EFFECTS OF PUBLIC TRANSPORT SYSTEM CHANGES ON MODE SWITCHING AND ROAD TRAFFIC LEVELS

Transfund New Zealand Research Report No.179

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Transfund New Zealand Research Report No. 179

ISBN 0-478–11586–5
ISSN 1174–0574

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Booz ·Allen & Hamilton, 2000. Effects of public transport system changes on mode switching and road traffic levels *Transfund New Zealand Research Report 179.* 48 pp.

Keywords: mode switching, urban public transport,, traffic volumes, diversion rates

An Important Note For The Reader

The research detailed in this report was commissioned by Transfund New Zealand.

Transfund New Zealand is a Crown entity established under the Transit New Zealand Act 1989. Its principal objective is to allocate resources to achieve a safe and efficient roading system. Each year Transfund New Zealand invests a portion of its funds on research that contributes to this objective.

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Executive Summary

1 The Project

This report summarises the results of a research project to appraise international evidence on the effects of changes in urban public transport systems and services on the extent of mode switching to/from car travel and on road traffic volumes, and to develop guidelines for use in the evaluation of urban transport projects in New Zealand.

The project's objectives were, for situations where changes are made to the public transport system:

to obtain and review international evidence on the 'diversion rate' between public transport usage and car driving (i.e. the proportion of additional public transport trips that would otherwise be car driver trips)

- to obtain and review international evidence on the effects on overall road traffic volumes
- in the light of this evidence, to develop recommendations on the most appropriate 'diversion rates' for New Zealand's major urban centres; and to comment on the relative merits for project evaluation of using such 'diversion rate' proportions as against undertaking case-specific surveys.

The project's findings were designed to be used in assessing the inter-modal effects of urban public transport measures, including in the application of multi-modal urban transport models and in evaluation of existing public transport services, service improvement and new services.

2 'Diversion Rates' – International Review

The major part of the project investigated the international evidence on 'diversion rates' relating to urban public transport system changes: the 'diversion rate' was defined, for cases where the public transport system is improved, as the proportion of additional public transport person trips (on the improved services) that would previously have been car driver trips.

It assembled and appraised the international evidence on 'diversion rates', mainly from Europe, USA and Australia. This evidence was categorised by the type of public transport change, i.e. major public transport projects, service enhancements, fare changes and other project types.

It was found that the 'diversion rate' varied by country, dependent on initial mode shares, car availability, urban density, alternative modes and other factors. Within a given country, similar diversion rates applied to major new projects, service enhancements and general fare changes; but with higher rates for projects particularly oriented to motorists and with lower rates for projects with a more 'social' focus.

3 Diversion rates - recommendations

In the light of all the international evidence, a standard car driver 'diversion rate' in the range of 35%-40% is recommended for use in New Zealand urban/metropolitan centres. This should be regarded as a base value, for application in 'standard' conditions. It would be generally appropriate for major public transport development projects, most service enhancement projects and general fare changes.

For 'non-standard' conditions, no specific percentage value is recommended, but the following guidance is provided:

- For public transport projects particularly oriented to motorists, higher than standard diversion rates will be appropriate. This would include Park & Ride projects (diversion rates typically 70%+) and express bus services (diversion rates typically 50-75%).

- For public transport projects with a more 'social' focus, lower than standard diversion rates will be appropriate. This would include off-peak fare schemes and service routes (diversion rates typically 20-30% in both cases).

Recommendations are also made, in the context of the evaluation of urban passenger transport projects, as to when the recommended diversion rate proportions might be applied on their own, and when they should be supplemented or replaced by case-specific surveys (typically using stated preference methods).

4 Road Traffic Effects

The international evidence found that major public transport projects can have significant effects on modal shares and road traffic, with between 2% and 10% of motorists in the corridors affected switching to public transport. However, in practice, surveys have rarely been able to detect significant changes in overall road traffic volumes: the extra road capacity made available as a result of the mode switching appears to be taken up by additional car traffic (through additional trip generation, changes in the time of travel and changes in routing).

Abstract

A research project was undertaken to appraise international evidence on the effects of changes in urban public transport systems and services on the extent of switching to/from car travel and on total road traffic volumes, and to develop guidelines for use in the evaluation of urban transport projects in New Zealand.

The major part of the project involved collection and appraisal of international evidence, for situations where changes have been made to the urban public transport system, on the proportion of additional public transport trips that would otherwise be car driver trips, and on the effects of the mode switching on overall road traffic volumes. Evidence was collected mainly from Europe, USA and Australia and appraised by type of public transport change, ie. major new corridor projects, service enhancements, fare changes and on-road priority projects.

It was found that the 'diversion rate' (i.e. the proportion of additional public transport trips that would otherwise be car driver trips) varied by country, dependent on initial mode shares, car availability, urban density, alternative modes and other factors. With a given country, similar diversion rates applied to major new projects, service enhancements and general fare charges; but with higher rates for projects particularly oriented to motorists and with lower rates for projects with a more 'social' focus.

Recommendations were made in regard to the most appropriate 'diversion rates' for use in New Zealand's major urban centres; and as to when case–specific surveys should be undertaken instead of or to supplement such 'diversion rates'.

The international evidence found that major public transport projects can have significant effects on road traffic, with between 2% and 10% of motorists in the corridors affected switching to public transport. However, in practice, surveys have rarely been able to detect significant changes in overall road traffic volumes: the extra road capacity made available as a result of the mode switching appears to be taken up by additional car traffic (through additional trip generation, changes in the time of travel and changes in routing).

1. Introduction

1.1 This Report

This is the final report of a project for the Transfund New Zealand Research Programme 1998-99: Topic Area E – Traffic and Transportation (reference PR3.0324). It has been prepared for Transfund by consultants Booz·Allen & Hamilton (New Zealand) Ltd.

The project is concerned with assessing the "Effects of Public Transport System Changes on Mode Switching and Road Traffic Levels".

1.2 Project background

A major part of the justification for many public transport improvement projects, and for public funding to existing public transport services, is their effects in terms of reduced levels of road traffic, with consequent benefits in terms of reduced congestion and reduced environmental impacts. The extent of these benefits is crucially dependent on how successful the public transport projects (or subsidies) are in attracting extra passengers to use the services, and on what proportion of these extra passengers would have otherwise been car drivers. The project focuses on assessing what proportion of additional public transport passengers would switch from car driving (ie the proportionate 'diversion' rate between car driving and public transport use), and on assessing the resultant change in road traffic volumes.

Information on this 'diversion rate' is a critical input to:
Urban transport models and their application in assessing the inter-modal effects of urban transport measures.

- Evaluation of 'Alternatives to Roading' (ATR) projects, as required by Transfund under its Passenger Transport – Alternatives to Roading output class.
- The evaluation of existing passenger transport services.

The current ATR procedures in New Zealand ('Evaluation Procedures for Alternatives to Roading', Transfund New Zealand, February 1999) provide no advice on appropriate diversion rates, but leave this up to the analyst. However, there is very little information readily available on diversion rates in the New Zealand context. ATR evaluations undertaken to date (e.g. for public transport projects in Auckland) have confirmed the critical importance of diversion rates to estimation of the benefits of ATR projects in terms of the relief of road traffic congestion.

In the light of this situation, this project was required to develop best estimates of diversion rates and changes in road traffic volumes appropriate in different situations, based on review of the available international and New Zealand evidence; and to provide advice on the application of these rates and or the use of local market research to estimate the diversion for specific types of projects.

1.3 Project objectives and scope

The overall objectives of the project were defined as, for situations where changes are made to the public transport system:
to obtain and review international evidence on the 'diversion rates' between public transport usage and car driving
to obtain and review international evidence on the effects on overall road traffic volumes
in the light of this review, to develop recommendations on the most appropriate 'diversion rates' for New Zealand's major urban centres; and to comment on the relative merits for project evaluation of using such 'diversion rate' proportions as against undertaking case-specific surveys.

It was envisaged that the project findings would be particularly relevant for use in:

- Evaluation of ATR projects (required by Transfund).
- Evaluation of existing passenger transport services (for which procedures are currently being developed by Transfund).
- More widely in assessment of the inter-modal effects of urban public transport measures, including in the application of multi-modal urban transport models to estimate such effects.

The limitations of the project should also be noted, and in particular:

- It does not provide procedures for estimating the total change in public transport patronage resulting from a system change: rather it focuses on the proportion of any patronage change that would switch from (or to) car driving.
- It does not address 'diversion rates' to/from public transport associated with changes in road system conditions.

1.4 Report structure

The remainder of this report is structured as follows:
Chapter 2 -presents our summary and assessment of the international evidence on 'diversion rates' and effects on road traffic volumes resulting from changes to the public transport system.
Chapter 3 -presents our conclusions and draws recommendations on the application of this evidence to project evaluation in the New Zealand context.

The detailed international evidence is presented in Appendices A-D, each covering a different type of public transport system change (refer Contents page). Appendix E contains the full list of references.

2. Assessment of the Evidence

2.1 Approach adopted

The general approach adopted in the project was as follows:

- Assemble relevant evidence (reports, journal articles, conference papers, etc). Sources used include:
  - further literature search
  - data already held by BAH
  - direct enquiries of key researchers.
- Initial review of evidence, as to its relevance, including further discussions with researchers/ practitioners as appropriate.
- Detailed appraisal and summary/tabulation as appropriate.
- Draw conclusions from evidence and develop recommendations.
- Prepare draft report.
- Review of draft report findings by peer reviewer.
- Prepare and submit final report.

The evidence has been grouped by type of public transport change, as follows:

- Major public transport development projects (eg new rail lines or busways) – refer Appendix A.
- Public transport service enhancements – refer Appendix B.
- Public transport fare changes – refer Appendix C.
- Public transport on-road priority projects – refer Appendix D1.
- 'Park & Ride' projects – refer Appendix D2.
- Public transport marketing projects – refer Appendix D3.

The focus has been entirely on urban public transport changes, as it is primarily in the urban context that mode choice and traffic congestion effects are a major issue.

Wherever possible, the project has focused on the observed effects of public transport projects/changes already implemented, ie revealed preference (RP) data. Where such data is available, it is a more reliable guide to traveller behaviour than is stated preference (SP) data. In some situations, where there is very limited RP evidence available, we have also included selected SP evidence in the review.

2.2 'Diversion Rate' - Definition

For purposes of this project, the 'diversion rate' is defined as:

- in cases where the public transport system is improved, the proportion of additional public transport person trips (on the improved services) that would previously have been car driver trips; and
- in cases where the public transport system deteriorates, the proportion of deterred public transport person trips (previously on the relevant service) that would become car driver trips.

This is illustrated in Figure 2.1. The total number of trips on the new/improved public transport service is (B+N), where:

B = all trips which were previously made by public transport, either on the unimproved service (B1) or on alternative services (B2)

N = the total new trips to the public transport system.

N may be broken down according to the previous mode of these new public transport trips:

D = previously car drivers

P = previously car passengers

S = previously slow mode (walk or cycle)

G = previously no equivalent trip (i.e. generated).

The 'diversion rate' is calculated as D/N.

The project was concerned with evidence on the value of D/N, not with evidence on the absolute value of N (total new public transport trips).

2.3 Assessment of Diversion Rates

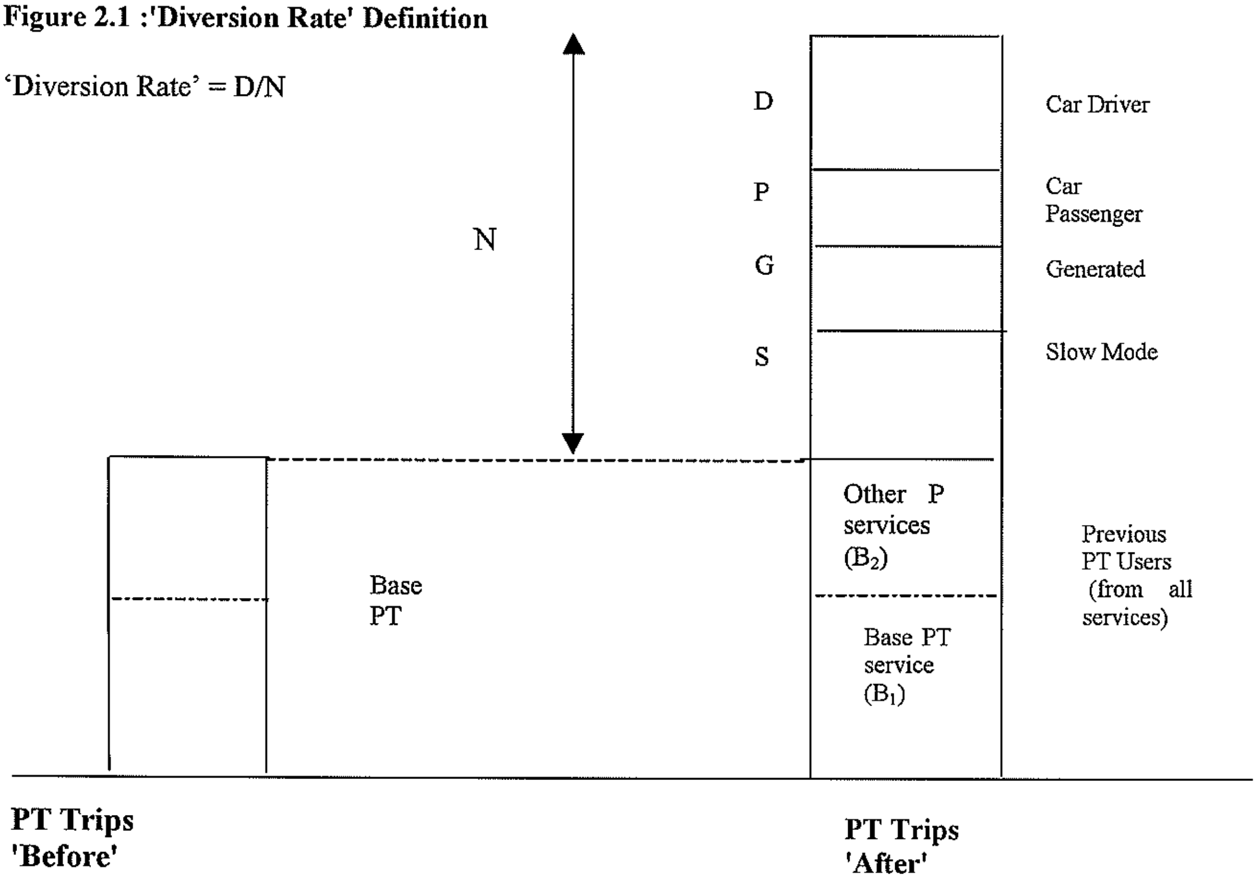
2.3.1 Overview of evidence – major public transport development projects

Appendix A sets out the evidence relating to major new projects or system extensions in UK/Europe, USA and Australia, and involving suburban (heavy) rail, light rail and busway modes. Table A1 provides the project-by-project evidence; while Table A2 summarises market shares and diversion rates relating to the main projects for which the data is available. All the data is of RP type, i.e. relates to changes in actual behaviour resulting from the projects.

In terms of changes in market share associated with these major projects, Table A2 shows that the proportion of trips that were previously made by public transport is typically about 60-70%, with a range over all projects from 56% to 88%. In broad terms, it may be stated that about two-thirds of trips were previously made by public transport, while one-third are 'new' public transport trips (or, for every two previous public transport trips using the service there is one new public transport trip).

Figure 2.1 :'Diversion Rate' Definition

'Diversion Rate' = D/N



In terms of 'diversion rates', for most projects 'car driver' and 'car passenger' mode have not been separated (this is a substantial deficiency of much of the data available). The evidence on car drivers/passengers together as a proportion of all new public transport trips may be summarised as:

- Europe - typically 35-40% (range 30-42%)
- UK - typically 45-50% (range 30-52%)
- Australia - typically 50-60% (range 49-69%)
- USA - 68% (one example only).

These results show significant differences in diversion rates between the different countries. It is hypothesised that these differences are primarily the result of differences in:

- car ownership and availability (e.g. higher in USA than Europe)
- 'base' mode shares of public transport (substantially higher in Europe than in USA/Australia)

- urban densities and trip lengths, which influence the scope for walking/cycling as an alternative (e.g. higher densities/shorter trip lengths in Europe/UK than USA/Australia).

.The above new trip proportions relate to car drivers and passengers together. Our primary requirement is to separate the car driver component. The best evidence on this from Table A2 is for the Adelaide O-Bahn (the Perth Northern Suburbs results are somewhat dubious). The O-Bahn results give a driver:passenger split of approximately 2:1, which appears intuitively plausible, and is sensibly consistent with the split for other types of projects (see Appendix B). (While average car occupancy is around 1.2 in the Adelaide context, car passengers would generally be more likely to switch mode than drivers, as they tend to be less 'captive' to car.)

This 2:1 ratio implies that the diversion rates for car drivers only are two-thirds of the results quoted above. This gives the following typical diversion rates for each group of results:

- Europe c.25%
- UK c.30%
- Australia 35-40%
- USA 45-50%.

2.3.2 Overview of evidence – other public transport project types

In cases of public transport service enhancements (Appendix B), the evidence on new trip proportions and diversion rates may be summarised as follows:

- Adelaide: total car share 55-60%, with driver share around two-thirds of this (33% share in peak, 42% in off-peak).
- Norway: total car share varies from about 25% to 50%, depending on project type.
- USA: total car share generally in the range 60-80%, with around three-quarters of this being car drivers.

All indications are that these diversion rates are generally similar to those for major projects (above) in the same country. However, there is clear evidence of variations by project type: for instance, express bus services have a relatively high diversion rate (particularly if combined with a heavy Park & Ride emphasis); while service routes and minibuses (Norway) have much lower diversion rates.

In cases of **Fare Changes** (Appendix C), the pattern of diversion rates is broadly similar to that above. In USA, around 50% of new public transport trips are typically from car drivers, while in Europe the proportion is around 25-35%. Again, diversion rates depend on the type of fare change: off-peak fare reduction schemes appear to exhibit lower diversion rates than average; while fare reduction schemes associated with frequency improvements have higher than average rates.

In cases of **Park & Ride** projects (Appendix D2), the diversion rates (in the absence of the P+R facility) are typically very high (over 70%), ie the great majority of the new public transport trips resulting from the facility would otherwise have been undertaken as car drivers (of course, a proportion of existing public transport trips also switches to use of the P+R facility).

There is insufficient evidence to draw useful conclusions on diversion rates for bus priority projects and for marketing initiatives.

2.3.3 Disaggregation of diversion rates

This section draws together and summarises the evidence on variations in diversion rates according to key dimensions:

- country
- type of urban area
- project type
- trip purpose
- trip destination
- service improvement or deterioration
- timescale of effects.

Country. As noted above in the context of major projects (Section 2.3.1), there appear to be substantial differences in diversion rates between countries/continents, influenced (it is hypothesised) by base mode shares, car ownership/availability, urban densities and prevailing trip lengths. In the broad, the diversion rate differences that occur for major projects also appear to hold for other project types (to the extent that sufficient evidence is available).

Type of urban area. The evidence here is very limited. For fare reductions, the Norwegian trials indicate the highest diversion rate in urban/suburban areas, a lower rate in smaller towns, and a still lower rate for regional (longer distance) services. These relativities seem likely to reflect the base mode shares and the potential attractiveness of the services to those with a car available (the result of a high quality of public transport services and/or difficulties of car use). There is little other evidence on this dimension, although our professional judgement would be for higher diversion rates in situations where car use is more difficult (due to congestion, parking restraints etc).

Type of project. Diversion rates appear to be in general similar for both the major public transport development projects and the more modest system enhancements: there is no evidence that the major projects are more attractive *proportionately* to car drivers.

Diversion rates for other project types appear to vary in a way that is consistent with informed judgement, having regard to the extent to which the project is likely to appeal to people with a car available:

- For **fare changes**, diversion rates are generally similar to those for major projects/service enhancements. This is perhaps surprising as it might be expected that people with a car available would be relatively more sensitive to service enhancements than to fare changes. However, diversion rates vary with the type of fare change: they are lower than average for off-peak fare reductions (which

- would largely appeal to people without car access); and higher than average when accompanied by service enhancements (which are more likely to appeal to people with a car available).
- For **service enhancements**, express bus and similar projects have relatively high diversion rates, which is consistent with their being targeted to a considerable extent at car commuters; whereas more socially-oriented services (eg service routes, minibuses) have lower than average rates, consistent with their target markets.
- For **Park & Ride** projects, diversion rates are typically very high (over 70%) relative to other projects. Again, this is expected given the nature of such projects: they are designed to attract people with a car available.

Trip purpose/time period. There is very limited information on this dimension, and mostly from Adelaide. The Adelaide O-Bahn results indicate marginally higher diversion rates in the peak (42%) than the interpeak (39%). However the Adelaide TransitLink services exhibit lower diversion rates in peak (average 33%) than in the interpeak (average 42%).

Our professional judgement would have been for higher diversion rates in the peak, lower in off-peak (when trip suppression is likely to be greater). However, it would be dangerous to draw any conclusions on general differences given the limited evidence available.

Trip destination. The main issue here is differences in diversion rates between CBD trips (for which parking is likely to be difficult, but levels of public transport service relatively good) and non-CBD trips. Again the evidence is very limited. The Honolulu bus priority/express bus scheme exhibited higher diversion rates for CBD trips than for other trips, but these other trips are believed to be dominated by university travel. No general conclusions can be drawn from the evidence available.

Service improvement or deterioration. Most of the projects examined have involved improvements in public transport services (i.e. reductions in the 'generalized cost' of travel): only a few have involved deteriorations, mainly by way of fare increases. There is insufficient evidence to indicate any difference in diversion rates in the two cases.

2.4 Assessment of Road Traffic Effects

2.4.1 Overview

The proportion of total car trips that will switch to public transport as the result of a public transport system improvement will depend on:

- The base ratio of public transport passenger:car driver mode share in the relevant corridor or area.
- The proportionate increase in public transport trips (which depends on the attractiveness of the improvement project).
- The ‘diversion rate’ (for car drivers).

The maximum proportionate effect on road traffic volumes will occur in situations where the public transport base mode share is high, the improvement project is a major/attractive scheme, and the diversion rate is relatively high.

The previous evidence is that the first and last of these factors offset each other to some extent: in Europe, where the public transport mode share is relatively high, the diversion rate is relatively low. However, in general, those schemes having the greatest (proportionate) effect on road traffic volumes are likely to be major schemes in situations where public transport mode shares are relatively high (e.g. UK/Europe), and schemes of types most attractive to car users (e.g. express bus and Park & Ride schemes). Where public transport mode shares are low, road traffic effects will be relatively small.

2.4.2 Proportion of car trips switching to public transport

For a number of major projects, estimates have been made of the reduction in car traffic volumes in the relevant corridors based on the numbers of new public transport travellers and the estimated diversion rates:

- Adelaide O-Bahn: up to 10% reduction in peak road traffic in corridor.
- Manchester Metrolink: range of estimates, between 3% and 8% reduction in car traffic in the corridor.
- Tyne & Wear Metro: between 1.7% and 5.1% reduction in traffic in the corridor.
- Berlin Metro Extension: 5-10% car traffic reduction in the corridor.

These figures give an indication of the range of 'theoretical' traffic reductions that might be expected from major public transport projects (in both European and Australian conditions).

Some of the fare change projects also indicate significant 'theoretical' reductions in traffic levels, eg:

- Basel (Switzerland) 'Environmental Pass': 2.6% reduction in car travel in the city.
- Paris 'Carte Orange' Passes: 2.8% reduction daily (4% PM peak) in car travel within the Paris area.

A number of the bus priority measures have also resulted in significant reductions, up to 20%, in car travel on the routes concerned (refer Table D1).

2.4.3 Overall effects on road traffic volumes

In practice, the observed changes in road traffic volumes resulting from major public transport projects have rarely been as great as indicated by the above modal switching estimates, and have in most cases been such that they were not able to be detected with any confidence. This has particularly been the case in congested urban areas, where it appears that any temporary reduction in traffic volumes has been offset by the range of car travel responses expected in such situations (re-assignment, changes in time of travel, trip redistribution, trip generation).

A number of studies have come to similar conclusions in this regard, e.g.:

- *"The effect on car traffic, though, is not noticeable, and in cities where public transport use is low, rail may attract a few car users but will not make a dramatic impact".* (Walmsley and Perrett).
- *"The findings...support the view that any improvements to the public transport system, even in conditions of suppressed demand, have only a marginal effect on removing car traffic from parallel roads."* (Younes).
- *"Traffic volume changes were minimal, ... and there was insufficient evidence to confirm the magnitude of the impact on traffic volumes".* (Chapman – re Adelaide O-Bahn).
- *"The analysis of extensive highway surveys proved to be largely inconclusive... ".* (Parkin et al. – re Sheffield Supertram).
- *"Surveys on the new metros in Marseilles, Lyon and Lille came to the conclusion that they do attract some motorists away from their cars, but that the road space released is taken up by other motorists".* (Simpson).

Thus, in general, we find that even major public transport projects have had only marginal (often undiscernable) impacts on traffic volumes in the relevant corridors: the 'first order' mode switching effects tend to be offset by 'second order' road traffic responses (reassignment, redistribution, etc) to reach a new equilibrium apparently little different from the previous equilibrium.

However, it should not be concluded from this that the road traffic benefits of such projects are negligible. Even though the degree of congestion may not have significantly reduced, there will be benefits to the car users that take advantage of the situation through reassignment, redistribution, etc.

3. Conclusions and Recommendations

3.1 Diversion Rates – Conclusions and Recommendations

Section 2.3 summarised the international evidence on 'diversion rates'. Among other things, it was found that:

- Typical diversion rates vary by country, influenced by base mode shares, car availability, urban density, alternative modes, etc.
- In a given country, similar diversion rates are found for major public transport development projects, typical service enhancements and standard fare changes.

Given the similarities of urban form, mode share, car availability, etc, we recommend that diversion rates for New Zealand be based principally on the evidence from Australia. On this basis, we recommend a standard car driver 'diversion rate' in the range of 35% - 40% for use in New Zealand urban/metropolitan centres. This should be regarded as a base value, for application in 'standard' conditions. It would be generally appropriate for major public transport development projects, most service enhancement projects and general fare changes.

For 'non-standard' conditions, no specific percentage value is recommended, but the following comments are made based on the international evidence:

- For public transport projects particularly oriented to motorists, higher than standard diversion rates will be appropriate. This would include Park & Ride projects (diversion rates typically 70%+) and express bus services (diversion rates typically 50-75%).
- For public transport projects with a more 'social' focus, lower than standard diversion rates will be appropriate. This would include off-peak fare schemes and service routes (diversion rates typically 20-30% in both cases).

Given the limitations of the evidence available, there is no basis at this stage for recommending disaggregation of diversion rates by trip purpose/time period, trip destination, type/size of urban area, timescale of effect, or any other factors.

3.2 Road Traffic Effects – Conclusions and Comments

From our review of the international evidence (Section 2.4), two main conclusions can be drawn:

- Theoretically, major public transport projects can have significant effects on road traffic volumes in the corridors affected. Based on estimates for a number of major development projects, changes in traffic volumes in the range 2-10% might be expected. The estimated level of changes will depend very much on the base mode split and the effectiveness of the project in improving public transport travel conditions.

- In practice, road traffic surveys have in most cases not been able to detect any statistically significant changes in traffic volumes. One reason for this is the difficulty in separating out the effects of the project from all the other events that affect traffic volumes. Another reason is that, to the extent that some traffic may be removed from the corridor road system, it is largely offset by the range of car traveller responses expected in such situations.

Given this evidence, we would make the following comments in regard to project modelling and evaluation:

- To assess the extent of mode shift between car (driver) and public transport, the 'diversion rate' approach is appropriate. This needs to be combined with some method of forecasting the total change in public transport trips resulting from the project, eg through a combination of public transport network assignments and 'generalised cost'/elasticity modelling.
- The matrix of the change in car driver trips resulting from this process can then be applied to the 'base' car matrix, and the effects of the matrix change on traffic speeds, car user costs, etc can be calculated using 'standard' traffic modelling procedures. To the extent these changes take place in peak periods in congested areas, congested network modelling procedures will be appropriate. The resultant changes in road user costs can then be included in the benefit assessment of the public transport project (for use in ATR evaluations etc).

3.3 Application of Diversion Rates in Project Evaluation

The project was required to comment on the relative merits of using the recommended diversion rate proportions (Section 3.1 above) or of undertaking project-specific surveys (using SP and similar approaches) for the evaluation of passenger transport projects in New Zealand.

Our conclusions on this issue are as follows:

- Diversion rates are only one component in an approach to forecasting the patronage and modal share effects of public transport projects. They need to be accompanied by other components (which forecast the change in total patronage). They are therefore on their own not a full substitute for SP surveys and their application through econometric modelling methods.
- The evidence indicates that diversion rates are reasonably stable and consistent between projects of a given type, country, etc. The recommendations on standard rates (and situations where these might be varied) should therefore provide a reasonably good guide to rates appropriate for potential projects.
- Therefore for smaller and medium-size public transport projects, we suggest that appropriate diversion rates be applied (together with other components of patronage forecasting), without any market surveys being undertaken.
- For large, complex and/or more unusual projects, the case for augmenting standard 'diversion rates' with market surveys (of SP or similar nature) will be greater – particularly for projects involving new modes or unusual features, and

especially in cases where the economic merits of the project are sensitive to the 'diversion rate' assumptions adopted. The most appropriate approach for each such project should be assessed on its merits.

Appendix A

Detailed Evidence – Major Public Transport Projects

This appendix provides the detailed evidence from the sources identified on diversion rates and road traffic effects for major public transport investment projects (new infrastructure projects, rail extensions etc).

This evidence is presented in two tables:

- Table A1 : main evidence
- Table A2 : supplementary evidence on previous mode shares of users of the new projects.

TABLE A1: EVIDENCE ON DIVERSION RATES AND ROAD TRAFFIC EFFECTS – MAJOR PUBLIC TRANSPORT PROJECTS

Project	Effects on PT Usage	Diversion Rates	Effects on Road Traffic	Additional Comments	References
Adelaide O-Bahn 12.6 km guided busway, opened in 1986 Stage 1) and 1989 (Stage 2). Total patronage 22,000/day	"O-Bahn patronage in 1994 was 45% higher than…if the facility had not been built". After survey recorded 7.9% new patronage in AM peak, 13.3% in interpeak.	• Former modes of new (inbound) passengers were: • Car driver 40% (pk 42%, i/pk 39%) • Car pass 17% (pk 15%, i/pk 19%) • No trip 27% (pk 25%, i/pk 29%) • Other 15% (pk 18%, i/pk 13%).	• 40% of new passengers (ex car drivers) represents c.1,000 car trips reduction in AM peak (close to capacity of 1 lane on urban arterial route) • This reduction may be partly offset by some existing users switching to P+R access. (There are c.1,000 P+R places, which are generally full). • Direct surveys suggest an AM peak road traffic reduction of c.200 vehicles (Stage 1 and 2 combined). • It was concluded that the O-Bahn "could have resulted in up to a 10% reduction in road traffic travelling towards the city during the AM peak hour. This is equal to a saving of perhaps 3 years of traffic growth".	• It appears that the 'theoretical' reduction in car traffic was substantially taken up by traffic growth, reassignment, etc. The surveys found that "traffic volume changes were minimal,…and that there was insufficient evidence to confirm the magnitude of the impact on traffic volumes." • Some independent surveys (RAA) before/after the opening of Stage 2 found on average 1.5 mins savings (over a 26 minute trip) for AM peak inbound travel on one of the two main arterial routes in the corridor. (These savings were conservatively valued at $320,000pa).	Bray, 1995 PPK, 1990 Wayte, 1991 Chapman, 1992.
Perth N Suburbs Railway 29 km double track railway (mostly on freeway median), opened 1993. Total patronage 32,000/day.	Best estimates are that NSR has resulted in increase in northern suburbs PT patronage of 6% in AM peak, 20% over the whole day relative to no change situation. (NSR carries approx two-thirds of the current total northern suburbs patronage).	• No comprehensive survey undertaken. • Sample survey of NSR users found that 24% were ex car drivers, 1% ex car passengers. • Some doubt re the validity of these results is noted: they suggest that virtually all new passengers are ex car users.	• Diversion rates would suggest a reduction of c.1,500 cars in AM peak 2 hours (equivalent to c.half a freeway lane). • Not been possible to verify this by direct observation: insufficient count data available, also freeway was widened in relevant period. • Other factors cast doubt on extent of any traffic reduction: some ex bus passengers and car passengers may have converted to car drivers; 24% ex car driver rate seems high; extensive use of P+R mode to access NSR.		McDougall & Piotrowski, 1994 Alexander & Houghton, 1993 Transit Australia, 1994 Ker & Ryan, 1994

TABLE A1: EVIDENCE ON DIVERSION RATES AND ROAD TRAFFIC EFFECTS – MAJOR PUBLIC TRANSPORT PROJECTS (Cont'd)

Project	Effects on PT Usage	Diversion Rates	Effects on Road Traffic	Additional Comments	References
Manchester Metrolink (LRT)					
T30km LRT scheme (conversion of 2 existing suburban rail lines), opened 1992.otal patronage 45,000/weekday 10km extension under construction.	• Approx one-third increase in PT travel in corridor: of Metrolink users, 50% ex train, 25% ex bus, 10% ex car, 15% new trips. • More recent estimates are that ex car users were c.14% of all Metrolink users (22% of users to Central Manchester). • Largest increase in patronage is in off-peak periods.	Of new PT passengers, 40% are ex car (D+P), 60% are new trips.	Various estimates: • "For trips between catchment areas of Metrolink stops, car share has fallen from 55% to 33%." • "Car traffic in the corridors most affected has fallen by up to 8% in the peak period". • Reduction of c.4% in AM peak traffic flows across screenlines on the Bury corridor and 6% on the Altrincham corridor. • "Around 3% of all road trips in this corridor have transferred to Metrolink: this amounts to 0.3% of all road trips in the Greater Manchester conurbation." • Reduction in car journeys in order of 3,000/day.	Preliminary evidence that car ownership in the Metrolink corridors has fallen, while it has continued to rise elsewhere.	Local Transport Today, 1994 Tyson, 1997 Worsley 1995
Tyne & Wear Metro LRT scheme, involving conversion and joining of existing suburban rail lines, opened 1981.	Approx 25% increase in PT patronage in Metro corridors ("if Metro did not exist, 80% of passengers would use the bus".)	• Full details n/a. • States that "7-8% of non-car arrivals (at Metro stations) would otherwise travel by car".	• If car drivers to Metro stations (P+R) had continued by car into CBD, this would increase daily inbound traffic by 1.7%. • If all surveyed passengers who claimed their alternative would be to drive to the CBD, this would increase daily inbound traffic by 5.1%. • These figures compare with average annual traffic growth (CBD cordon) of 2.2% pa.	Metro initially resulted in a major reduction in buses into Central Newcastle (c.900 inbound buses/day reduction on Tyne Bridge). However, this was largely negated on deregulation.	Heseltine & Mulley, 1993

TABLE A1: EVIDENCE ON DIVERSION RATES AND ROAD TRAFFIC EFFECTS – MAJOR PUBLIC TRANSPORT PROJECTS (Cont'd)

Project	Effects on PT Usage	Diversion Rates	Effects on Road Traffic	Additional Comments	References
Sheffield Supertram					
30 track kms LRT, opened 1994-95.	N/a	N/a	"The analysis of extensive highway surveys proved to be largely inconclusive, with highway changes due to Supertram either being negligible in comparison with the scale of the highway network and its usage, or being drowned by the exogenous factors of local roadworks and the construction of new highway infrastructure". "It was therefore not possible to validate the forecast highway decongestion benefits."		Parkin et al, 1997
Victoria (Metro) Line, London					
22 km new Metro line, opened 1969-71.	'After' surveys indicated proportions of VL trips new to PT: 1969: 9% (ex car 1.5%, generated 7.5%) 1970: 22% (ex car 2%, generated 20%).	Proportion of new PT trips: Ex car 17% (69), 9% (70). Generated 83% (69), 91% (70). No split car driver v passenger available.	• 'After' surveys indicated removal of c.4,000 car trips/day (about half the prior estimate) • Central London cordon counts indicated apparent fall in car travel (6.5%, 1968-69), but offset by large increases in the previous and next years. Effects of VL therefore not clear. • Household survey in area near N end of VL before/after opening (1 year apart) showed 7.6% increase in private transport use as main mode, 2% fall in PT use (but with transfer from bus and BR to VL).	Conclusions drawn include: • "The opening of the new line had a very marginal impact on car traffic on the roads influenced, which continued to carry almost the same levels of traffic as before. The relief offered was marginal and only temporary." • "The provision of the VL had only a marginal effect on relieving road traffic congestion. It appears that capacity released on the road network is taken up by the suppressed demand."	Younes, 1995

TABLE A1: EVIDENCE ON DIVERSION RATES AND ROAD TRAFFIC EFFECTS – MAJOR PUBLIC TRANSPORT PROJECTS (Cont'd)

Project	Effects on PT Usage	Diversion Rates	Effects on Road Traffic	Additional Comments	References
Stuttgart S-Bahn Extension					
S-Bahn extension to suburban area of Stuttgart, 1985.	S-Bahn patronage increased 53% at inner cordon, 11% at outer cordon (1984-86).	N/a	• Cordon counts showed greater traffic increases in S-Bahn corridor than on equivalent cordons for city as a whole – no evidence of project reducing road traffic. • Only small shift recorded from car to PT, with most of ex-car trips becoming P+R trips.	Conclusions drawn include: • "The impact (of PT improvements) on private vehicle travel on parallel roads is rather marginal." • "It is also clear that any spare capacity, which may have been made available on the corridor roads, is taken up by the suppressed demand."	Younes, 1995
Berlin Metro Extensions					
Extension to Berlin U-Bahn to Spandau area, 1980/84. Assessment based on detailed surveys 1979 and 1985.	• PT mode share of all trips by Spandau residents increased 25.3% to 27.3% (1979-85). Relative to the control area, this was a 39% increase. • For Spandau journeys directly affected by U-Bahn extension, PT mode share increased 37.5% to 42.5%. • 84% of U-Bahn trips were previous PT trips.	New PT trips on U-Bahn (16% of total) were from: Car driver 55% Car pass 0% Bicycle 30% New trips 15%	• For Spandau journeys directly affected by U-Bahn extension, car driver mode share decreased 45.3% to 42.9%; car pass mode share unchanged (7.9%). • This indicates a 5% reduction in car use for these journeys: the underlying reduction is probably larger (perhaps c.10%), given the trend towards increased car travel. • No road traffic counts are available.	• Results indicate a significant (but not large) shift from car to PT for trips directly affected. • This also suggests a significant reduction in car traffic volumes in the corridor, although it is not clear whether other factors negated this.	Younes, 1995

TABLE A1: EVIDENCE ON DIVERSION RATES AND ROAD TRAFFIC EFFECTS – MAJOR PUBLIC TRANSPORT PROJECTS

Project	Effects on PT Usage	Diversion Rates	Effects on Road Traffic	Additional Comments	References
European LRT Schemes					
Grenoble LRT (France)	• In first 3 months after opening, corridor PT patronage increased 50-100% over prior level; and total conurbation PT patronage increased by 15%. • 12% of PT passengers in the corridor did not previously use PT for their trip	Split of new PT trips was ex car c.40%, ex-walk/cycle c.25% generated c.35%.			Walmsley & Pickett, 1992
Nantes Tramway (France)	PT patronage in corridor increased c.50%.	Split of new trips was: ex car 30%, other mode 21%, generated 48%.			ECMT, 1994
France – General			• "Surveys on the new metros in Marseilles, Lyon and Lille came to the conclusion that they do attract some motorists away from their cars, but that the road space released is taken up by other motorists." • "In Lille, it is estimated that 3,000 car trips/day were transferred to rail into the city centre, but the noticeable effect on congestion is minimal."		Simpson, 1989 Walmsley & Perrett, 1991
Hanover LRT (Germany)	Proportion of LRT passengers who would not otherwise have used PT was 10-20%.				ECMT, 1994
Nieuwegein LRT (Netherlands)	23% of LRT passengers were additional PT trips.	35% of new trips were from car.			

TABLE A1: EVIDENCE ON DIVERSION RATES AND ROAD TRAFFIC EFFECTS – MAJOR PUBLIC TRANSPORT PROJECTS Cont'd)

Project	Effects on PT Usage	Diversion Rates	Effects on Road Traffic	Additional Comments	References
UK Heavy/Light Rail Schemes					
Various UK metropolitan heavy rail/metro extension / upgrading projects.	• Refer Table A2 • Between 56% and 71% of scheme users were ex-PT, 11-20% were ex car, and 15-26% were generated/ other.	• Refer Table A2. • % of new PT users ex car in range 45-52%, except one case 30% (Birmingham). • No split driver/ passenger available.	N/a		Various
USA Light Rail Schemes					
Various LRT projects	Refer Table A2 (San Diego)	Refer Table A2 (San Diego)	Reductions in car usage resulting from LRT systems negated the following amounts of 'natural' traffic growth in region: -Portland <50 days -San Diego 25 days -San Jose 15 days -Sacramento 15 days -Los Angeles 3 days	Report concludes that: "The construction of light rail has not resulted in a decrease in traffic congestion in any of the (USA) urban areas studies." "Most evidence suggests that, even in the rail corridor, traffic may decline with the opening of the rail system, but within a short period of time, rise to (or above) pre-rail levels."	Cox & Love, 1991
Melbourne Tram Extensions					
Bundoora	Increase in corridor PT patronage of 47%.	Breakdown of new PT passengers: 49% ex car, 15% ex walk and 36% generated.	N/a		Kinnear 1993
East Burwood	Increase in corridor PT patronage of 40-70%				
Auckland Rail Transit Project					
Forecasts re ART project		Estimated two-thirds of new passengers would be ex car users.	"It is estimated that the ART system would result in traffic volumes on the Southern Motorway being around 0-2% less than they would otherwise be. Elsewhere any effects will be relatively smaller.		ARC, 1996 Kilvington, 1992

TABLE A2: PREVIOUS MODES OF PUBLIC TRANSPORT USERS AFTER THE IMPLEMENTATION OF MAJOR PT PROJECTS								
Project	Proportions of Market by Previous Mode (1)							
	Car Driver	Car Pass	Did Not Travel	Walk/ Cycle	Other	Total New PT Market	Prev PT	O'all Total
UK Heavy/Light Rail Schemes								
Birmingham (cross-city rail link)	11 (30)		26 (70)			37 (100)	63	100
Merseyside Rail (Link/Loop Project)	20 (45)		24 (55)			44 (100)	56	100
West Yorkshire (new rail stations)	16 (52)		13 (42)		2 (16)	31 (100)	69	100
Manchester Metrolink	14 (48)		15 (52)			29 (100)	71	100
Glasgow Rail (cross-city rail link)	15 (50)		15 (50)			30 (100)	70	100
London Underground	20 (51)		19 (49)			39 (100)	61	100
European Light Rail Schemes								
Grenoble LRT	5 (42)		4 (33)	3 (25)		12 (100)	88	100
Nantes LRT	10 (30)		16 (48)		7 (21)	33 (100)	67	100
Nieuwegein LRT	8 (35)					23 (100)	77	100
USA Rail Schemes								
San Diego Trolley	30 (68)		10 (23)		4 (9)	44 (100)	56	100
Australian Schemes								
Adelaide O-Bahn	13 (40)	6 (17)	9 (27)		4 (15)	33 (100)	67	100
Perth N Suburbs Railway	23 (66)	1 (3)	10 (29)		1 (3)	35 (100)	65	100
Bundoora (Melb) Tram Extension	16 (49)		11 (36)	5 (15)		32 (100)	68	100

Sources: SDG 1990, Kinnear 1993.

Notes: (1) Unbracketed figures are previous mode proportions of total PT trips (with new project). Bracketed figures are previous mode proportions of total new PT trips.

Appendix B

Detailed Evidence – Service Enhancements

This appendix provides the detailed evidence from the sources identified on diversion rates and road traffic effects for public transport (principally bus) service enhancements, including:

- new bus services
- increased service frequencies
- express bus services.

The evidence is presented in two tables:

- Table B1 : main evidence

- Table B2 : supplementary evidence on previous mode shares of users of the enhanced services.

TABLE B1 : EVIDENCE ON DIVERSION RATES AND ROAD TRAFFIC EFFECTS – SERVICE IMPROVEMENTS

Project	Effects on PT Usage	Diversion Rates (New PT Trips)	Effects on Road Traffic	Additional Comments	References
Adelaide TransitLink (Limited Stop) Bus Services					
	• Refer Table B2 • Average proportion of new PT trips on services is 20% (peak) and 24% (interpeak)	• Refer Table B2 • Ex car drivers: 33%(pk), 42% (i/pk) Ex car pass: 23%(pk), 16% (i/pk) New trips: 37%(pk), 34%(i/pk) Other: 7%(pk), 7%(i/pk)	• No statistics available • Analysis indicates c.750 car driver trips likely to be removed from road network over the S Corridors, ie 150 trips/corridor: about half these would be in peak periods • It is unlikely this effect is discernable.	• New limited stop bus services between CBD and major regional centres, superimposed on existing bus network • Introduced 1992-94 • Services together carry c.9,000 trips/day of which about 2,000 are new PT trips, including c.750 ex car driver trips.	STA 1993,1994
Auckland Link Bus Service					
	• Over 1.5million passengers in first 12 months, of which 67% had not previously made the trip by bus		• No statistics available	• New inner-city bus distributor services	TACL 1997
Norwegian Trials:					
(1) Service Routes	• Refer Table B2 • Average proportion of new PT trips on new service routes is 63%	• Refer Table B2 • Ex car users (drivers/passengers) 35%, ex walk/cycle 51%, new trips 6%, other 8%	N/a	• For Service Routes/Smaller Bus trials, proportion of new PT trips averaged 80% for regional and local traffic, 36% for urban traffic (for which there were already reasonable PT services). The proportions of new trips from car were 35% (local/regional) and 28% (urban).	Norwegian Institute of Transport Economics, 1993
(2) Smaller Buses	• Refer Table B2 • Average proportion of new PT trips on services is 48%.	• Refer Table B2. • Ex car users 27%, ex walk/cycle 48%, others 19%.	N/a		
(3) Increased Frequency	• Refer Table B2 • Average proportion of new PT trips on services is 21%	• Refer Table B2 • Ex car users 44%, ex walk/ cycle 33%, others 23%	N/a		
(4) Express/ Direct Services	• Refer Table B2 • Average proportion of new PT trips on services is 30%	• Refer Table B2 • Ex car users 50%, ex walk/cycle 27%, others 23%	N/a	• Most of new passengers are men with car available travelling to work. Also some school pupils.	

TABLE B1 : EVIDENCE ON DIVERSION RATES AND ROAD TRAFFIC EFFECTS – SERVICE IMPROVEMENTS

Project	Effects on PT Usage	Diversion Rates (New PT Trips)	Effects on Road Traffic	Additional Comments	References
Increased Bus Frequency – Massachusetts (various experiments)					
		• Previous mode of new PT trips: Own car 15-57% Carpool 9-25% Train 0-9% Taxi 0-6% Walk 0-9% No trip 10-20%	N/a		Barton-Aschman (1981)
Increased Commuter Rail Frequency – Boston					
		• Previous mode of new PT trips: Own car .65% Carpool c.20% No trip 10-20%	N/a		Barton-Aschman (1981)
New Radial-Suburban Bus Routes – St Louis					
	•60% of trips from other PT services, 40% new transit trips	• Previous mode of new trips: Single car driver 40% Carpool 30% No trip N/a Walk/other 30%			Barton-Aschman (1981)
New Circumferential Bus Route – Boston (3 mile radius)					
	•94% of trips from other PT services, 6% new transit trips	• Previous mode of new trips: Car 60-70% No trip c.10% Walk/other c.30%			Barton-Aschman (1981)
Transit Strike – San Francisco (1974, 45 days)					
		• Trip suppression: 9-21% of work trips, 49-59% of other trips • Alternative modes for non-suppressed trips: Car(driver/pass) 68% Train 15% Walk 8% Bike etc 5% Taxi 4%	Daily vehicle traffic on 3 main bridges across SF Bay increased 6-16%; average peak car occupancy increased 1.44 to 1.75; peak period congestion extended 30 to 120 minutes		Barton-Aschman (1981)
Bus Service Improvements – USA (general)					
			"Discernable traffic volume changes thought to be associated with modification of bus transit routing and associated improvements have only been observed in one reported instance… Normally auto traffic impacts cannot be seen and isolated from other events."	Unsurprising result, given the low proportion of transit use in USA cities and the prevailing service level elasticities	Barton-Aschman (1981)

TABLE B1 : EVIDENCE ON DIVERSION RATES AND ROAD TRAFFIC EFFECTS – SERVICE IMPROVEMENTS (Cont'd)					
Project	**Effects on PT usage**	**Diversion Rates (New PT trips)**	**Effects on Road Traffic**	**Additional Comments**	**References**
Express Bus (Freeway) Services–USA					
(1) Seattle:	Prior mode:	Proportions of new transit passengers (excluding those with no previous trip):			Barton-Aschman (1981)
All express routes	75% transit, 25% other	Car driver 76%, car pass 24%			
P+R express routes	35% transit, 65% other	Car driver 83%, car pass 17%			
Local routes	88% transit, 12% other	Car driver 60%, car pass 40%			
(2) Minneapolis: Express Routes	52% transit, 48% other	Car driver 79%, car pass 21%			Barton Aschman (1981)
Local routes	49% transit, 51% other	Car driver 69%, car pass 31%			
Express Bus Services (USA):		Proportions of new transit passengers (car drivers/car pass/other or no trip):		Express bus services are proportionately more attractive to ex car users when they operate on freeways, serve P+R sites, have priority facilities; and less attractive when they operate on arterials, provide local 'collector' services and have no priority facilities.	Barton Aschman (1981)
(1) Major P+R Emphasis	Prior Mode:				
San Bernadino Fwy, LA,CA	10% buss, 90% other	64,18,18			
1-95 Miami, FL	16% bus, 84% other	59,11,30			
1-84 Hartford, CT	23% bus, 77% other	74,20,6			
NW7 Avenue, Miami, FL	22% bus, 78% other	63,19,18			
S Dixie Hwy, Miami, FL	17% bus, 83% other	83,10,7			
Several routes, Washington DC	30% bus, 70% other	54(D+P), 46			
Average (Major P+R)	20% bus, 80% other	64,15,21			
(2) Moderate P+R Emphasis					
Shirley Hwy, Washington DC	38% bus, 62% other	66,19,15			
1-83 Baltimore, MD	42% bus, 58% other	41,17,41			
Average (Moderate P+R)	40% bus, 60% other	54,18,28			
(3) Limited P+R Emphasis					
Banfield Fwy, Portland, OR	47% bus, 53% other	83(D+P), 17			
Santa Monica Fwy, LA, CA	36% bus, 64% other	61,12,27			
1-5 Seattle, WA	64% bus, 36% other	44,13,42			
1-35W Minneapolis, MN	41% bus, 59% other	51,13,26			
S Capitol St, Washington, DC	62% bus, 38% other	37,21,42			
2 routes, Calgary, Alberta	71% bus, 29% other	66,21,14			
Several routes, St Louis, MO	60% bus, 40% other	40,30,30			
Average (Limited P+R)	54% bus, 46% other	51,19,30			

TABLE B2 : PREVIOUS MODES OF PUBLIC TRANSPORT USERS AFTER THE IMPLEMENTATION OF SERVICE ENHANCEMENTS								
Project	**Proportions of Market by Previous Mode (1)**							
	Car Driver	**Car Pass**	**Did Not Travel**	**Walk/ Cycle**	**Other**	**Total New PT Market**	**Prev PT**	**O'all Total**
Adelaide TransitLink Services								
Peak: TL2	7.5	4.5	4.0		3.0	19.0	81.0	100.0
TL3	8.4	4.6	12.0		2.0	27.0	73.0	100.0
TL4	5.9	5.1	5.0		1.0	17.0	83.0	100.0
TL5	4.1	3.9	5.0		1.0	13.0	87.0	100.0
TL10	12.0	12.0			-	24.0	76.0	100.0
Average Peak	6.6 (33)	4.6 (23)	7.4 (37)		1.4 (7)	20.0 (100)	80.0	100.0
Interpeak: TL2	13.7	4.3	8.0		1.0	27.0	73.0	100.0
TL3	11.5	5.5	11.0		2.0	30.0	70.0	100.0
TL4	8.1	2.9	6.0		2.0	19.0	81.0	100.0
TL10	11.0	8.0			2.0	21.0	79.0	100.0
Average Interpeak	10.3 (42)	3.9 (16)	8.3 (34)		1.7 (7)	24.3 (100)	75.7	100.0
Norway Trials								
Service Routes	22 (35)		4 (6)	32 (51)	5 (8)	63 (100)	37	100
Smaller Buses	13 (27)		3 (6)	23 (48)	9 (19)	48 (100)	52	100
Express Services	15 (50)		? (?)	8 (27)	? (?)	30 (100)	70	100
Increased Frequency	9 (44)		? (?)	7 (33)	? (?)	21 (100)	79	100
Service Routes/Smaller Buses:								
Urban trials	10 (28)		3 (8)	17 (47)	5 (14)	36 (100)	64	100
Local/Regional trials	28 (35)		3 (4)	39 (49)	10 (12)	80 (100)	20	100

Notes: (1) Unbracketed figures are previous mode proportions of total PT trips (after service enhancements). Bracketed figures are previous mode proportions of total new PT trips.

Appendix C

Detailed Evidence – Fare Changes

This appendix provides the detailed evidence from the sources identified on diversion rates and road traffic effects for public transport fare change projects, including:

- fare reductions and increases
- peak/off-peak fare differentials
- free fares
- travelcard/pass tickets
- fare changes accompanied by service changes.

This evidence is presented in two tables:

- Table C1 : main evidence
- Table C2 : supplementary evidence on previous mode shares of user market after implementation of the fare changes.

TABLE C1 : EVIDENCE ON DIVERSION RATES AND ROAD TRAFFIC EFFECTS – FARE CHANGES

Project	Effects on PT Usage	Diversion Rates	Effects on Road Traffic	Additional Comments	References
USA Fare Reductions		Previous modes of new transit trips (car driver/car pass/ walk/ other/no previous trip):	• Comments that, in USA situation: -transit has low market share - effect of fare reductions on car traffic will be small - traffic reductions are generally too small to measure successfully • Boston (desk) study found that free fares would increase peak transit ridership by 20%, decrease peak car travel by 6-9% in Boston proper (in situation where numbers of car and transit trips are approx equal).	• Concludes that car driver mode is generally the alternative choice of one-third to one-half of travellers that shift to/from transit in response to fare changes. (Seattle results are clearly a special case).	Barton Aschman (1981)
• Atlanta (fare redn & service improvement)		42,22,4,10,22			
• Los Angeles (fare redn & service improvement)		59,21,-,10,10			
• Trenton (free off-peak fares)		16(D+P),23,16,45			
• Denver (free off-peak fares)		46(D+P),-,22,32			
• Seattle (free CBD fare)		12(D+P),47,3,38			
USA Fare Increase New York City – fare increase		New modes adopted by lost transit trips resulting from fare increase (work trips): Car driver 48% Car passenger 21% Walk 19% Other 13%	• Theoretical studies of a 50% fare reduction in Denver, Fort Worth and San Francisco showed an increase of c.5% in transit work trips, a reduction of 0.1%-0.8% in car commuting VKT. • Actual responses to fare reductions and service increases in San Diego and Atlanta showed transit ridership increases of 30-60%, but VKT/fuel savings in order of 0.5%.		Barton Aschman (1981)
Basel (Switzerland) Fare Reduction	PT travel increased 15% in first year, 30% total over 4 years		Private car travel reduced 2.6%, after having risen for several years previously.		Norwegian Institute of Transport Economics (1993)

TABLE C1 : EVIDENCE ON DIVERSION RATES AND ROAD TRAFFIC EFFECTS – FARE CHANGES (Cont'd)

Project	Effects on PT Usage	Diversion Rates	Effects on Road Traffic	Additional Comments	References
Norwegian Fare Reduction Trials					
	• Refer Table C2 for details • Average proportion of new PT trips on services is 37% • Proportion higher than average in case of combined fare reductions and frequency improvements.	• Refer Table C2 for details • On average ex-car users (D/P) 43%, ex m/cycle 5%, ex walk/cycle 35%, new trips 8%, other 11% • Higher than average proportion of ex-car users on urban services (53%), lower than average on regional services.	• Calculated effects of trials were reduction of up to 1,100 car trips/day – but many trials had reductions of less than 200 car trips/day • No direct observations of road traffic volumes available.	• New users more likely to have car available and driving licence than existing users.	Norwegian Institute of Transport Economics, 1993 Roll-Hansen & Norheim, 1993
Trondheim (Norway) Fare Differentials					
SP survey of likely effects of introducing peak/off-peak fare differentials on Trondheim bus services.	• Overall patronage increase c.2%: peak periods reduction c.9%, off-peak increase c.7%.	• N/a	• Car traffic reduction estimated at 0.8% overall: peaks c.1.5% increase, off-peak c.0.7% reduction.	• SP survey results (not RP)	Norheim et al, 1993
Regional Bus Card Systems – Finland					
Introduction of monthly regional bus cards for travel between smaller communities and major centres at discounted rates. Assessment in 2 regions through a range of surveys.	• Proportion of RBC users that were new bus users was 27% (1993) and 45% (1994).	• 10-20% of RBC trips estimated as formerly by car (no D/P split available). This represents 40-50% of new bus trips being formerly by car.	• N/a		Dargay J & Pekkarinen
London Fare Elasticities					
London Underground estimates of fare elasticities.	• LUL estimated conditional own-price (long run) elasticity of passenger kms wrt fares = -0.26.	• Estimated proportions of additional passengers are 52% from car, 13% from walk/cycle, 35% generated.			Hobbs and Wright, 1995.
Paris Monthly Tickets					
Introduction of 'Carte Orange' in Paris (July 1975)	• Passenger increases by mode: Paris bus 36%, suburban bus 5%, metro 1%, regional rail 5%.	• Approx proportions of new PT users on Paris bus services: ex car 25%, ex walk 53%, new trips 23%.	• Estimated reductions in car travel within Paris area of 2.8% over whole day, with approx 4% in PM peak.	"Carte Orange' directed mainly at commuters, but also allows additional non-peak trips at zero charge.	?

TABLE C1 : EVIDENCE ON DIVERSION RATES AND ROAD TRAFFIC EFFECTS – FARE CHANGES (Cont'd)

Project	Effects on PT Usage	Diversion Rates	Effects on Road Traffic	Additional Comments	References
South Yorkshire Low Fare Policy					
Assessment of effects of low fare policy (introduced 1974) on travel changes over period 1972-81.	• "Low fare policy has succeeded in arresting and even reversing the decline in bus use". • "Some evidence that the (fare elasticities) are greater than would have been expected under conventional estimates…"	• No direct evidence • Noted that proportion of bus trips having car available was only c.7% (1981) as against 2% (1972). Unclear to what extent this growth is result of low fare policy.	• "The conclusion remains that the low fare policy has at best had a marginal effect on traffic volumes."	One of the most comprehensive 'trials' of low fare policies over an extended period.	Hay, 1986
Sydney Cross-Price Elasticities					
(1) IPART 1996	• Estimated direct price elasticities for Sydney are –0.25 (rail) and –0.38(bus)		• 10% increase in rail fares estimated to increase road traffic in Sydney by 0.15%; 10% increase in bus fares to increase road traffic by 0.07%.		IPART, 1996
(2) Hensher & Bullock 1978			• Cross-elasticities of car travel wrt rail fare for Sydney peak work trips = 0.09; ie 10% fare increase increases road traffic by 0.9%		Hensher & Bullock, 1978
(3) Madan & Groenhout, 1987			• Cross-elasticity of car travel wrt rail/bus fares for Sydney peak work trips = 0.06; ie 10% fare increase increases road traffic by 0.6%.		Madan & Groenhout, 1987
Free Public Transport – Castellon de la Plana (Spain)					
Introduction of free PT (1991) in city of 140,000 population	• Patronage increased c.50% (off a low base).	• N/a. But most of additional PT trips believed to be ex walk/cycle or new trips.	• Evidence indicates zero or very slight change in traffic trends.		Echeverria-Jadraque et al, 1994

TABLE C2 : PREVIOUS MODES OF PUBLIC TRANSPORT USERS AFTER THE IMPLEMENTATION OF FARE REDUCTIONS								
Project	**Proportions of Market by Previous Mode (1)**							
	Car Driver/Pass	**MotorCycle**	**Did Not Travel**	**Walk/ Cycle**	**Other**	**Total New PT Market**	**Prev PT**	**O'all Total**
Norway Trials(2)								
Averages by type of change:								
Fare reductions only	11 (33)	4 (12)	3 (9)	12 (36)	4 (12)	32 (100)	68	100
Fare reductions + new ticket types	17 (49)	1 (3)	3 (9)	10 (29)	4 (11)	35 (100)	65	100
Fare reductions + improv frequency	22 (33)	4 (6)	5 (8)	31 (47)	4 (6)	66 (100)	34	100
Average overall	16 (43)	2 (5)	3 (8)	13 (35)	4 (11)	37 (100)	63	100
Averages by service type:								
Urban transport	16 (53)	1 (3)	2 (7)	9 (30)	4 (13)	30 (100)	70	100
Local transport	20 (45)	2 (5)	5 (11)	15 (34)	3 (7)	44 (100)	56	100
Regional transport	9 (31)	3 (10)	3 (10)	10 (34)	5 (17)	29 (100)	71	100

Notes: (1) Unbracketed figures are previous mode proportions of total PT trips (after fare reductions). Bracketed figures are previous mode proportions of total new PT trips.
(2) Taken from Norwegian Institute of Transport Economics (1993).

Appendix D

Detailed Evidence – Other Public Transport Project Types

This appendix provides the detailed evidence from the sources identified on diversion rates and road traffic effects for three 'other' types of public transport projects:

- Table D1 : Bus and HOV Priority Measures
- Table D2 : Park & Ride Facilities
- Table D3 : Public Transport Marketing Campaigns

TABLE D1 : EVIDENCE ON DIVERSION RATES AND ROAD TRAFFIC EFFECTS – BUS AND HOV PRIORITY MEASURES

Project	Effects on PT Usage	Diversion Rates (New PT Trips)	Effects on Road Traffic	Additional Comments	References
Priority Measures - USA					
Express bus, part on 4km bus lane, Honolulu		• Previous mode to CBD: car driver 57%, car pass 22%, bus 18%, other 3%; • Previous mode to University: car driver 39%, car pass 27%, bus 28%, other 6%.		New service	TRRL 1980
18 km bus lane, Shirley Highway Washington		• Bus modal share increased from 27% to 41% : nearly all new PT trips from car	• Car traffic decreased by 18%	Bus travel time reduced by 10-25 mins	TRRL 1980
4.2 km bus lane & signal pre-emption, Miami	20% increase am peak 8-14% increase pm peak				Barton-Aschman 1981
18 km bus lane, San Bernardino Freeway, Los Angeles	Increased by factor of 5 over 3 year period			20 mins saving on peak bus journey	TRRL 1980
Summary comments re bus priority measures		• Mode shifts to PT are often small; however, PT market share increases of 50+% have been reported for metropolitan corridors with substantial prior PT service			Barton-Aschman 1981
Priority Measures - Europe					
3.8 km bus lane & 12.3 km HOV lane, NVI corridor Madrid		• Total PT share (bus + rail) decreased from 51.3% to 51.1%. Bus share increased by 3%, rail share decreased by 3.2%.	• Total motor vehicle share static, but car occupancy rates increased: single occupant share decreased from 34% to 28.7%.		Monzon, Gonzalez & Cristobal 1997
15 km bus lane, Rotterdam			• 10% of people with choice to use car or bus switched to bus - this group 11% of total peak traffic		TRRL 1980
3.3 km bus lane, Dublin	13% increase				Barton-Aschman 1981
Priority Measures – New Zealand					
1 km HOV lane, Onewa Road, Auckland	9% increase		• 36% increase carpool vehicles, 18% decrease other traffic		Traffic Design Group 1991

TABLE D2 : EVIDENCE ON DIVERSION RATES AND ROAD TRAFFIC EFFECTS – PARK AND RIDE FACILITIES

Project	Diversion Rates (New PT Trips)	Additional Comments	References
P+R - UK			
Survey of bus-based P+R users in York and Oxford.	• Prior to P+R beginning: 60% of York weekday users travelled as car drivers, 6% car pass, 26% by PT, 7% other. • If P+R unavailable: 55% of York weekday users travel by car, 24% by bus, 11% travel elsewhere or not that day, 4% other.	• Alternative mode differed by trip purpose: work/education trips more likely to be by PT or cycle; shopping trips likely to travel elsewhere or not make trip. • Oxford results similar to reported York results	Parkhurst 1994
Survey of bus-based P+R in 4 UK towns	• 59-78% of users would have driven to town if facility not available. Of those who wouldn't drive, 11-25% would have made same trip by bus, 4-9% not travel at all, 2-8% visit another location.		Pickett & Gray 1994
London-Network South East (NSE) rail services	• For each person using P+R facilities there are 0.16 new return trips. Most P+R users would have used train if no P+R.	• 21% of NSE pass to Central London use P+R	
P+R – USA/Canada			
USA review study of P+R sites served by express services	• 40-60% of P+R users previously commuted as car driver; 8-15% previously car pass; 25-40% former PT trips	• 15-20% would have walked directly to PT if no P+R	Barton-Aschman, 1981
Californian study	• 27% of P+R users previously drove vehicle to destination		California DOT 1988
Vancouver survey	• 38% of P+R users former car drivers, 21% former bus travelers (all the way)		Barton-Aschman, 1981
P+R - Australia			
Adelaide: P+R spaces with O-Bahn	• P+R share by 'new' users similar to that by 'existing' bus users		Wayte 1991

TABLE D3: EVIDENCE ON DIVERSION RATES AND ROAD TRAFFIC EFFECTS – MARKETING

Project	Effects on PT Usage	Diversion Rates	Effects on Road Traffic	Additional Comments	References
Perth Individualised Marketing Project					
'Individualised marketing' project in South Perth area	For selected sample, increased PT use 21% (+15 trips pa/person)	N/a: complex changes in trip-making occurred as result of campaign.	• • Car trips for sample reduced 3.3 to 2.8 per day. • Average trip lengths reduced. • 14% reduction in car kms for sample.	• • Results relate to selected sample of households which were 'interested' in alternative modes to solo car. • Results from survey shortly after marketing campaign (including free PT pass) had expired.	James, 1998
Winchester (UK) Individualised Marketing Project					
Individualised marketing project of sample households with limited bus use.	• • Only 23% of selected sample offered free bus pass made significant use of it. • 13% of pass users said trial had great effect on their travel behaviour. • Overall pass users did reduce car use and increase bus use, but difficult to isolate seasonal factors. • For shopping trips, was a significant reduction in car use (75% to 61%) and an increase in bus use (3% to 11%).	N/a	No evidence. Unlikely to be significant.	Short term effects disappointing. Longer term effects unknown.	King et al. 1997

Appendix E:

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