $L^x (a_o, a_1, a_2,....., a_m) - L^x (a^1_o, 0, 0,....., 0)$, $2 \log \lambda$ is approximately distributed like chi-square with m degrees of freedom for large samples: m is the number of independent variables. If the value of $2 \log \lambda$ is significant, one may reject the hypothesis that the logit function is independent of its parameters. This is analogous to the F test in regression.

APPENDIX C

A REVIEW OF POTENTIAL IMPROVEMENT OPTIONS

C.1 BUS SERVICE IMPROVEMENTS

The bus is a form of passenger transport capable of much variation and is flexible enough to adapt to present and changing needs. For comparatively little capital outlay, buses provide an opportunity to make better use of existing road space. Thus road space can be utilized more effectively by concentrating improvements on measures that facilitate the movement of persons rather than vehicles. More use can be made of existing rail, tram and ferry services by making them more accessible to potential users with suitable bus feeder services. Experience in the conventional bus industry has shown that buses are well suited to the following roles:

(i) **Local Distributor.** This is the most common role in suburban areas in which buses act as feeders from residential areas to rail, tram, ferry, or other bus interchanges. These are fixed route services which include schools, shopping centres and other local centres of activity.

(ii) **Line-haul.** Buses can perform line haul tasks between any major activity centres or along corridors, and can therefore cater for central business district – oriented radial demands as well as cross suburban movements.

(iii) **Express.** In this role buses operate non-stop at relatively high average speeds along freeways, expressways and main roads. Express coach services often extend to outer-urban or country centres. Express operations usually depend on supporting feeder services but it is not uncommon to find express buses playing a dual role operating distributor services at either end of the express run.

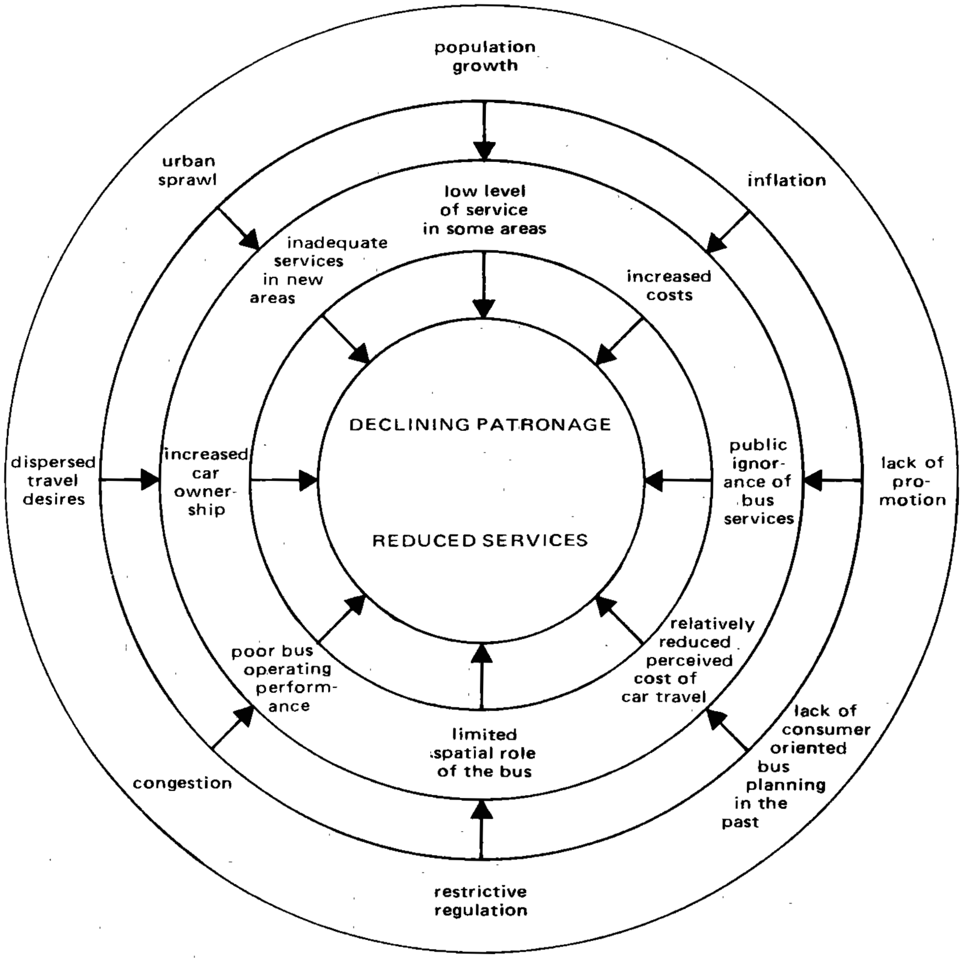
(iv) **Charter.** This role meets the regular and occasional demand for school, military or other group travel.

(v) **Special Services.** There are sectors of the community which have specialised travel needs. Buses can provide personalized door-to-door service for small groups, although minibuses and taxis can often play this role more effectively.

In these roles, buses have a proven record of satisfying large passenger flows. Traditionally, heavy reliance has been placed on bus services to perform the task of transporting people in urban areas. In fact 70% of all public transport users in the United States are bus patrons. However the trend in Australia and U.S.A. of total bus patronage in urban areas has shown a steady decline since the Second World War. Some of the causes of this trend in the private and government bus industries are depicted in the outer ring of Figure C.1. The middle ring illustrates the means by which these causes have induced the resultant effect of declining patronage and the subsequent economic response of operators, the reduction of services.

FIGURE C.1

THE DECLINE OF THE BUS INDUSTRY



This should not be construed as evidence to the effect that buses will not be able to attract, or at least maintain, patronage in the future, but rather that the role of buses will need to change in order to do this. The rationalization of operating regulations and the adoption of new marketing strategies in some urban areas have shown that these trends need not continue.

Investigations in Sydney indicated that the recent economic climate with its increased rate of cost and wage inflation has contributed to the already increasing deficit of government bus operations. On the other hand, for the private bus industry, profit margins have generally increased at a steady rate due to the ability of private operators to respond quickly to changing demand and operating conditions and to reach agreement with unions. These margins have not always provided an adequate return for the capital invested. Established private operators run commercially efficient services within their franchised areas and are well equipped to provide additional services to meet any increase in demand. There would seem little advantage in planning extensions to government bus operations in their present role due to the high cost differential and difficult industrial relations.

A feeling of the need for "rationalization"* improvements within the bus industries has developed from current trends. While rationalization can be considered as a desirable medium to long-term objective, there are many transport improvements that could counteract the current trend and be consistent with this objective. Much criticism can be directed towards the use of financial assistance (and continued government deficit) unaccompanied by transport improvements, which merely sustains an ailing system. In the light of results of overseas experiments, immediate social and operator benefits can be realised from bus transport improvements when they can be developed within a rationalised plan, or as part of the existing transportation infrastructure with a rational objective.

The two extremes of rationalization are:

1. City-wide, rationalization – a long-term, inflexible, capital-intensive option amounting to the formation of one unified (possibly nationalized) bus industry.
2. Mini-rationalization – an optimization of bus stops, routes or headways within local operating areas. Typically this type of localised improvement would have the features of a low cost, small scale, flexible project.

The Sydney Area Transportation Study proposed a rationalization of government and private services using a concept of primary and secondary routes with government-private co-operation in key areas. The main objection to a "hierarchy" of routes is that it would involve passenger transfers which decrease convenience and reliability. However, if the net effect was to improve inter-connectivity of routes and provide better route coverage (or to reduce operating costs), such a proposal could be worthwhile. For Government services, rationalization would minimise the amount of duplication of routes as a cost reduction measure.

Any planned alterations to the existing urban bus networks whether they be in the form of new fares, timetables, routes, facilities or additional buses, will probably involve negotiation with operators, the Bus Proprietors' Association, unions and the regulating authorities. In Sydney the Department of Motor Transport has control over the operations of private bus operators by means of service licences, permits for route deviations, road charges, and allocation of fares.

A major inadequacy of the present bus networks in Sydney is the lack of effective promotion. For most journey purposes and for typical travelling distances in Sydney, the bus (or any other public transport mode) is not at present a real alternative to the car. No matter how poor is the level of service offered by public transport, it is partly the lack of public awareness of routes and time tables that appears to eliminate any consideration of the public transport alternative. Promotion of private and public bus services, as an integral part of the total transport system, is an important aspect of the marketing philosophy once that services have been improved to meet the requirements of the consumer.

C.2 RESERVE LANES

Although bus vehicle capacities and frequencies are generally too low in Australian cities to warrant exclusive rights to road space, there are many opportunities for preferential use of lanes by buses together with pooled car usage, taxis and perhaps commercial vehicles.

* "Rationalization" can be interpreted as an optimal co-ordination of routes, timetables and fleets to meet demand in a system (city-wide) context. It does not necessarily imply an amalgamation of operators.

The "Transit Lane" introduced in North Sydney in November 1974 is a successful demonstration of a priority lane for buses, pooled car usage, and taxis in a situation where peak hour congestion problems were severe. The freight composition of all traffic was low, traffic volumes were typically 21,000 vehicles from 6.30 a.m. to 9.30 a.m. and bus frequencies were as high as 80 buses per hour. Monitoring early in 1975 by the Department of Motor Transport (N.S.W.), identified:

1. A 42% reduction in the average travel time for buses and 29% for "transit lane" vehicles. Travelling times in the other lanes have increased by 8.6%.
2. A marked reduction in the variation of travel time for "transit" vehicles, for example 87% of buses previously took more than 15 minutes with 46% in excess of 25 minutes. In comparison 36% of buses now take more than 15 minutes with none in excess of 25 minutes.
3. A 28% increase of passengers in "transit" vehicles principally from greatly increased car-pooling, although there are some indications of an increase in bus passengers. This is despite a reduction in buses on some services due to maintenance problems.
4. An overall reduction of 15% in the average time spent by commuters (car or bus) on the approaches to the section of road embraced by the transit lane.
5. An increase of only 1% in the combined vehicular traffic volumes over Spit and Roseville Bridges during the study period, compared with an average of 6% for the corresponding periods of the previous three years.

The project has been remarkably successful in providing large overall benefits to the community for a small monetary outlay. A major factor in its success was the existence of a 6-lane road over a long distance. The increase in occupancy of the private cars (28%) shows that people respond to incentives such as transit lanes.

Reserve lanes need not be long. Short lengths of bus lanes in residential areas may give valuable time and distance advantage over other vehicles. Bus lanes allow buses to avoid congestion and other problems associated with large traffic volumes in peak periods and also help to separate passengers alighting or waiting for buses from other road traffic.

On congested freeways and inner urban arterials, significant delays are imposed on buses by other traffic. The low speeds encountered under these conditions also increase bus operating costs. By allocating exclusive use of certain lanes on arterials and freeways, or preferential use of segments of streets within inner urban areas, significant benefits can accrue to buses. Such is the potential of schemes of this nature that over 200 programmes have been initiated throughout the world.

Freeways, or major arterials, carrying large volumes of buses and other traffic, to the CBD are potential candidates for exclusive bus lanes. These lanes can be either with-flow or contra-flow and may, or may not, be separated from other traffic with physical barriers. In some cases the bus lane can be constructed in the median strip of freeways. Another possibility is to construct busways alongside railway lines in unused easement space. Multiple use of this space ought to be considered. Exclusive bus-only streets may be appropriate within major centres where congestion is severe and the conflict between pedestrians and traffic is great. Benefits to bus users and pedestrians may be realised. Delays to other vehicles also need to be assessed if exclusive bus lanes are being considered.

C.3 BUS PRIORITY AND TRAFFIC MANAGEMENT

The aim here is to obtain better use of an existing road network. Where one adopts a philosophy of maximizing the flow of vehicles, or maximizing the flow of persons, much scope exists for obtaining significant benefits. Intersections are a source of major delays to all road traffic, and vehicle operating costs are sensitive to stop-start conditions. Improved signalling techniques at intersections are therefore of much interest. Manual and automatic techniques are available to this end.

The problems of peak-hour bus flow are encountered when traversing congested roads as well as travelling along them. Signal actuation by buses at intersections has been introduced successfully by the Metropolitan Perth Passenger Transport Trust. Signal actuation deserves consideration along with the usual traffic management improvements -- signals, turning bans, parking restrictions, clearways, etc.

C.4 PARKING AND INTERCHANGE FACILITIES

In the **Bureau of Roads Report on Roads in Australia, 1973**, it was suggested that new rapid-rail systems would not attract significant increases in patronage away from the motor vehicle under conditions experienced in Australian cities. More recent work has confirmed this view. If passengers are to be attracted from the car to existing radial rail routes, efforts should be concentrated on easing transfers, making improvements to the access and egress stages of the journey, and improving comfort characteristics of rail travel. Transfers can be eased and bus access/egress improved, by coordinating bus and train timetables, providing passenger protection from the weather while waiting, reducing walking distances between modes, and reducing the number of busy streets to be crossed while making transfers. Access and egress to rail is made by car, bus, bicycle and walk. Improvements to parking facilities at railway stations would improve conditions on the access stage if a car was used. Transfer bays could also be established to encourage "kiss and ride". Bicycle and walk stages of the journey can be improved by eliminating conflict with busy traffic and by providing protection from the weather as far as is possible. Comfort and convenience characteristics of rail travel can be enhanced by improvements that reduce the level of crowding, reduce the amount of time the vehicle is stopped, and improve the reliability of the service.

In all, a total view must be taken of the public transport system with emphasis on integrating services. Improvements to one segment of a trip may not yield significant user-benefits over the whole trip, or for the whole system. The dependence of fixed-route modes on other modes that can provide feeder and distributor services must be recognized. This has been the case in Sydney with the Eastern Suburbs railway where extensive use of buses to provide feeder services via an interchange complex is a feature of the project.

C.5 BUS FACILITIES

For a sufficiently large bus service operating regularly, supporting facilities can be used to reduce walking times to and from buses (e.g. crossings, access paths, car parks, bus interchanges) and to increase convenience of waiting (e.g. seats, shelters).

C.6 IMPROVEMENT OF PASSENGER-CARRYING VEHICLES

Improved vehicle design can play a part in increasing comfort, travel speed, and convenience by measures such as automatic fare collection and increased power/weight ration for new buses. This type of improvement may well be considered for the purchase of a new fleet although it will not stand alone as an effective option in this study.

A standardized bus design code does not necessarily imply that buses will be manufactured in one size. Optimal bus size is an important consideration for new or expanding bus fleets. Operators of minibuses and double-decker buses have been found to incur high ratios of labour costs/passenger revenue due to the small passenger capacities of mini-buses and union enforced two-man operation of double-decker buses in peak hours. Private and government route service operators in Sydney and Melbourne have indicated optimal bus size to be of 40-45 seating capacity (single deck).

Minibus services are best suited to fine route networks in areas of low population density for special purposes. They can provide a high level of service and allow easy vehicle manoeuvrability in situations which would otherwise be limited for normal-sized buses.

C.7 DIAL-A-BUS

Dial-a-bus and other demand responsive buses are aimed at improving accessibility to fixed route facilities and at improving intra-area mobility. Qualified successes have been achieved with such projects overseas, mainly in the U.S. and Canada. In all cases operating subsidies were required, even though fares were high by Australian standards. The overhead burdens are typically great, except in cases where very simplified subscription type services are operated on a small-scale basis, because the facilities for despatching vehicles need to be quite sophisticated. The justification of dial-a-bus, therefore, depends largely upon the social benefits associated with the service. One source of these is the value that can be attached to the improved accessibility of certain transport disadvantaged groups, most notably housewives, the elderly, the handicapped, and the young. Further benefits can be gained if some diversion of work trips to the public transport system occurs, thus relieving congestion on the roads at peak-hours.

Considerable planning effort is required for successful implementation such that dial-a-bus schemes are considered in the first round to be outside the classification of low cost, short gestation period options. Furthermore, limited experience in Australia does not afford the planner a high degree of certainty of success and positive benefits.

APPENDIX D
A METHODOLOGY FOR BUS COSTING*

D.1 INTRODUCTION

This appendix outlines the development of a method for the accurate costing of small-scale incremental bus projects. The approach involves the estimation of the marginal financial cost to the operator and then calculates (by removal of transfer payments) the marginal resource cost. The method should be applicable to operators within the private and government bus industries, although the arguments presented here are based on management policies, operating conditions and the structure of costs in the private bus industry in Sydney.

D.2 DEFINITION OF COSTS

The relevant costs of additional bus services are the financial costs for budgeting purposes, and the resource costs for use in cost-benefit analysis. Several parts of society incur a share of the costs of an incremental improvement to its bus system: operator(s), council(s), the State regulatory authority, the government, residents, bus users and other road users. The largest share of the costs falls on the operator. This methodology considers those costs incurred by bus operators for management, employees and the purchase and operation of vehicles. It does not deal with costs borne by other parts of society, such as the costs of road and signal maintenance, the establishment costs of bus shelters and bus bays, or the social disutilities of noise and the use of residential streets although these may be important parts of the full cost of an improvement. These non-operator costs are best identified after the project has been designed for a particular location.

Costs to the operator may be divided into "operating" and "capital" costs. Operating costs are costs closely associated with the rate of output whereas capital costs are (usually fixed) investments (essentially in vehicles) which relate to the scale of the firm. This classification avoids the confusion of grouping into fixed and variable costs. The relevant time period for this short-term analysis for operating and capital costs is up to five years.

D.3 SOURCES OF COSTING DATA

An itemized account of the total costs of bus operations is usually prepared annually by operators as the sum of monthly accounts plus the annual costs that have been incurred. Such a record is required for taxation purposes, for submission to the State regulatory authority, and for internal review of operations. The operator's annual account is a reliable and useful source of cost information when available in a sufficiently disaggregated form with corresponding fleet characteristics and utilization patterns. Published statistics** are an unacceptable alternative source. They are aggregated over an urban area and do not reflect local operating conditions and individual fleet characteristics.

* This appendix is adapted from R.A. Smith (1976) **Evaluation of Small-Scale Urban Bus Improvements: A Case Study in Sydney**. Unpublished M.Eng.Sc. Thesis, University of Melbourne.

** Such as in the annual reports of the regulating authorities i.e. the Department of Motor Transport in New South Wales and the Transport Regulation Board in Victoria.

Annual accounts are usually available for the most recent financial year. These records represent a history of cash payments for operating expenses (including taxes) and an accountancy interpretation of capital costs itemized as "depreciation" and "interest on capital debt". Unfortunately "reported depreciating figures tell more about the way a firm keeps its books than about the real cost of its capital assets" (Miller 1967). To overcome this problem incremental capital costs have to be calculated by a separate procedure from that for operating costs. Further problems arise in the use of accounting records, the second one being that the data is usually aggregated for all types of services. In costing additional route services, the costs and output resulting from charter, touring and other services should be separated from the cost and operating data on route services, where this is possible. A third problem is that accounting records are several months out of date before they become available and it is often incorrect to base decisions on retrospective information. A forecasting procedure has been developed for updating cost information and is presented in Section D.6.2. A fourth problem is the difficulty of tracing and disaggregating cost components so that their tax proportions can be eliminated. Some assumptions which enable the removal of transfer payments are stated in Section D.9.1.

D.4 REVIEW OF COSTING TECHNIQUES

The standard method for interpreting historical total cost data is through "unitization" (Horngren 1972). It is accepted practice to use average unit costs for long-term evaluation of system effects and large projects. In the context of road-rail competition, Kolsen (1968, p. 52) asserts that "Marginal costs can usually be determined in the form of average unit costs for the marginal 'lump', without doing much harm to precision". Meyer, Kain and Wohl (1965), comparing different modes, estimate bus operating costs using 'annual bus unit-related costs', 'annual bus-mile costs' and 'annual route-mile costs' as measures of average cost.

Managements within the private and government bus industries have until recently used average cost per mile as the basis for costing service changes. This implies that every additional bus mile costs the same to operate as an existing bus mile irrespective of the type and composition of the increment in service output. However some transport economists have suggested that marginal costing is preferable under certain conditions. For example, Webb (1971) proposed a simple model to illustrate the effects of peak distribution of demand and poor back-loading on unit costs. Average unit costs represent all-day operating conditions and cannot be used for costing peak-only improvements. Also Nash (1974a) points out some limitations of the average unit cost approach which he describes as

> "inappropriate where major changes in equipment used or operating methods are envisaged. In particular, it does not allow for greater efficiency of new services than old; nor does it allow for non-constant returns to scale within any of the measures of output adopted".

Certain operating expenses (e.g. administrative salaries) do not vary uniformly with scale so an increment in service does not involve a proportional increase in total costs. Average (unit) costing cannot guarantee accuracy in the short-term evaluation of small projects as it is difficult to allocate historical costs to relevant measures of output so as to reflect the true costs of change.

Regression analysis can be used to improve the allocation of costs by testing the significance of various measures of output in explaining the variation in total costs (e.g. Miller and Rea's (1973) comparison of cost models). Lee and Steedman (1970) and Brown and Nash (1972) used this technique to demonstrate the cost differential of conversion to one-man operation of buses. However, because of the data requirements for this approach and the uncertainties surrounding the cost coefficients, it is preferable to use the deterministic unit cost approach in this study.

The change in total cost associated with a unit increment of service output over a defined period is defined as the marginal cost. It can be higher, lower or equal to the average cost. The use of marginal costing in place of average costing has caused some controversy between operators and planners. In economics, marginal cost "is the appropriate measure to determine whether, given demand, output should be increased . . . or remain unchanged" (Kolsen 1968, p. 31). Marginal costing is, however, not free of criticism since operators argue that revenue and subsidies must contribute to fixed costs. This argument has merit since continuing investment is required in the long term for modernization, replacement and renewal of capital assets, as average costs imply. It is less relevant in the short term and for small-scale increments, nevertheless it is reasonable to attribute the capital cost of new assets to the service increments requiring them and not to all services except when it can be shown that all services are improved by the investment.

In principle, marginal costing should be used to determine the increase in total cost at the margin of expanding the service by a discrete amount involving additional bus kilometres, extra buses and labour (i.e. the incremental cost). Sometimes, average costing may provide information for the same decision to be made on whether or not to increase the service as if marginal costing were used, but the principle is questionable and its accuracy uncertain. This is not to say that average costing is unacceptable in applications other than the short-term evaluation of small-scale projects. Recent literature* does, however, support this *a priori* preference for marginal costing in the context of this study.

A poor alternative to marginal costing based on historical costs is that of "engineering estimates". Nash (1974a) claims:

> "These estimates are obtained by calculating in physical terms the various inputs of labour, capital and materials necessary to run the service and then costing them at expected market prices. Such estimates require much technical information and have a tendency to underestimate overheads and administrative expenditure that would be incurred in practice."

Engineering estimates bear little relationship to existing management policies and are relatively unsuitable for costing incremental improvements.

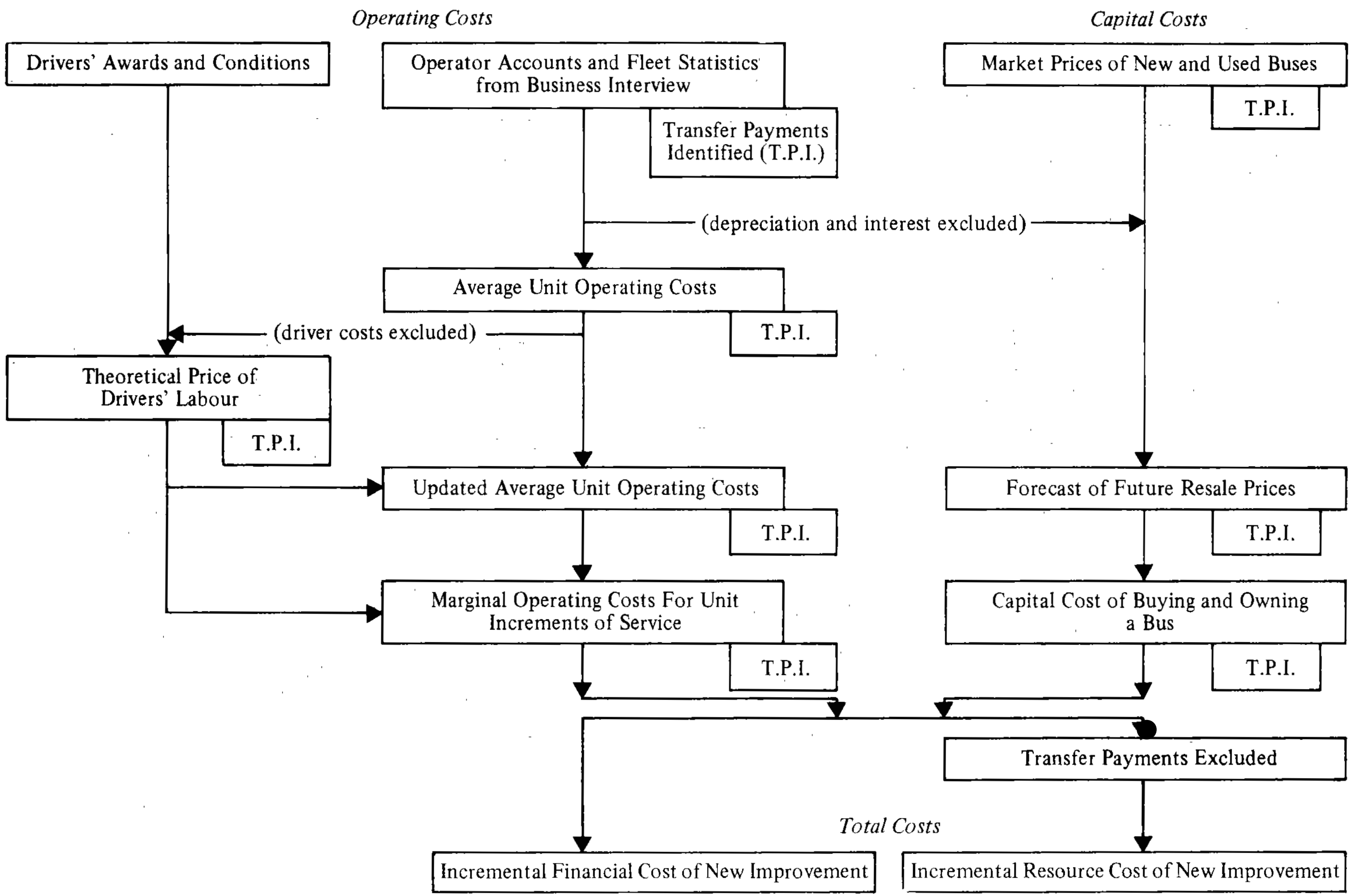
D.5 METHOD FOR MARGINAL BUS COSTING

The method proposed for determination of the incremental costs of small-scale urban bus service improvements is presented in the flow chart in Figure D.1. Operating and capital costs are derived separately. The method of costing relies on several assumptions which are discussed in the following sections.

* Reports into costing of comparatively large government bus undertakings in England by Travers Morgan (1974) and Arthur Andersen (1974) became available following the application of the proposed method, consequently limited comment is provided here. The approach of Travers Morgan is similar to the marginal costing method proposed in that it determines the operating cost at the margin of expanding the total fleet operations by one bus, one crew and additional mileage. For large fleets operating on several routes (which is not the case of most private operators studied here) the Arthur Andersen method of marginal route costing has advantages in some situations since allocation of total costs to a particular route enables decisions to be made in isolation from other routes and the total fleet.

FIGURE D.1

FLOW CHART OF THE METHOD FOR MARGINAL BUS COSTING



Average unit operating costs are found from annual accounting records by excluding depreciation and other capital expenditures. The remaining historical costs are then updated to give present day average operating costs from which marginal operating costs are calculated for unit increments in service at the margin. Marginal operating costs multiplied by the additional units of service gives the incremental operating cost which, added to the marginal capital cost of extra buses, yields the total incremental cost of an expansion. The exercise is undertaken firstly in financial cost. The incremental cost of the improvement (in financial terms) can be expressed algebraically as:

$$C_F = C_{FOP} + C_{FC} \qquad \text{.......... (Equation D.1).}$$

where C_{FOP} is the incremental operating cost and C_{FC} is the incremental capital cost. The exercise is repeated in resource costs by removing transfer payments. The incremental resource cost of the improvement can be written as the sum of the incremental resource operating cost C_{OP} and the marginal resource capital cost C_C, i.e.

$$C_R = C_{OP} + C_C \qquad \text{.......... (Equation D.2).}$$

D.6 OPERATING COSTS

D.6.1 Categorization Of Unit Costs

The relevant measures of service output to use for the purpose of costing increments to existing bus services, are those which explain variations of historical costs and which also relate to the physical characteristics of the proposed service change. The supply aspects* of an increment of service are best described by "additional bus kilometres", "extra buses" and "additional service hours". These are the essential design parameters. The corresponding measures of output which explain variations in existing services are respectively "bus kilometres", "number of buses in fleet" and "paid hours of drivers' labour". Miller and Rea (1973) conclude from a comparison of cost models that a four-variable cost function based on these three variables plus a measure of "annual revenue passengers" explain "virtually 100 per cent of the variation of total costs". "Passengers" are an unsuitable measure of output for service improvements as they are predicted from a demand function and are not a physical design parameter. Also, operator estimates of "passengers" carried on existing services are unreliable and so this is of limited use as a measure of output to which costs may be allocated. There are no obvious advantages in including a service-environment variable (e.g. population, fleet age or speed) since the small differences in operating conditions among firms are difficult to measure.

The assignment of cost items to measures of output is shown in Table D.1 and the average operating cost function can be written as

$$C_{AOP} = X.A + Y.B + Z.C \qquad \text{.......... (Equation D.3).}$$

where C_{AOP} is the total operating cost, X is the cost per bus kilometre, Y is the average cost per bus, Z the average cost per hour of drivers' labour payable, A is the annual bus kilometres, B is the number of buses in the fleet and C is the annual hours of drivers' labour. This assumes that all cost items are variable or at least partly-variable. The number of buses in the fleet, B, is necessarily those buses in operation and not idle or spare buses which do not contribute to operating costs. In the private bus industry it may

* Conversely the demand characteristics of a service increment can be explained by "seat-kilometres", "passenger-kilometres" or "passengers" which are useful for investigating bus sizes and busway flow capacities.

be assumed that the buses operating include the total fleet of route, school, charter and touring buses as none of these are usually permanently out of service. This situation is different from that of the government bus industry in which significant proportions of most fleets are permanently out of operation for maintenance purposes. Costs would then be allocated to the operable proportion of the fleet which is usually the number of buses in peak-hour service when demand is greatest.

TABLE D.1

ASSIGNMENT OF COST ITEMS TO SERVICE OUTPUT MEASURES

Cost Item	Bus Kilometres	Buses	Hours of drivers' labour
Fuel and oil	x		
Tyres and tubes	x		
Maintenance and parts	x		
Registration and licences		x	
Insurance		x	
Depreciation and interest		(x)	
Hire and lease		(x)	
Office and sundries		x	
Mechanics wages		x	
Administration		x	
Rates and rent		x	
Drivers			x
Payroll tax			x

* Brackets indicate that these capital costs are separated from operating costs.

Fuel and oil, tyres and tubes, and maintenance are assumed to be directly related to the annual bus kilometres. It could be argued that some components of maintenance such as the cost of spare parts are more a function of the number of buses than of bus kilometres, but for the sake of avoiding untraceable costs this item is apportioned *in toto* to annual bus kilometres.

Licences, registration and bus insurance are payments made for each bus. Depreciation and interest on buses are per-bus costs rather than kilometre related costs since "evidence suggests that the lives of buses . . . are governed more by age and obsolescence than by utilization" Nash (1974b), however these and other capital costs are excluded from the operating cost function (i.e. Equation D.3). Private bus operators interviewed in Melbourne and Sydney believed that mechanics' work (and hence wages) is more closely correlated with the number of buses in a fleet than the bus kilometres travelled. Management and clerical staff salaries, office expenses, rates and rent on land and buildings vary *inter alia* with fleetsize for which "number of buses" is a good surrogate.

D.6.2 Forecasting Operating Costs

The need to forecast costs arises when historical costing information does not coincide with the project base year for budgeting and cost-benefit analysis. The relative proportions of operating cost components have changed over recent years. Labour costs are inflating at a greater rate than non-labour operating components, due to the compounding effect of contingencies on award rates. As labour costs constitute more than 40 per cent of total costs, it is important that updated values be used.

Standard forecasting procedures which assume a continuous smooth trend of costs based on appropriate economic indicators are suitable for adjusting historical values. The Department of Motor Transport (New South Wales) proposed a set of forecasting indices for assessment of operating cost variations over time. These serve as examples and are shown in Table D.2.

TABLE D.2

FORECASTING INDICES FOR BUS OPERATING COSTS: SOME EXAMPLES

Cost Item	Base Index
Wages – Drivers, Conductors and Inspectors	Award Rate – Bus Driver
Wages – Mechanics	Award Rate – Mechanic
Salaries – Office Staff	Award Rate – Senior Female Clerk
Salaries – Manager	Award Rate – Senior Female Clerk
Petrol and Diesoleum	Wholesale price of diesoline
Lubricants	Wholesale price of oil
Maintenance, Parts	Consumer Price Index
Tyres and Tubes	Retail price of 8.25 x 20 12-ply new tyre
Work Let Out	Hourly labour rate-Motor Traders Assoc.
Interest	Bank interest rate
Other Expenses	Consumer Price Index

Source: Adapted from Bus Proprietors Association (1974, pt. 4).

Historical costs collected over a financial year, say 1973/74, can be assumed equivalent to a single payment in the middle of that year, i.e. 31 December 1973. Costs may then be updated from 31 December 1973 to the base point of time for evaluation using appropriate indices such as those shown above. The updated average operating cost function is thus:

$$C'_{AOP} = X'.A + Y'.B + Z'.C \qquad \text{.......... (Equation D.4).}$$

where C'_{AOP} is the updated total operating cost, X' is the updated average cost per bus-kilometre, Y' the updated average cost per bus, and Z' is the updated average cost per hour of drivers' labour.

D.6.3 Marginal Costing

Having derived updated average unit costs for existing bus operations, the next task is to define how these are affected by changes at the margin. Marginal costs equal average costs when unit expenses are constant with scale and time. However, most components are non-constant at the margin. The incremental operating cost (C_{FOP}) is given by the equation,

$$C_{FOP} = (X' + \frac{A.\Delta X}{\Delta A})\Delta A + (Y' + \frac{B.\Delta Y}{\Delta B})\Delta B + (Z' + \frac{C.\Delta Z}{\Delta C})\Delta C \qquad \text{........ (Equation D.5).}$$

where (ΔA, ΔB and ΔC) represent the additional measures of output associated with the improvement and $X' + \frac{A.\Delta X'}{\Delta A}$, $Y' + \frac{B.\Delta Y'}{\Delta B}$ and $Z' + \frac{C.\Delta Z'}{\Delta C}$ are the respective marginal operating costs which are discussed below.

D.6.3.1 Bus-kilometre Related Costs At The Margin

Fuel and oil costs per kilometre for an additional bus having the same fuel consumption, mechanical efficiency and operating conditions as an "average bus" in an existing fleet are the same as the average fuel and oil costs. Kilometre related unit costs vary with a number of operating characteristics including:

(a) Speed,
(b) Number of stops per kilometre,
(c) Road surface condition,
(d) Hilliness,
(e) Size, type and age of bus, and
(f) Driver performance.

Cost variations due to changes in operating performance are complex and difficult to assess. Increased costs due to poor road surfaces may, in any case, be offset by higher-than-average speeds, or fewer stops per kilometre. The cost-performance relationships for buses are virtually unknown so there is no alternative but to neglect the cost effects of most of the operating characteristics above. Only two relationships can be considered:

(a) **Fuel cost versus bus type.** Many operators have reliable measures of fuel consumption for each type of bus in their fleets. When considering the fuel costs due to an extension of service, actual fuel consumption figures for the particular busy types may be used. The marginal fuel and oil cost can be approximated by the expression:

$$\left(\frac{\text{Fuel consumption of new bus}}{\text{Average fuel consumption for fleet}}\right)\text{(Average fuel cost)}$$

when the oil component of the cost is small.

(b) **Fuel cost versus average speed.** This is useful for measuring the effects of congestion and traffic delays on operating costs. A recent study shows the variation of fuel consumption costs with speed for different types of vehicles. Fuel savings for buses can be approximated by the results for a two-axle utility. Fuel saved as a result of large reductions in traffic delays (as measured by increases in average speed) are likely to be substantial (See Table D.3). For example, 1½ minutes operating time saved per kilometre achieves a 23 per cent reduction in average fuel costs. Small speed changes can be neglected as other factors come into play.

In the absence of any alternative evidence, it can be assumed that the costs per mile of tyres, tubes, maintenance (excluding labour) and parts do not vary with the number of additional bus kilometres travelled. This implies that there are no changes in operating performance nor any new discounts for bulk purchases.

D.6.3.2 Costs Per Bus In Operation At The Margin

Registration charges are set according to vehicle weight or power so conventional sized new vehicles have the same registration cost as old vehicles. Service licence fees are proportional to the number of buses licensed to the marginal cost can be assumed equal to the average cost.

Insurance premiums for third party and public risk are the same for all buses of similar specification irrespective of age whereas the vehicle comprehensive insurance is approximately proportional to the value of a vehicle. It can be assumed that the marginal insurance cost for a new bus equals the cost for an average bus in service if a vehicle comprehensive contract is not included.

TABLE D.3

MARGINAL FUEL COST VERSUS SPEED

Average Speed		Fuel Consumption (litres/100 kilometres)	Percentage Fuel Saved	Ratio of Marginal Fuel Cost to Average Fuel Cost
k/hr	minutes/ kilometres			
18	3.41	2.9	−10.8	111%
21 (existing mean)	2.89	2.6	0	100%
24	2.50	2.4	+ 9.5	90%
27	2.21	2.1	+17.5	82%
30	1.98	2.0	+22.9	77%
34	1.79	1.9	+27.0	73%

Source: Extracted from Australian Road Research Board (1973) results for a two-axle utility with comparable power/weight ratio as a bus.

Administrative salaries do not increase uniformly with scale in bus operations. For most services the addition of one bus to a fleet requires little extra administration. In this case, the marginal cost is small (although rarely zero). The addition of five buses is likely to require less administrative expense than the previous five buses, due to some under-utilization of existing staff. The actual incremental variation in costs is most accurately estimated by the individual operator, since it depends on the size of establishment and existing utilization patterns of staff.

Office expenses and mechanics' wages are also expected to show marginal savings with small increases in fleet. The amount of mechanical work required for bus maintenance varies with the age of a bus. It was found that a new bus in one operator's fleet required only about one third of the mechanical work needed for an average bus during its first three years of service but on the other hand an old bus may require considerably more than average maintenance. The relevant information can be acquired by asking operators how many extra mechanics would be required to maintain 1, 5, or say 10 additional new buses and then costing at updated average rates.

D.6.3.3 Cost Per Hour Of Drivers' Labour At The Margin

Accurate calculation of drivers' labour costs is important because these costs could constitute as much as 80 per cent of the marginal operating cost of peak hour service improvements. The financial cost of employing drivers is determined by two factors:

(a) wage determination based on awards and rostered hours; and

(b) indirect costs – payroll tax, workers compensation, sick leave, annual leave.

To supply the labour needed for increased services, an operator would normally choose one or more of the following alternatives:

(a) make better use of existing drivers by scheduling changes;

(b) increase the overtime worked by existing drivers; or

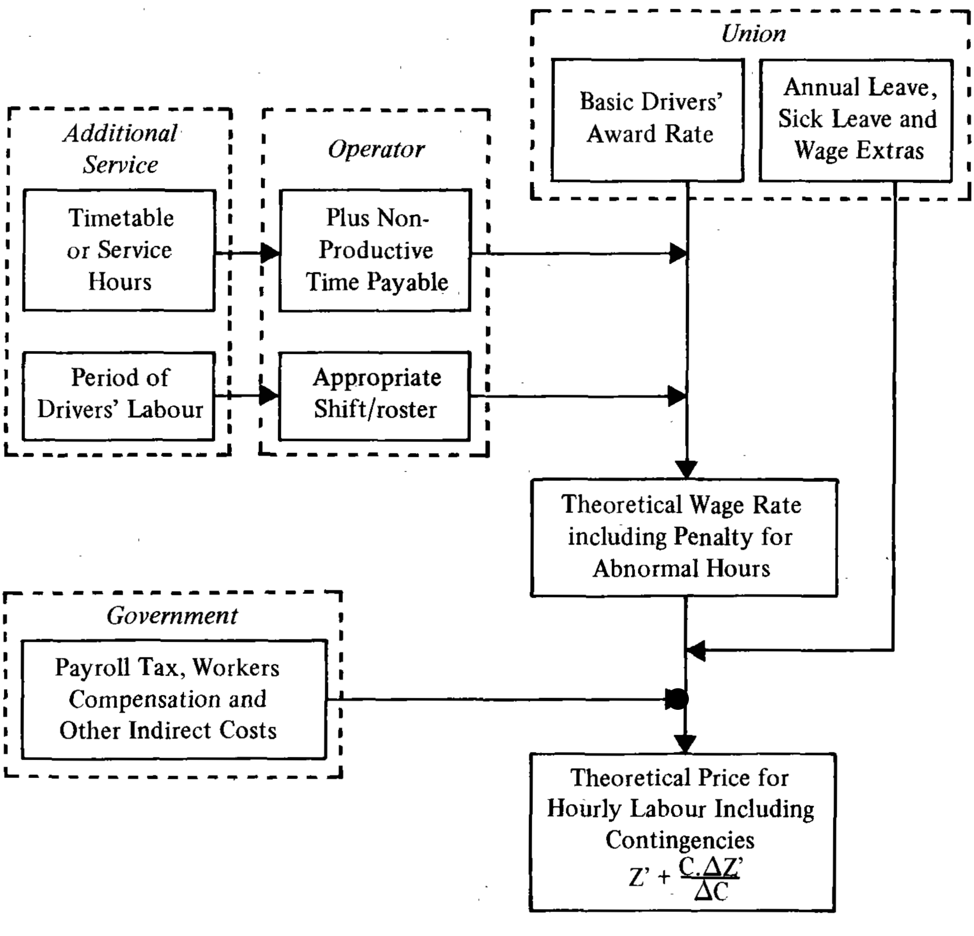
(c) employ additional drivers.

The choice is governed by existing driver utilization patterns and the scale of the service improvement. Complexities of manpower scheduling necessitate that marginal drivers' wages be calculated independently of any rostering procedures if this method for bus costing is to be kept reasonably simple. A theoretical pricing approach is proposed so that the cost of drivers' labour can be calculated without the need to investigate actual roster combinations of drivers and hours. The procedure is shown as a flow chart in Figure D.2.

An operator's choice is simulated by considering the additional drivers' hours in a straight, broken, or other particular type of shift and pricing at the respective award rates including shift allowance, margins and penalty loadings. The total hours of labour payable consist of the time spent in service and the "non-productive" starting, finishing and meal times in accordance with conditions of the drivers' award. The type of shift must be compatible with existing rosters and suitable to the arrangement of new service hours. This yields a theoretical wage rate for drivers employed on a service in the respective period; peak only, all-day or off-peak. To this wage rate is added the normal contingencies which constitute the gross cost of employing drivers. For a normal all-day service extension, the historical driver costs can be used to reflect scheduling efficiency through existing penalty loadings with respect to the award rate. However, historical data for all-day operations cannot be used to cost peak-only or off-peak increments.

FIGURE D.2

FLOW CHART FOR CALCULATION OF MARGINAL DRIVERS' LABOUR COST



The procedure does not take into account the difficulties of rostering additional numbers and arrangements of hours. It assumes that labour can always be scheduled efficiently by operators. For example, the theoretical price for additional drivers' labour in peak periods does not include any non-peak charge although in practice the driver may be employed on a straight shift. In this case, it is assumed that the non-peak cost is recouped from the benefits of his productivity (as a driver, mechanic, or cleaner) outside the peak period. The theoretical price for hourly labour approximates the marginal cost of employing drivers for any given period of the day independent of information about the roster that is actually used. Small errors may therefore arise due to under-estimation of the marginal cost when effective use cannot be made of labour which has to be employed on shifts longer than the required hours. This synthetic approximation may be unacceptable for government bus operations in which union awards prohibit the use of drivers for other duties.

D.7 CAPITAL COSTS

D.7.1 Decline In The Value Of Assets Over Time

Since small-scale improvements do not usually warrant further investment in land, buildings and depot facilities this discussion is confined to capital costs of buses. When an improvement requires an operator to provide additional capacity it is most common for him to purchase new buses. From discussions with operators it was found that the purchase of used buses and lease/hire arrangements are not as likely and therefore are not discussed. Grants are not available (in New South Wales) so it is assumed that purchases are financed by the operator. The cost of a new bus is attributed wholly to the improvement except where secondary benefits are derived from use of the bus for other services. For example, where the buses are purchased for an extended peak service, and there are already buses underutilized in the off-peak, the capital costs are allocated wholly to the new peak service.

Capital costs for a short-term project constitute the costs of owning and using buses. The decline in value of a bus which is its loss of usefulness may be caused by:

(a) obsolescence due to quality improvements on later models,

(b) age deterioration, the loss of utility due to natural causes necessitating increased maintenance, and

(c) wear from kilometre-related usage and tear from environment-related usage.

Depreciation based on taxation schedules gives an untrue approximation to average decline in value of vehicles for the reason given earlier in Section D.3. Also the average depreciation and interest allowances for existing buses in a fleet averaging several years old are not good substitutes for the capital cost of a new bus, particularly in times of high bus price inflation. Furthermore, depreciation may contain profits if there is wide-spread use of rapid write-off procedures and other devices to overstate capital consumption (Wells *et al.* 1972, p p. 3-11). Amortization and annuitization techniques which presuppose a definite life span also seems difficult to justify as an accurate measure of the actual cost of owning a bus for a short term. Given the active market for second hand buses, market valuations are expected to give a more reliable estimate of the decline in the real worth of buses over the first 5 years of use. The need to assume a relationship between value of a bus and its age, kilometres or life span is eliminated.

D.7.2 Method Of Calculating Capital Cost

The net capital cost of a bus over a period of between one and five years is thus defined as the purchase price less the resale price at the end of the project discounted to present values. This approach requires the prediction of future resale prices.

The future resale price for a particular bus model could be determined by simply asking vehicle dealers for subjective estimates based on their experience or from a survey of second-hand prices in relation to new prices and assuming a similar relationship for the future. The latter method relies on the assumption that the future rate of decline of second hand prices as a proportion of new bus price equals the past rate of decline with respect to past prices of new buses, implying a stable supply and demand. The relationship of second hand prices to new prices is largely a function of inflation of new bus prices. To obtain a general rate for the decline in value of buses, the survey of second-hand prices should be restricted to used buses that (a) have not experienced more than one change of ownership* and (b) have a normal history of utilization and maintenance. Both methods can be used jointly.

D.8 FINANCIAL COST OF AN IMPROVEMENT AND INFORMATION REQUIREMENTS

The incremental financial cost used in budgeting or financial analysis of an improvement comprises marginal operating and capital costs as given by Equation D.1. The proposed method for marginal costing necessitates collection of information relating to fleet composition, employees, service performance characteristics, existing efficiency measures, assets and resources required for increments to services, drivers' awards and conditions, and new and second hand bus prices to supplement the annual accounts. A questionnaire was designed to formalize the collection of information from operators (Appendix E). Drivers' awards and used bus prices may be obtained independently from the relevant sources.

D.9 RESOURCE COST OF AN IMPROVEMENT

A financial cost can be considered to have two components, a real resource cost and a transfer payment. The resource cost is a measure of the net cost to the nation of additional resources consumed irrespective of who pays for them. It is the value of resources in their alternative use. It generally excludes transfer payments between individuals when these do not reflect the value of the marginal benefits that can be gained from the commodity purchased. Divergences between prices and resource costs in the transport sector derive principally from taxation. For instance, the price of petrol is made up of the production cost (resource cost including normal profit) and fuel excise charged by the government (transfer component).

D.9.1 Resource Costs And Transfer Payments

In the literature there is a consensus that taxes should be excluded from resource costs when these do not represent a real cost to society:

> "taxes, although they represent a cost to a private concern, are not a cost from a social point of view. Consequently they are properly left out of the cost-benefit analysis of alternatives" (Marglin 1962, p. 210).

* Buses do not usually change ownership more frequently than once in their first years of life.

"If taxes are transfers and not real costs, then the fact that the government can affect their magnitude and incidence at will cannot make them any less relevant than they already were. By assumption one is not interested in the tax changes resulting from a project, not even the net effect on government revenue, but on the real effect, however this is shared between government and the rest of the community" (Foster 1973, p. 65).

"Market prices will, in practice, contain elements of direct taxation, or, alternatively, may be below the true cost in so far as the product is subsidized. Where a product is highly taxed, the use of unadjusted market prices will exaggerate the maximum benefits, while the benefits of a subsidized product would be undervalued. To correct for these biases, all outputs should be valued net of indirect taxes and subsidies, i.e. at 'factor cost'" (Dasgupta and Pearce 1972, p. 107).

"Transfer payments are nevertheless usually netted out of the consumers' surplus calculations, i.e. all benefits and costs are calculated net of transfer payment, subject to the restriction that the term transfer payment is reserved for government revenue (or expenditure in the case of a subsidy) and not applied to other private sector rental elements, e.g. other factors owners' surpluses. The rationale behind this procedure is that any net change in government revenue merely 'transfers' benefits from one set of beneficiaries (transport purchasers) to another, i.e. the government uses this revenue for the benefit of other consumers, with the result that no net change in consumers' surplus takes place, except insofar as a change in the distribution of income itself gives rise to some benefit. Alternatively, it can be argued that, since the overall incidence of government taxation is likely to remain the same, a project which alters the government's tax income will merely transfer part of the tax burden from one set of consumers to another" (Heggie 1972, p. 22).

There are, however, exceptions to this general principle that transfer payments should be excluded to measure the costs (and effects) of re-allocating resources due to a project*. A different treatment applies when a tax acts as an efficient price for a service rather than as a legal surcharge (government surplus) or when tax revenue represents a real gain to society**. Practical difficulties also arise in tracing tax components of secondary inputs (e.g. tax on materials used by a bus repair organisation). The rule generally adopted is that taxes on indirect inputs are not excluded from resource costs as their effect is small.

D.9.2 Treatment Of Transfer Payments

The respective arguments for the treatment of transfer components need to be assessed separately for the different categories of cost. The salient issue to decide is to what extent elements of tax, subsidy, duty, rental, excise, toll and levy can be regarded as a price. The criterion adopted in this study is that the marginal resource cost shall be the identifiable resource flow into the project, including or excluding taxes as the case may be. Hence taxes should be removed when they are not part of the cost of achieving a marginal gain in productivity. Where resource costs are obtained by removing transfer payments from market prices, those prices should be free of monopolistic influences (such as excessive profits), otherwise corresponding shadow prices should be imputed.

* See Stanley and Nash for the treatment of taxes in benefits for generated and diverted traffic.

** Foster (1973) offers a fuller exposition of the arguments for and against removal of transfer payments.

This rule is open to different interpretations according to a definition of the physical bounds of the society for which the analysis is being performed. The general accepted view is that "cost-benefit analysis is undertaken on behalf of the nation at large, and is designed to capture the benefits and losses accruing to all groups in the nation" (Mishan 1971, p. 67). The national frame of reference is adopted here for ensuring consistent treatment of transfer payments. The treatment may differ if resource costing were carried out on behalf of a state or a subset of Australian society.

Some reasoning for the inclusion or exclusion of transfer payments in typical operating cost items is given in Table D.4. By making the suggested adjustments to the financial costs of Equations D.4 and D.5, two corresponding resource cost functions are developed. The first is the average operating resource cost function:

$$C'_{OP} = (X')(1-t_x)A + (Y')(1-t_y)B + (Z')(1-t_y)C \qquad \text{..........(Equation D.6).}$$

where C'_{OP} is the updated total operating resource cost and t_x, t_y, t_z are the proportions of transfer payment in X', Y', Z' the updated average operating resource costs per unit respectively. The second is the marginal operating resource cost function:

$$C_{OP} = \left(X' + \frac{A.\Delta X'}{\Delta A}\right)(1-t_x)\,\Delta A + \left(Y' + \frac{B.\Delta Y'}{\Delta B}\right)(1-t_y)\,\Delta B + \left(Z' + \frac{C.\Delta Z'}{\Delta C}\right)(1-t_z)\,\Delta C$$

$$\text{..........(Equation D.7).}$$

where C_{OP} is the updated incremental operating resource cost and t_x, t_y, t_z are the transfer payment components* of $X' + \frac{A.\Delta X'}{\Delta A}$, $Y' + \frac{B.\Delta Y'}{\Delta B}$, $Z' + \frac{C.\Delta Z'}{\Delta C}$ the marginal operating resource costs respectively.

Further explanation of the treatment of transfer payments in the costs of capital assets is offered in Table D.5. The notion of resource cost for used buses is fictitious and deserves further comment. Consider the decline in market value of a new bus from its initial purchase price P (Figure D.3).

FIGURE D.3

NOTIONAL RESOURCE COST OF USED BUSES

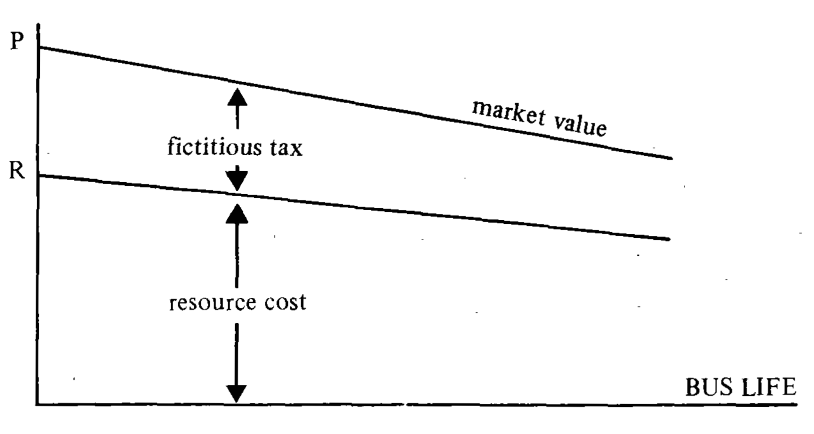


TABLE D.4

TREATMENT OF TRANSFER PAYMENTS IN TYPICAL OPERATING COST ITEMS

Resource	Resource Cost is Set Equal to:	Explanation
Fuel	competitive market value less fuel excise	Fuel excise as a transfer payment is netted out of the fuel price. Market value should not be influenced by monopolistic controls otherwise these may contain non-competitive profits. This requires many buyers and sellers.
Tyres and Tubes	market value less sales tax	Sales tax is a pure transfer to government so it is also excluded.
Maintenance and Parts	financial cost less the estimated sales tax on parts	The financial cost paid by the operator includes an element of sales tax on parts used directly in the bus service. This element is a pure transfer. External service charges consist of prices for labour and parts however taxes on these secondary inputs can remain in the resource cost as they are negligible.
Registration and Licences	0	When these fees are non-hypothecated they do not constitute a price. A proportion of the fees is usually hypothecated to the transport sector as a contribution to the costs of improvements. As such, this proportion of the average price represents a resource cost. However, the marginal effect of fees collected from small-scale improvements on social welfare (benefits) is negligible (assumed zero) hence registration and licence fees are treated as pure transfer payments.
Bus Insurance	financial cost	It is assumed here that the marginal resource cost of insurance equals the average price paid by bus operators. The average price of insurance represents an average provision for repayment of accident and injury claims. It is set according to the amount of cover (risk aversion) and the number of past claims. To the operator it represents security of future accident payments. It can therefore be considered a resource cost. The marginal effect is unknown and there is no meaningful alternative other than to assume it is equal to the average.
Rent for Buildings or Land	financial cost	Resource cost equals financial cost where this is the opportunity cost of using an alternative site and where the capitalized rent reflects the change in value of the site as a result of its use.
Labour (employed)	gross wage i.e. net wage PLUS income tax, PLUS indirect-wage costs	Income tax is not removed from labour cost because productivity is measured by gross wage rather than net wage. For instance, if the income tax scale changes, labour output (as measured by gross wage) remains unaffected. Bonuses, indirect wages and other awards are considered measures of productivity and are included in resource costs.
Payroll Tax	0	Payroll tax contributes not to society's output but to government surplus and is not a measure of resource consumption since the same work output is achieved for a given wage bill whether or not payroll tax is paid.

TABLE D.5

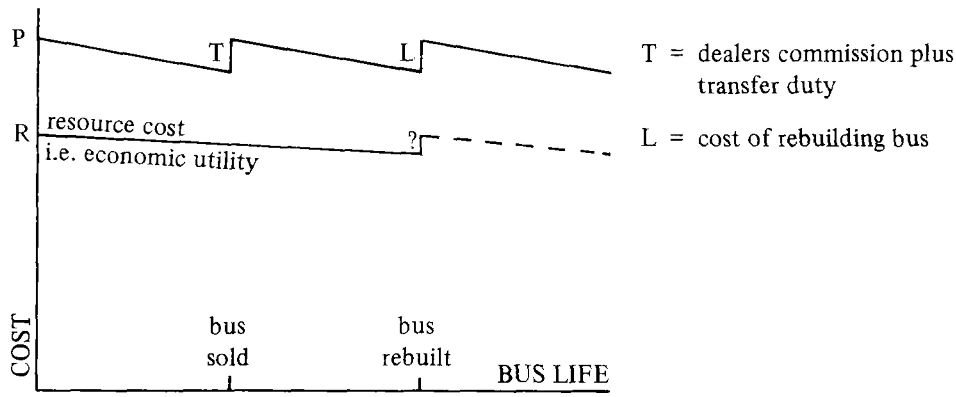
TREATMENT OF TRANSFER PAYMENTS IN CAPITAL COSTS

Capital Asset	Resource Cost is Set Equal to:	Explanation
New Buses	purchase price less import duty (27½% of the chasis) less Sales Tax (0) & Stamp Duty (2½%)	It is the landed price in Australia less the government surplus (import duty) which reflects the resource cost to the Australian society. These are excluded when non-hypothecated. Private operators are exempt from Sales tax on new buses.
Used Buses	market resale value less proportion of duties which apply to new buses	The economic utility (resource cost) of a bus is assumed a constant proportion of the market values hence a "fictitious proportion of tax" is removed from used bus prices to give a pseudo resource value (see text).
Land for bus lanes, parking areas, or bus bays	market value	When a site is destroyed, converted or filled its users presumably benefit and therefore must pay for its use (via the purchase price). Transport – land use interaction should be considered when property values are directly affected.
Depot land	change in market values over the duration of the project	Transaction is entirely a transfer payment (i.e. change of title) if no change in use or benefits is realizable from the land. The resource cost equals the depreciation or appreciation of land due to scarcity or reusability.
Way Facilities shelters signs or signals	market value	Sales tax on inputs to construction are indirect and are therefore not excluded from resource costs.

The tax element of the purchase price is removed to give the resource cost of the new bus, say B. It is argued that the utility of the bus as an economic resource would diminish over time due to age, absolescence and usage at a rate equal to the rate of devaluation of market values, i.e. the ratio of market value to resource cost is constant over time. This implies that if all taxes on new buses were abolished their used market values would decrease proportionally (to equal their resource cost). This appears to be the most logical assumption. Complexities arise: firstly, when a bus changes ownership and its market price is boosted by the dealer's commission plus government transfer duty, while the utility (resource cost) remains unchanged; and secondly, when buses are either rebuilt or undergo major maintenance expenditure which increase both their market value and economic utility (See Figure D.4). The latter case should not be encountered within the first 5 years of bus life which is the concern in this study.

FIGURE D.4

CONCEPTUAL DIFFICULTIES: LIKELY EFFECT OF BUS SALES AND BUS REFURBISHING



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APPENDIX E
PRIVATE BUS OPERATIONS SURVEY
MARCH 1975

OPERATOR ____________________

CONTACT ____________________ PHONE __________

ADDRESS ____________________

BUSES

1. How many buses are there in the fleet including spares? ________

2. Maximum number of buses on route and school services in peak periods? ________

3. Maximum number of peak route buses (excluding school buses)? ________

4. Of the remaining buses, how many are available for all day charter?

   TV plates ________ Other ________

5. Excluding charter buses what is the approximate number of buses on the road at various times of the day?

Weekday	6.00 a.m.	________
	8.30 a.m.	________
	11.00 a.m.	________
	3.30 p.m.	________
	5.00 p.m.	________
	8.00 p.m.	________
Saturday		________
Sunday		________

EMPLOYEES

6. Total number of employees in the bus service? ________

7. Number of full-time drivers? ________

8. Number of mechanics and depot workers? ________

9. How many of the mechanics and depot workers also drive buses? ________

10. Number of office staff and management? ________

PASSENGERS AND RUNNING SPEEDS

11. What is the average speed of buses on route service?________

12. What is the average number of stops per mile?________

13. Average number of seats per bus?________

14. Average number of passengers on a school bus?________

15. Average number of passengers on route buses at various times of the day?

Weekday	6.00 a.m.	________
	8.30 a.m.	________
	11.00 a.m.	________
	3.30 p.m.	________
	5.00 p.m.	________
	8.00 p.m.	________
Saturday		________
Sunday		________

DRIVERS

16. What is the average time spent by drivers in the depot each day?________ minutes.

17. What is the average dead running time per driver each day?________ minutes.

18. **In one hour's running**, how much turnaround time is "lost" by a bus at the end of its route? Peak________ minutes, off-peak________ minutes.

19. What is the total weekly wage for an average driver on school and route services?

    $________ per week.

20. Including overtime, weekend and other (e.g. "TBC") shifts, how many hours does the average driver work each week?

    during school term ________ hours

    during school holidays ________ hours

FLEET

21. List the types of bus in the fleet and number, age and miles per gallon (mpg).

Make	Model	No. of buses	Average age	Mpg.

22. Average miles per gallon for the fleet__________ mpg.

23. Average age for all buses in the fleet__________years.

24. If more buses were needed in your fleet for route operations which type would you choose?

    1st preference, make ______________ model______________

    2nd preference, make ______________ model______________

25. If you required another bus in peak period, do you own a spare bus that could be used? YES/NO.

REQUIREMENTS FOR INCREASES IN FLEET

26. If the fleet was increased by 1, 5 or 10 extra buses operating on route and school services, how many extra employees would be required?

	1 extra bus	5 extra buses	10 extra buses
No. of extra drivers required			
No. of extra mechanics and depot workers			
No. of extra office staff			

27. How many extra buses could be added to the fleet before new depot buildings would be required?__________

28. How many extra buses could be added to the fleet before new depot land would be required?__________

29. ANNUAL OPERATING COSTS AND STATISTICS

For the financial year 1973/74

	1973/74
Wages – drivers	
– mechanics and depot staff	
– office and management	
Payroll tax	
Fuel and oil	
Tyres and tubes	
Maintenance – parts and outside work	
Registration and service licences	
Insurance	
Depreciation	
Hire and lease of vehicles	
Rates and land taxes	
Office and miscellaneous expenses	
Other	
Total expenses	
Total revenue	
Net profit	
Miles	
Number of buses	
Passengers carried	