Quantifying the Impact of Social Severance Caused by Roads

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Contents

Executive Summary . . . 7
Abstract . . . 10

1. Background . . . 11
- 1.1 Summary of Proposal . . . 11
- 1.2 Evaluation of Transport Projects . . . 11
  - 1.2.1 Transfund's Objective . . . 11
  - 1.2.2 Cost-Benefit Analysis (CBA) Approach . . . 11
  - 1.2.3 Project Evaluation Manual (PEM) Approach . . . 12
- 1.3 Purpose of Study . . . 13
- 1.4 Defining the Terms . . . 13

2. Concept of Severance Impacts of Roads . . . 14
- 2.1 Ways that Roads Impact on People . . . 14
  - 2.1.1 Community Severance . . . 14
  - 2.1.2 Dislocation . . . 16
  - 2.1.3 Overview . . . 16
- 2.2 Traditional Assessment of Social Impacts of Roads . . . 18
  - 2.2.1 Physical Indicators of Severance . . . 18
  - 2.2.2 Social Indicators of Severance . . . 19
  - 2.2.3 Qualitative Assessment of Social Impacts . . . 21
- 2.3 User Preference Assessment of Social severance . . . 21

3. The "Swedish" Methodology . . . 25
- 3.1 Introduction . . . 25
- 3.2 Overall Measure of Community Severance . . . 25
  - 3.2.1 Disturbance to Pedestrians . . . 25
  - 3.2.2 Delays to Pedestrians . . . 26
  - 3.2.3 Disturbance to Cyclists . . . 26
  - 3.2.4 Summary of Factors and Assumptions . . . 26
- 3.3 Critique of Swedish Methodology . . . 27
  - 3.3.1 Relevant Factors Excluded . . . 27
  - 3.3.2 Other Limitations . . . 27
- 3.4 Conclusions . . . 28

4. A New Zealand Methodology . . . 30
- 4.1 Identifying a Suitable Methodology . . . 30
- 4.2 Developing a Methodology for Pedestrians & Cyclists . . . 31
  - 4.2.1 Stage 1. Understanding Key Impacts of Changes to Roads . . . 31
  - 4.2.2 Stage 2. Collecting Data on Stated Preferences . . . 32
  - 4.2.3 Stage 3. Modelling Reaction and Behaviours . . . 32
  - 4.2.4 Stage 4. Measurement and Valuation . . . 33
  - 4.2.5 Adapting the Methodology for Cyclists . . . 34

4.3 Applying the Methodology 34
4.3.1 Stage 1. Establishing Project Parameters 34
4.3.2 Stage 2. Defining the Affected Population 34
4.3.3 Stage 3 Establishing Social Severance Costs of a Project 35
4.4 Reviewer's Comments 35
4.4.1 Overall Comment 35
4.4.2 Specific Comments 36
4.5 Reviewer's Conclusions 37
4.6 Comment on Reviewer's Conclusions 37

5. The Way Ahead 38
5.1 Further Research 38
5.2 The Broader Decision-Making Framework 38
5.3 Recommendations 40

6. References 41

Appendices

A. Modelling & Measuring Physical, Psychological & Social Severance 43
A1. Introduction: Understanding the Problem 43
A2. The Components of the Problem 44
A3. Solving the Problem 45
A3.1 Conceptual Framework 45
A3.2 Proposed Approach 47
A4. Summary of Modelling and Valuation 53
A5. Anticipated Costs 54
A6. References 55

B. Project Review Assessment of the Community Severance Effects of Roads 57
B1. Background 57
B2. Introduction 58
B3. Understanding the Impact 58
B4. Presenting the Stimuli 59
B5. Responses and the Payment Vehicle 61
B6. Summary 63
B7. The Way Forward 63
B8. References 65

Executive Summary

Purpose of the Study

This study was commissioned by Transfund New Zealand to *"develop a framework for the whole community that identifies and measures negative social severance impacts arising from road developments"*.

The project is directly related to two of Transfund New Zealand's 1999/2000 Key Topic Research Areas: Safety, and Environmental Effects.

The study's methodology is based on previously developed frameworks for analysing some aspects of the social impacts of roads.

The methodology, as set out in the Study Proposal, proposed *"a brief literature review, of both New Zealand and overseas information"*. ... The previous frameworks were to be ... *"further adapted to develop unit quantification for identifying and measuring social severance impacts on the general population. The utility of this developed framework (was to) be assessed by applying it to a bypass case study"*.

Concept of Severance Impacts of Roads

The changes to roads and traffic that lead to social impacts may include:

- changes to traffic volumes (which result in changes to noise levels, the intimidating effects of traffic, delays in crossing roads, changed perception of risk of injury);
- changes to the layout of the road and footpath system, including both modifications to existing roads and the construction of new roads or footpaths;
- changes to those aspects of traffic flows – noise, dust, glare of lights, visibility – that change the amenity of those living near or crossing roads.

The impacts of changes to roads on communities can be considered, in part, in terms of the impacts of community severance and of dislocation.

Community severance effects can be disaggregated into physical severance effects and their social and psychological outcomes. Severance, whether referring to physical or social aspects, is usually measured as a relative change. Attempts among social researchers to provide an objective or monetary value are the exception.

Dislocation effects of roads and traffic arise from the relocation of households out of an area, or the removal or destruction of facilities as a result of road construction, thereby disrupting the social connections of those households that are relocated or those which interacted with the facilities that are removed (e.g. a local park, or a local shop).

A number of methodologies and techniques have been identified for measuring the physical or social severance effects of changes to roads and traffic, or of contributing to an understanding of these effects. These involve either or both:

- defining a number of physical measures of changes to roads that can act as indicators of the social impacts of the overall changes, or
- identifying social indicators of potential disruption.

Physical measures of changes to roads are useful as indicators of physical severance and have been applied in both Swedish and Danish methodologies to assess the physical severance effects of changes to roads. However, these indicators are only of value if other research has established a relationship between them and the related physical severance effects. No research of this kind has been cited.

Social indicators of the predicted physical or social severance effects of changes to roads are largely based on demographic factors. A number of researchers have developed different indices which they have used to compare the severance effects of different road proposals. While these methodologies have been useful, there is no widespread support for their use and no clearly defined basis for their quantification of comparative impacts.

Qualitative assessment of, and comparison between options for, changes to roads is traditionally undertaken using a combination of research techniques, including demographic indicators and social research based on highly consultative processes. Comparisons between road options are based on a number of criteria, and using informal or qualitative analytical procedures.

An alternative approach is based on the use of a methodology drawn from market research developed for costing non-market-related goods such as passive recreation and environmental resources. This research draws on the stated preferences of the target population to quantify or provide a monetary value for the various intangible outcomes of changes to roads.

This latter research can provide an understanding of the physical, psychological, and social severance effects of changes to roads through the measurable relationships between physical changes in roads and traffic, changes in psychological perceptions, social valuations, and trip-related behaviours. In turn, these can act as direct input into decisions about how these traffic changes are likely to disrupt social networks and community functions.

Methodology for Assessing Severance Impacts of Roads in New Zealand

A number of fundamental difficulties stand in the way of applying an established overseas methodology, such as the Swedish methodology or other techniques, to New Zealand conditions. These include the absence of any cited research basis to explain (or create an alternative to) the mathematical expressions which are used in the Swedish methodology to establish a monetary value from the road-function parameters; the exclusion of a number of variables likely to be relevant to New Zealand; and reliance on theoretical pedestrian trip-generation rates for households that would be difficult to establish.

The original expectation of this project was that, with some further elaboration, the Swedish methodology could be adopted for New Zealand use/conditions. With the further analysis undertaken as part of this study, this is clearly not practicable. Consequently, an alternative methodology has had to be identified.

Recommendations

The recommended approach to quantifying and putting a monetary value on the physical or social severance effects of roads is based on contingent valuation methodology. This is a well established, if sophisticated, research-based approach.

The steps required to undertake further research involve:

- establishing the willingness-to-pay values for pedestrians in relation to changes to roads;
- establishing the willingness-to-pay values for cyclists in relation to changes to roads;
- for a particular project:
  - defining the nature of the changes to the road and/or traffic,
  - defining the affected population,
  - establishing, from the above, the physical/social severance costs of the different road/ traffic options.

In recommending further research based on contingent valuation, this report also identifies a number of issues that should be considered before any commitment is made to implement this recommendation. These are:

- the degree of risk involved in proceeding further with the recommended research methodology, i.e. to apply contingent value techniques to perceptions of roads, which is an area where these techniques have not been widely applied;
- the relatively high cost of this research;
- the number of road projects for which this methodology may be justified in the future;
- the availability of alternative methodologies (e.g. multi-criteria analysis) that could be used separate from, or as an alternative to, contingent valuation in order to understand the costs of physical severance, or even of other aspects of the community impacts of roads.

Abstract

This report describes investigating ways of quantifying the severance effects of roads. Extensive investigations were made of overseas practice, to see what, if any, potential existed for modifying existing procedures to New Zealand conditions. The research concluded that insufficient background information existed to transfer other methods in a reliable manner. Therefore a stated preference survey was designed to quantify the parameters associated with a contingent valuation appraisal of this issue. Details of the survey design are presented, but significantly more work is needed to trial this approach. Estimates of the resources required to carry out this additional work are also included in the report.

1. Background

1.1 Summary of Proposal

This study was commissioned by Transfund New Zealand (Transfund) in order to *"develop a framework for the whole community that identifies and measures negative social severance impacts arising from road developments"*.

The project is directly related to two of Transfund's 1999/2000 Key Topic Research Areas: Safety, and Environmental Effects.

The study's methodology was to be based on previous work by Tate (unpublished), who had developed a framework for analysing some aspects of the social impacts of roads.

The methodology, as set out in the Study Proposal, proposed *"a brief literature review, of both New Zealand and overseas information. Then Tate's and Halsted's frameworks (were to) be further adapted to develop unit quantification for identifying and measuring social severance impacts on the general population. The utility of this developed framework (was to) be assessed by applying it to a bypass case study"*.

1.2 Evaluation of Transport Projects

1.2.1 Transfund's Objective

Transfund is a Crown entity established in July 1996 under the Transit New Zealand Amendment Act 1989. The Act clearly separates the funding and delivery of roading and passenger transport, with responsibility for all funding activities being vested with Transfund. In managing the National Roading Programme (NRP), Transfund strives to fulfil its mission:

> *To achieve the greatest benefit to road users and the nation from every dollar spent.*

1.2.2 Cost-Benefit Analysis (CBA) Approach

The number of potentially worthwhile projects usually exceeds the amount of money Transfund has available to distribute. For this reason, it has to rank projects in order of priority on a national basis before the Transfund Board considers them for approval. To do this a Cost-Benefit Analysis (CBA) framework is used to determine the discounted benefits and costs of the project over its lifetime. In the case of roading projects, the (discounted) benefit:cost ratio (BCR) is a tool used by Transfund to do this. For projects that are Alternatives to Roading, it uses an efficiency ratio. An efficiency ratio is calculated in the same way as a benefit:cost ratio except that it also takes into account private revenue (such as bus fares) that could be generated by the proposed project.

A CBA approach aims to compare project costs and benefits in common monetary terms wherever feasible. A project's benefits are identified and the monetary benefits estimated in terms of its potential to reduce accidents, travel times, and vehicle-operating costs. Strategic factors and intangible benefits (including environmental factors) are also considered and, where feasible, represented in monetary terms. Costs include the project's capital, maintenance and operating costs in dollar terms. On the basis of these factors, a BCR is calculated for each project.

The number of projects Transfund approves each year depends on the anticipated flow of revenue into the National Roads Account. Projects are prioritised based on their BCR. For 2000/01, new roading projects with a BCR above 3.0 will be funded.

1.2.3 Project Evaluation Manual (PEM) Approach

The PEM is the definitive guidebook for completing a roading project evaluation in conformity with Transfund's requirements. Three levels of effects are considered in the PEM (Section A8.1 of the PEM):

- Tangible effects with standard monetary values including vehicle-operating costs, and the value of work travel time;
- Intangible effects which have been given standard monetary values including the statistical value of human life, the value of non-work travel time, the comfort value from avoiding unsealed road driving conditions (all derived from Willingness to Pay surveys), and the damage caused by carbon dioxide emissions; in addition the PEM gives indicative values for the impact of small size particulates, noise and site-specific (mostly related to perceived safety) discomfort; and
- Intangible effects which have not been given a standard or indicative monetary value in the PEM, either because it is inappropriate or it has proved difficult to establish such a value; these include some aspects of air quality impacts, water quality, ecological and visual impacts, and the effects of community severance.

For those significant intangible effects where a monetary valuation is not provided, the PEM recommends either a rigorous Willingness to Pay (WTP) survey, or the use of the "back-calculation" procedure to derive an implied value. Using the latter approach, the BCR is adjusted to reflect the intangible's impact and this implies a specific increase in discounted benefits. The benefits are then undiscounted to give a typical annual value and this can then be related to a meaningful unit effect for the intangibles concerned (e.g. $ per affected household). A judgement is then taken on the reasonableness of this unit impact and accordingly accepted or revised.

Social severance is often a clearly identified social impact of road improvement schemes, and has proved difficult to measure. The motivation for this research project was to improve the approach used by Transfund to evaluate this impact.

1.3 Purpose of Study

This project's purpose was to establish a quantitative measure of the social severance effects of changes to roads and, if possible, to establish monetary measures for these costs. This was seen to be a means of assisting in Transfund's assessment of the benefits (and disbenefits) of road projects, given that no standard or indicative values are provided for the severance effects.

1.4 Defining the Terms

Terms used when discussing the social impacts of roads on communities are difficult to define because they are inter-related and also they are interpreted differently by different researchers.

For the purposes of this report, such terms have been given the following meanings:

Community impact – refers to all the various ways that roads impact on a community. It includes physical severance which leads to social severance, and also to dislocation impacts and psychological impacts.

Physical severance impact – refers to the physical changes to the ability of people to move around the locality, particularly on foot or by cycle.

Social severance impact – refers to the wider social effects arising from physical severance.

Dislocation impact – refers to the impacts on people when they are relocated out of an area because of direct acquisition of property required for road construction.

Psychological impact – refers to the various psychological effects of other changes arising from the impacts of roads, e.g. how people perceive and value an area, changes in symbolic associations and imagery.

2. Concept of Severance Impacts of Roads

2.1 Ways that Roads Impact on People

Changes to the design and function of roads obviously can result in different social consequences for people living near them, that arise directly or indirectly from a number of sources.

Direct effects include:
- changes to local accessibility (local routes become more or less convenient to use);
- relocation of households and facilities, or other psychological effects;
- changes to the nature of the physical environment (noise, view).

Indirect effects arising from these direct physical and behavioural changes imposed by the road changes include:
- changes to the frequency and nature of social interactions in the area;
- changes to the satisfaction or enjoyment people gain from activities undertaken;
- changes to peoples' psychological response to the physical and social environment.

While the social impacts of changes to roads have long been studied and discussed, and while there is much agreement on the nature of the various impacts, there is no clearly agreed framework within which the overall phenomenon has been analysed. The following is an outline of social impacts of roads, using the framework identified by Cramphorn (1993) These elements are:

- *Community severance* – the impacts on a community resulting from some of its features being severed by changes to roads, e.g. *"the variety of disruptive effects that new roads can have in a local neighbourhood or community, including changes in or loss of access to neighbours, facilities or transport, changes to established patterns of activity, isolation of one area from another, changes to land use"* (VicRoads, Cramphorn 1993:15).
- *Dislocation* – the impacts of *"the involuntary displacement and relocation of people from their place of residence and can include financial and psychological loss"* (VicRoads, Cramphorn 1993:29).

2.1.1 Community Severance

The concept of social severance is itself complex and has been the subject of a number of attempted definitions, for example:

- *"the variety of disruptive effects that intrusive traffic or roads can have in a local neighbourhood or community area"* (John Paterson Urban Systems 1974);

- *"the long-term division of an existing neighbourhood structure and/or the separation of residents from facilities and services they use within the community as a result of change in road patterns and traffic levels"* (EIS North West Transport Link 1992);
- or as several types of severance – relocation severance, barrier severance and severance by traffic, as described by Appleyard & Lintell (1969).

Other researchers see *social disruption* as being a more comprehensive term than social severance in that it includes both the rupture of relationships between people and between people and institution. It also includes *"factors which dislocate a person's identity, pattern of life and psychological well-being"*.

Cramphorn (1993:16) noted that ... *"Essentially, severance is concerned with breaking connections. The most extreme form of severance is where people and businesses must leave premises that are acquired for road construction ...... Then there are the people, business or community facilities who remain in the area after the new road is constructed. For them, these broken connections may be behavioural or they may be perceived or psychological"*.

Community severance can be distinguished as resulting from the sequential outcome of the physical changes to a road and its environment (e.g. direct changes to local accessibility), and the social consequences of those changes (e.g. changes to the pattern of local interactions and choice of services). These are classed as the physical and social severance effects, and the psychological effects.

2.1.1.1 *Physical Severance*

Physical severance effects of road changes include:

- changes to the physical design of the roadway, e.g. increased lanes;
- changes to traffic volumes or proportion of large trucks (with consequential changes in noise or gaps between vehicles);
- the introduction of a road where none existed;
- changes to pedestrian crossing points or facilities, including truncation of existing routes;
- the addition or removal of bicycle lanes;
- changes to kerb-side parking;
- changes to access for adjoining properties.

Physical severance effects are readily observed and can in many cases be objectively measured.

2.1.1.2 *Social Severance*

The social effects of physical severance are the resulting social outcomes of physical changes on the community that undertakes activities in the vicinity of the changed road. These involve *breaking connections*, and include such factors as changes to local social interactions, changes to recreational activities, changes to access to local goods and services.

These can include abandoning the desired interaction altogether (e.g. giving up visits to the local park or picnic ground, or local milkbar), having less frequent interaction (e.g. only going once-a-week instead of daily), choosing alternative contacts or venues (e.g. going to other shopping centres or parks, joining other clubs), or at less convenient times, or changing mode of travel (e.g. driving children to school, instead of letting them walk).

2.1.1.3 *Psychological Severance*

Psychological effects of severance relate to the perception that places are more difficult to access, or less worthy of access, as a result of changes to traffic or roads. Psychological severance relates to changed perceptions, for psychological rather than objective reasons, of the accessibility of places and people.

Cramphorn (1993:2) observed that *"Indirect/psychological severance impacts are reflected in the way people feel about or relate to an area. This can result from physical changes to the qualities of familiar or valued places, important community symbols or icons, or by the intrusion into the scene of new road - related structures. This can result in people feeling cut off from, or less strongly connected with areas, places, people or services".*

2.1.2 Dislocation

Dislocation refers to facilities being abandoned or relocated away from an area because of the proposed roadworks, or because people are forced to relocate their homes. Cramphorn (1993:17) observed that *"Dislocation impacts occur primarily at the individual or household level as a result of direct property acquisition or disruption, or people moving away as a result of significant changes to the valued features of the residential environment. Some groups in the community are more vulnerable to dislocation than others - for example, elderly, long-located residents tend to find change more difficult. However, people who have chosen a locality for its specific environmental characteristics will find significant change to that environment difficult to cope with. Dislocation impacts can also have secondary effects in the broader community, if for example friends move away or business or service catchments are diminished".*

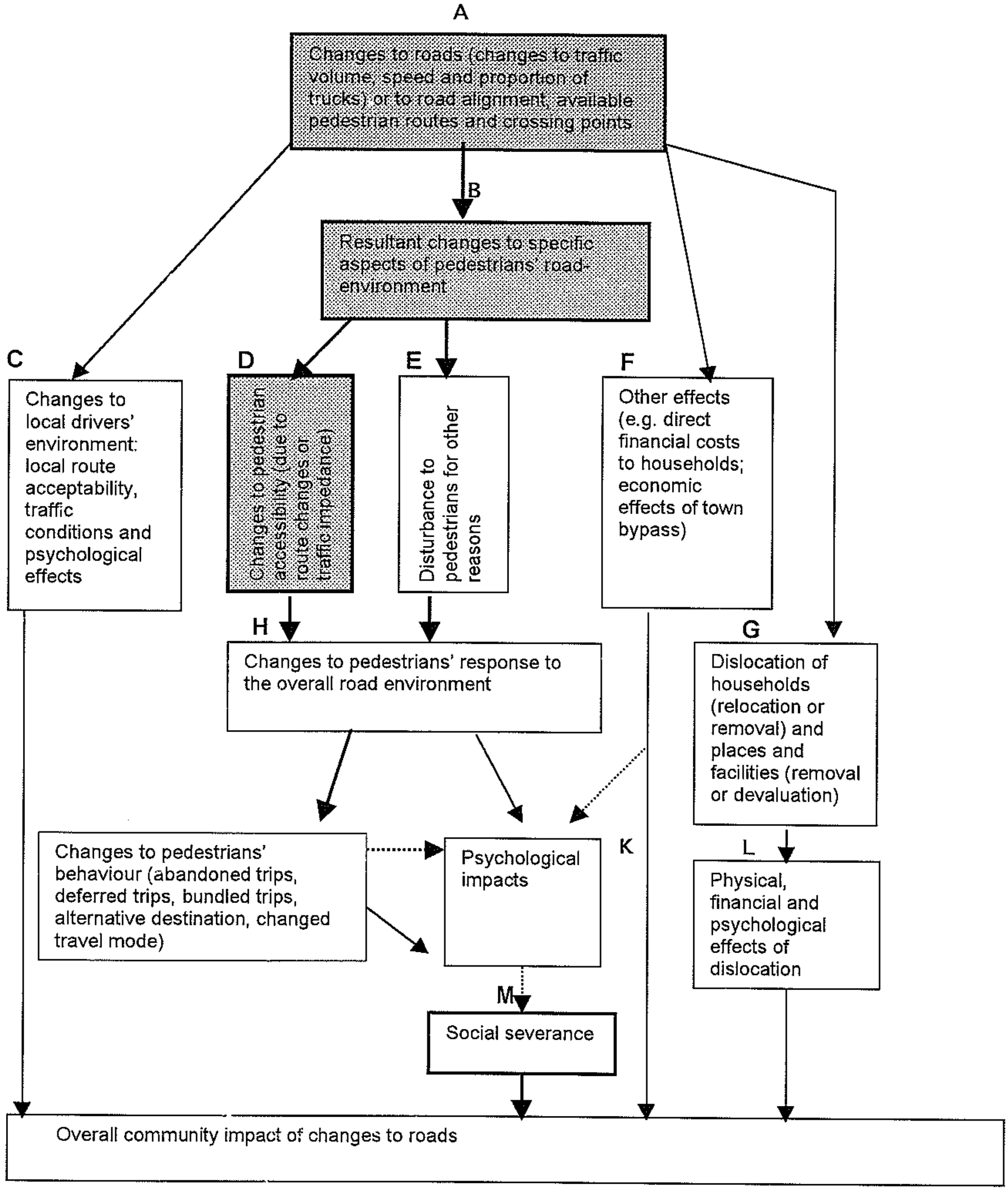
Dislocation effects will include a number of related effects:

- changes in accessibility to services and social contacts (as for physical severance);
- the psychological effects of loss of a familiar and valued community and home, together with psychological perceptions of other changes; and
- the financial effects of relocating – changes in the cost of housing or of accessing necessary or desired services, community and work.

2.1.3 Overview

Figure 2.1 illustrates the relationship between changes to roads and traffic, and the effects on the community in terms of severance, dislocation and other outcomes. This figure reflects community responses to changes to roads as being part of an overall environmental/social system.

Figure 2.1 Model of community severance effects of changes to roads (as part of overall social impact).



Legend: [shaded box] **= elements making up the *Physical Severance Effects* of roads**

Concerning physical and social severance, the figure indicates the relationship between the physical changes to roads, the consequent subjective perceptions of individuals of those changes, the personal responses to those subjective perceptions, and the eventual behavioural outcomes. However, this figure also illustrates the broader relationship between the physical and social severance effects of changes to roads, and the overall system by which changes to roads impact on the community's and individuals' social and physical well-being.

2.2 Traditional Assessment of Social Impacts of Roads

Traditional approaches to measuring social severance have involved the use of:

- physical measures of changes to roads that can act as indicators of the social impacts of the overall changes;
- social indicators of potential disruption;
- social research using both demographic and social factors that will indicate the qualitative aspects of physical and social impacts of changes to roads.

2.2.1 Physical Indicators of Severance

Some researchers have sought to identify physical characteristics of roads that can provide an indicator of the physical consequences for pedestrians or cyclists. Examples are discussed by Tate (unpublished), and include a *Conflict Index*, *Pedestrian Delay*, or measures correlating with pedestrians' perception of crossing-risk.

Comprehensive examples of the former approach are the Swedish and Danish methodologies for assessing the physical severance effects of roads. In these two methodologies, three objective measures of physical severance are defined:

- the "barrier" effect that changes to roads introduce to a pedestrian's propensity to cross that road;
- delays to trips for those pedestrians that choose to continue existing trips;
- the "disturbance" effect of changes in traffic for cyclists using the road.

The first and last of these measures are expressed mathematically in terms of such components of the road environment as traffic volume, traffic speed, and proportion of large trucks in the traffic stream. Other factors include some indicator of the propensity of pedestrians to cross the road, based in turn on either the latent pedestrian crossing-demand or the land-use type. The delay time created by changes to roads can more readily be based on objective measures of the expected increase in pedestrian trip-times.

The relevant mathematical expressions contained in the Swedish methodology (Swedish National Road Administration (NSRA) 1986) are presumed to be based on, and can be validated by, social research. However, these methodologies have been long-established, and no English research texts have been cited (other than English translations of Swedish operational manuals). This issue is discussed further in Section 3 of this report.

The advantage of this approach is that, if reliable indicators of social severance can be identified, the approach would allow quantification of at least the physical effects of changes to roads. However, to date it has not been possible to establish any reliable correlation between objective measures of the physical characteristics of roads and their consequences in terms of social severance. None of the texts referred to provide a sound theoretical basis on which a fuller developed, community-scale methodology could be based.

2.2.2 Social Indicators of Severance

Numerous attempts have been made to identify indicators of the potential disruption of changes to roads. The more important of these are outlined below.

Definitions of a community and measures of its vulnerability, typically based on such indicators, have been proposed by different researchers to include combinations of such factors as the following:

- household size;
- socio-economic status – presumed to be relate to reduced (financial) resources to adjust to changes, also to relate positively with community leadership and inversely with community cohesion;
- proportion of households with dependants;
- level of education (proportion of households with educational or trade qualifications) – relating to the propensity for community leadership;
- persons employed in community services – relating to the propensity for community leadership;
- residential mobility (persons living in the same dwelling for more than 5 or 10 years);
- car availability (or households without a car) – presumed to relate to patterns of neighbouring and to correlate inversely (for "households having a car") with the strength of local community linkages;
- proportion of those who cycle/walk to work – on the presumption that closer work-home linkages correlates with greater community cohesion;
- age and ethnic composition profiles (the proportion of older residents presumed to correlate positively with strength of social networks, particularly in combination with residential stability); proportion of persons aged 15 years or less – presumed to facilitate community cohesion;
- population density and length of residence – presumed to relate to social interaction;
- proportion of English-speaking households – presumed to correlate with social inclusion;
- housing tenure – with owner-occupancy presumed to correlate positively with community values and cohesion.

Data from a population census provides the necessary information to identify much of the above. However, much of this data is relevant only to the extent that a spatial community is appropriate and can be reliably defined.

Sociologists have tended to move away from the concept of a homogeneous spatial community, and towards the concept of areas being occupied by a series of overlapping communities, defined by such factors as shared interests or values, with individuals or households being members of several different communities.

Nevertheless, there appear to be benefits in identifying the physical framework in which the social interaction that may be affected by roads takes place. Ellis (1968, in Cramphorn 1993:24) emphasised the significance of residential linkages *"... between the housing site of the household and other spatially distinct points which are of importance to the individuals involved"*. He also observed, *"Communities in this context are defined through delineating concentrations of linkages and the greatest vulnerability occurs where linkages are not substitutable – probably where most interaction is locally based and pedestrian dependent"*.

Various forms of analysis and indices have been devised to provide comparative measures of community stability or vulnerability. Indices have included:

- Simple Negative Social Impact Index (Finterbusch & Wolf 1981);
- Mobility Index (Hill & Franklin methodology, California Division of Highways);
- Neighbourhood Social Interaction Index (Burkhardt 1973).

Other methodologies combined social characteristics of the community and its physical context, e.g. Social Feasibility Model (FHWA methodology, c.1970s).

Other work has sought to demonstrate the relationship between the social and spatial environments, e.g. the concept of landmark identification and mental maps, which identify the perceived important features of a neighbourhood. This is presumed to correlate with both the spatial characteristics and the strength of community interactions (Lee & Tagg 1976; Gould & White 1986).

A different approach has been sought by Tate (1991), wherein a limited number of specific social responses to the characteristics of roads (e.g. the propensity for parents to allow a child to cross a road unaccompanied) are proposed as surrogate indicators of the severance effects of traffic. However, Tate has not established any theoretical basis on which such surrogate indicators could be used to provide a wider, quantified assessment of the severance effects of roads.

The above indicators of the potential of communities to experience disruption by roads have achieved broad, if not detailed, agreement about many of the factors that are relevant to this issue. However, they tend to be based on generalised conclusions about social behaviour. They are useful in supporting qualitative conclusions and comparisons of different road proposals but they do not, in general, have the research basis to justify quantification of their conclusions in relation to specific road projects.

In conclusion, none of the methodologies or research techniques discussed above provides a useful basis for further developing this research project.

2.2.3 Qualitative Assessment of Social Impacts

The most common method, internationally, of assessing the social impacts of changes to roads relies on the qualitative assessment of a wide range of factors affecting the social outcomes for communities and individuals affected by changes to roads and traffic. This type of research uses both demographic indicators to describe the affected population and extensive consultation with both key representatives of, and a sample of representative members of, the affected communities (e.g. Sinclair Knight Merz 1999).

Comparisons between alternative road options are usually based on a qualitative comparison between options, using ordinal or scalar ranking of the options against a number of criteria. These criteria may in turn be weighted using informal or formal community consultation, peer or other expert assessments.

One example of a system for weighting and scaling road design options, including both the different components of community impacts, together with construction costs, the economic benefits of reduced travel costs and other intangibles, is one or other of the available scoring or weighting systems, e.g. Multi-Criteria Analysis (MCA). MCA can be used to apply weightings to different aspects of community severance, or to scale community severance effects against one or more of the other intangible or tangible effects. Various processes can be used to develop the necessary weightings, using professional assessments, community involvement, or a combination. One technique is to conduct a value management workshop in which both professional and community representatives participate.

While these methods of qualitative assessment are widely used, they are not appropriate to this study which is required to establish a method that will quantify the physical severance impacts of roads and give these impacts a monetary value.

2.3 User Preference Assessment of Social Severance

An alternative approach to developing an analytical structure within which to find ways of measuring the social severance impacts of road changes is provided by the use of stated preference or revealed preference choice models which have been derived through market research. This methodology depends on applying sophisticated market-research procedures that use consumer choices to develop logit models of individuals' choice-making behaviour. Consumer choices are either ***stated*** to researchers in response to demonstrations of abstract alternatives (stated preferences, or SP), or ***revealed*** to researchers through observations of individuals' real choices (revealed preferences, or RP). The assumption underlying this approach is that people base their choices (in this case, with respect to certain behaviours) on the attributes of the environment which in this case are road design and traffic conditions. The general methodology is also referred to as contingent valuation (CV) methodology.

An overall conceptual framework that can be used to relate changes to roads to eventual physical severance outcomes is described in Figure 2.2.

This approach starts from the understanding that changes to road, e.g. widening a road can lead to changes in a variety of physical variables, that in turn can impact the surrounding community. These changes may impact visual amenity, sound amenity, smells, and perceptions of well-being, safety, hassle, access, etc.

This methodology integrates a variety of well-developed approaches that each solve pieces of this problem, but also can be shown to logically fit together. Conceptual frameworks exist that can be readily adapted to this problem and technology exists to implement the proposed solution. This problem has been recognised for some time in other areas of application. For example, similar approaches are reasonably well-known in cognitive psychology and can be traced back to the work of Guildford in the 1950s, Anderson in the 1960s, and Louviere in the 1970s and 1980s. Recent discussions can be found in Hensher et al. (1999) or Louviere et al. (2000).

While the following discussion outlines the principles of this methodology, as applied to assessing the social severance effects of roads, a fuller description is provided by Louviere in Appendix A of this report.

Figure 2.2 indicates the stages that are involved in people changing their behaviour as a result of changes to roads. These stages include the process of individuals forming utilities or values about specific changes to roads, then about the overall collection of changes, then the collective evaluation by the community, leading at the end to different observable behavioural manifestations and/or different psychological manifestations.

The stages form a series of interrelated processes, which are consistent with random utility theory in cognitive psychology and economics. The conceptual framework shows that one can "mix and match" measures from different stages in the process to explain outcomes at later stages.

The framework also tells us that behavioural or psychological outcomes can be explained by direct observation/measurement of physical variables and/or managerial actions like road right-of-way, number of dedicated, marked pedestrian crossings, average traffic volume at time 't', etc. (project variables). However such direct estimations obscure intermediate processes and/or overlook the potential role of intermediate processes and measures. The advantage of the latter integration is that one can explain outcomes (impacts) in terms of:

- physically observable and measurable (engineering) variables; and/or
- psychophysical variables (beliefs/perceptions); and/or
- marginal utility measures; and/or
- holistic utility measures; and
- individual characteristics/differences.

The conceptual process underlying the theory on which stated preference analysis is based is set out in Figure 2.2, which also indicates the relationship between these steps and those described in the overall Model of Community Severance Effects, shown in Figure 2.1.

Revealed Preference (RP) methods have been used in transport studies to try to model the function implied by the composition of equations representing the Stages 1 to 5 that are outlined in Figure 2.2. Contingent valuation methods have been used to model processes involved in Stages 2 to 5. There has been considerable research in psychology, neurophysiology and human factors engineering involving the implied relations between Stages 1 and 2 (called "psychophysics", i.e. mapping physical reality into perceptions).

Figure 2.2 Conceptual framework for use in stated preference evaluation of physical severance effects of roads.

Stage 1 (Tasks A, B in Figure 2.1): Different actions that change observable characteristics (or variables) of roads and traffic (e.g. new roads, additional lanes, pedestrian crossings, traffic volumes, proportion of heavy vehicles in the traffic stream).

↓

Stage 2 (Tasks D, E in Figure 2.1): Subjective attribute of (dimension) used by individuals to assess each of the different project characteristics (i.e. a project can be considered to have a subjective attribute or dimension for each of its different characteristics.

↓

Stage 3 (part Task G in Figure 2.1): Evaluations by different types of people of each of the different subjective attributes or dimensions of roads and traffic.

↓

Stage 4 (part Task G in Figure 2.1): Evaluations by different types of people of overall projects as bundles of scores or values of each of the subjective attributes or dimensions.

↓

Stage 5 (Task J in Figure 2.1): Overall or total behaviours resulting from the impacts of a specified project (e.g. change in feasible pedestrian routes) and/or key social impacts (e.g. changes in perceived safety or amenity).

Table 2.1 outlines the extent to which factors identified in Figure 2.1 may be subject to analysis using the stated preference methodology.

This construction provides a logically consistent framework within which the overall problem can be solved. An understanding of physical, psychological, and social severance effects can directly provided through the measurable relationships between physical changes in roads and traffic, changes in psychological perceptions, social valuations, and trip-related behaviours.

In turn, these can act as direct input into decisions about how these traffic changes are likely to disrupt social networks and community functions. The methods used have considerable theoretical and empirical validity for applications like or analogous to these.

Table 2.1 Contingent Valuation (or Stated Preference) analysis and factors affecting community severance.

Factors of Overall Community Severance Effects[1]	Potential for Stated Preference or Other Analysis
Changes to pedestrians' behaviour in response to changes in traffic conditions	Subject to Stated Preference (SP) analysis. Requires separate assessment of number of pedestrians affected.
Delay in pedestrians' crossing times as a result in changes to traffic conditions	May be subject to assessment using SP analysis. Otherwise, will require separate assessment and costing of delay effects. In either case, would require separate assessment of number of pedestrians affected.
Changes to local drivers' behaviours in response to changed local traffic conditions	May be subject to SP analysis, but involves more complex issues. Requires further investigation. Also would require a separate assessment of the number of local drivers affected.
Changes in cyclists' behaviours in response to changed traffic conditions	Subject to SP analysis. Requires separate assessment of number of cyclists affected.
Psychological severance arising from perceptions of changed road conditions (relating to individuals' situations, expectations, values, etc.)	Not subject to SP analysis. Qualitative assessment most appropriate, based on extensive interviews with community representatives.
Physical, financial and psychological effects of dislocation of places or people	Not subject to SP analysis. Qualitative assessment most appropriate, together with financial assessment where appropriate.
Other effects, e.g. direct or indirect economic effects	Not subject to SP analysis. Combination of qualitative, financial and economic assessment where appropriate.

1 These factors are the same as those illustrated in Figure 2.1.

3. The "Swedish" Methodology

3.1 Introduction

The following discussion outlines the Swedish methodology for measuring the severance effects (changes in community linkages) of changes in the road system. This methodology has been described in some detail because it is one of only two methodologies that have been identified for assessing and quantifying the effects and costs of the physical severance effects of result from changes to roads. (The other is the somewhat equivalent Danish methodology, Road Directorate Denmark 1992.)

3.2 Overall Measure of Community Severance

The Swedish methodology provides a monetary value for the severance effect of roads and traffic. It is calculated in Kroner (Kr) as the sum of:

- the value of disturbance to pedestrians;
- the value of delay caused to pedestrians;
- the value of disturbance to cyclists.

An appropriate monetary value (in Kr) is applied to the factors for pedestrian delay and disturbance to cyclists. With respect to pedestrians, the monetary value of disturbance is weighted for different age groups, presumably to allow for their different degrees of vulnerability according to age, i.e. the total monetary value of disturbance for all pedestrians takes account of the age-group mix of those pedestrians.

3.2.1 Disturbance to Pedestrians

The measure of disturbance is a function of the product of the barrier effect of the final road alignment and of pedestrians' "unconstrained" need to cross it. Barrier effect is a function of traffic volume, traffic speed, and the proportion of trucks in the traffic stream.

Pedestrians' "unconstrained" need to cross a particular road alignment is the sum of all theoretical pedestrian movements across the route of the road as if the road itself did not exist, i.e. it did not create any barrier. This takes account of all pedestrians who are likely to travel across this alignment when travelling between their homes and other likely local destinations, including community facilities, parks, public transport stops, and so on.

Because this calculation is highly theoretical, the numbers of trips are calculated from a pedestrian trip-generation table. This is intended to reflect the trip-generating characteristics of pedestrians, as modified by age, attractiveness of different destination-types, and type of urban area.

3.2.2 Delays to Pedestrians

The extent to which pedestrians are delayed (or save time) in crossing an existing road or proposed road alignment, related to changes on the road or traffic conditions, is calculated as the sum of the change in time for all pedestrian trips across the relevant road alignment.

The number of trips across a length of road (or proposed route) is calculated from the trip-generation table (Section 3.2.1), for the relevant population and the previously identified trip destinations. The Swedish methodology requires separate, manual calculations to be made to allow for the effects of changes to traffic signals, the introduction of over/underpasses, or other physical features that will facilitate or impede pedestrians when crossing the road

Where pedestrians will directly cross the traffic stream, the calculated delay takes account of the average traffic volume.

The Kr value of delays to pedestrians is based on the value for time, which is treated as equal for pedestrians of all ages.

3.2.3 Disturbance to Cyclists

Disturbance to cyclists travelling along the road is calculated as the product of three factors: the longitudinal barrier effect of the road, the extent of overtaking by other vehicles, and the length of potential travel by cyclists along the road.

3.2.4 Summary of Factors and Assumptions

From the above, the Swedish methodology of calculating community severance effects of road changes is seen to be applicable only to residential areas, and to rely on the following information:

- average traffic speed;
- average traffic volume;
- average proportion of trucks in the traffic stream.

Likewise, information required to calculate the theoretical need of pedestrians to cross a road includes:

- dwelling locations and numbers (these need to be calculated from field observations);
- likely pedestrian destinations (10 different destination types are used, some of which appear to have no Australian or New Zealand equivalents, that would be calculated from field observations);
- proportion of different age groups present in the household population (e.g. this would be obtained from ABS[1] data at CCD[1] level in the Australian context and from equivalent data for New Zealand);
- a trip-generating table for pedestrians, modified by age (using 5 age groups), destinations (10 types are identified), and type of urban area (three types identified); a specific table would need to be established for the New Zealand context).

---

1 ABS Australian Bureau of Statistics
CCD Census Collectors' District

Calculation of delays to pedestrian crossing times requires data on the effect of changes in road design, and of the effect of any ameliorative design or management actions as they affect crossings made by pedestrians.

Calculation of disturbance to cyclists travelling along a road requires data on typical cyclist trip lengths (which is derived from field research).

3.3 Critique of Swedish Methodology

A number of problems that exist with the Swedish methodology are described here.

3.3.1 Relevant Factors Excluded

Factors which are likely to affect physical severance but which are not well identified in the Swedish methodology and therefore limit its usefulness include:

- some aspects of road width, which are needed for calculating the barrier size of roads such as:
  - road width, e.g. the number of lanes (though it is possible that road width, in terms of number of lanes, will have a reasonable correlation with traffic volume) and/or
  - facilities to support road crossings by pedestrians, e.g. median strips;
- the trip-generating potential of pedestrians (which will probably correlate with different types of urban area);
- types of urban areas (the Swedish methodology only identifies three types: 'central part of town', 'suburban part of town', 'rural area, small village with no children', though there are clearly variations on the type of suburban area);
- number of cars owned by the average household (which may also be related to household size, urban location, and socio-economic status);
- socio-economic status of the relevant population;
- average trip length (pedestrian trip numbers fall off rapidly with increased trip length, and the average trip length will vary for different age groups);
- with respect to disturbance to cyclists,
  - road edge conditions (which includes the presence of parked cars),
  - frequency of intersections,
  - road surface conditions,
  - near-side/adjacent lane width.

3.3.2 Other Limitations

Other limitations to applying the Swedish methodology to changes to roads in an existing urban environment, are noted in the following points.

1. The analysis must be used in the 'before' and the 'after' situation, i.e. there must be a measure of the relative change in barrier effect. In many cases, the need to measure changes in severance will relate to the effect of changes to an existing road rather than the introduction of a new road. However, the details of the Swedish methodology appear to relate only to a non-road/new-road situation and it is not clear from the available material how to apply the methodology to changes to existing roads and traffic.

2. The overall measurement for disturbance to either pedestrians or cyclists that is provided by the methodology is simply an index number. It is not clear what this number relates to in terms of meaningful changes in pedestrians' perceptions or behavioural responses. There is no way to determine what correlation, if any, is between the calculated disturbance index and changes in pedestrians' preparedness to cross a particular road after it has been modified.

3. No evidence has been cited to explain or justify the monetary values that are placed on this index number for different age groups.

In terms of the overall system representing community impacts of roads, the Swedish methodology appears to provide a direct prediction of Stage 5 effects as illustrated in Figure 2.2, on the basis of calculations relating to the Stage 1 variables. Presumably, the formulae have (or should have) been derived on some basis that encapsulates the factors in Stages 2 to 4. However, no evidence has been cited that would support any such assumption.

3.4 Conclusions

The Swedish methodology for calculating a monetary value for the severance effects of changes to roads provides an analytical framework and a specific methodology that is intended to provide a monetary value for severance effects. However, while the framework is useful, the specific methodology has a number of serious flaws that make it quite unsuitable to use as a basis for a methodology that could be developed for New Zealand conditions.

The original study brief was developed on the assumption that the methodologies considered by Tate (1997) and Halsted (1999) for assessing the costs of the physical severance effects of roads, which was in turn influenced by the Swedish methodology, would be supported, albeit with some modifications and elaboration. With this expectation, the original study brief proposed that the study's concluding phase should be a real-life case study, which would both demonstrate and test the proposed methodology. While Tate (1997) has provided a useful description of the Swedish methodology, his analysis did not identify the serious deficiencies of this methodology that would affect its direct application in New Zealand, as discussed in Section 3.3.

From the preceding analysis, neither the Swedish methodology nor any variation of it could be adopted because of a number of fundamental deficiencies. The most serious of these is the lack of any acknowledged, theoretical basis for the quantification of severance effects. Nor are any of the other approaches to quantifying physical severance, as discussed in Section 2 of this report, considered to be appropriate for use in the current New Zealand context.

However, the Swedish methodology does provide a useful, if broad, structure and within this structure it is possible, as discussed in Section 4, to apply more reliable methodologies to quantify and put into monetary terms the physical severance effects of roads.

4. A New Zealand Methodology

4.1 Identifying a Suitable Methodology

In reviewing options for a methodology to place a monetary value on community severance for New Zealand, two different approaches have been identified:

- A Swedish-based methodology containing three distinct components: disturbance to pedestrians; disturbance to cyclists; and delays caused to pedestrians crossing a road. These provide a useful analytic framework, but is seriously deficient as a means of developing any relative or monetary value for severance effects.

- A methodology based on developing stated preference (SP) models, relying on survey respondents' statements. These could be used to place a monetary value on the different variables of a road with respect to the different populations of cyclists and pedestrians. (A variation to these is the revealed preference, or RP, model, which relies on people's values being revealed through their real-life choices.)

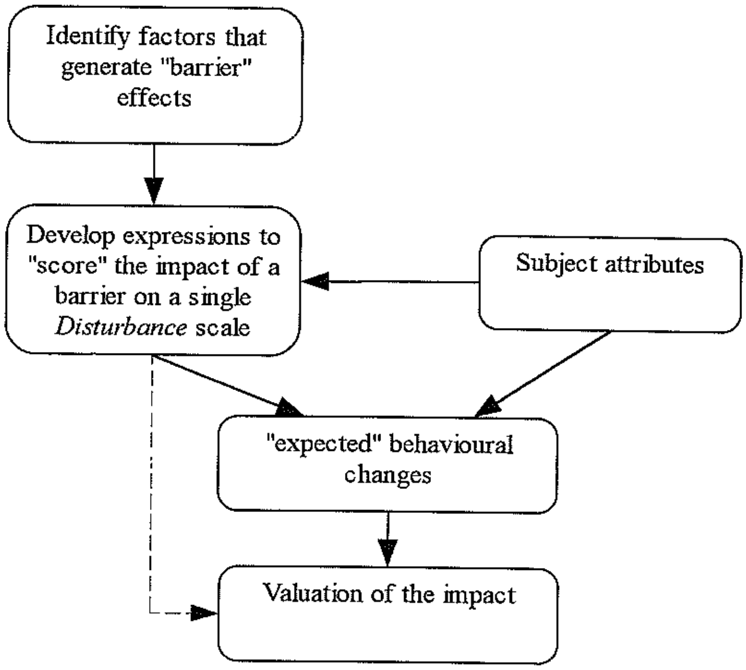
The Swedish methodology, together with other available methods for quantifying physical severance, have been rejected, as discussed in Sections 2.2.3 and 3.3.

The methodology based on the Stated Preference (SP) model is an alternative means of quantifying the costs related to disturbance to pedestrians and cyclists, and encapsulated in the Swedish methodology. It may be able to incorporate the costs of delays to pedestrians as part of the overall costs to pedestrians. Costs in all situations are established in terms of willingness to pay (to obtain, or avoid) (WTP) or willingness to accept (WTA) the proposed changes to roads.

A more detailed description of this methodology is set out in Appendix A. An outline of the version that is proposed for use in New Zealand is described below in Section 4.2. This version is based on the conceptual framework described in Figure 2.2.

A draft of this project report has been reviewed by Tate, peer reviewer for this project. Tate's full review is included in Appendix B for reference while his comments, generally supportive, are incorporated in Section 4.2 of this report. Tate has provided a useful illustration (Figure 4.1) of the concepts involved in the overall model that is recommended in this report, which draws together the common elements of the Swedish method and the SP method.

Figure 4.1 Model of the process for quantifying social severance (from Tate 2001).



4.2 Developing a Methodology for Pedestrians & Cyclists

In order to establish the social severance costs of a particular project, it is necessary to establish pedestrians' and cyclists' willingness-to-pay (WTP) or willingness to accept (WTA) values for all the elements of that project. This requires the steps set out below. The principles of the methodology can be applied to both pedestrians and cyclists, with only the affected populations being defined on a different basis for any project. In the following discussion, "pedestrians" should be read as "cyclists" unless specifically stated.

4.2.1 Stage 1. Understanding Key Impacts of Changes to Roads

A series of discussion sessions would be organised to include a broad cross section of the types of communities that are of interest to Transfund. The objective of these sessions would be to understand the variables that people considered important in assessing changes to roads and how they would react to them. A short-term response might be to change where they shop and a longer-term response might be to relocate their place of residence.

A cross section of key groups needs to include people likely to be affected by potential road and traffic changes. For example, this cross section might include large and small cities, high- and low-income areas, and those who use public or non-motorised forms of transportation. The groups should also include some individuals who already have and who have yet to experience such changes.

The focus group discussions should result in a comprehensive list of possible reactions to road and traffic changes. These would include any changes in perceived physical, psychological and social factors, expected experiences, trip and location valuations, and the resulting behaviours. This list should allow researchers to accurately describe potential changes in terms and in images relevant to community members, and to measure potential reactions in terms relevant to Transfund. If the list of reactions produced by the discussion groups is especially lengthy, it would need to be reduced to a manageable and actionable size.

Any unresolved issues relating to the questions of whether the road environments can be adequately represented by multi-media displays, or whether respondents are able to adequately assess the relevant road design variables, would require further research in this stage of the experiment, in order to validate these aspects of the research design.

4.2.2 Stage 2. Collecting Data on Stated Preferences

This stage requires the development of a stated preference experimental design. This would involve collecting stated preference data using surveys of a sample of community members and designing the relevant mathematical models.

Respondents would each be presented with a series of multimedia images (at least 100 images or "project scenarios" in total) that vary according to the transport project actions that may or may not be taken. Examples should show some images with heavy traffic and some images with light traffic. The images would be specifically selected or created to express the information identified as important to community members when they make judgements about the effects of road and traffic changes on them. Some of these images should be as descriptive as possible of the types of project(s) likely to be proposed for the interviewees' community.

With each image, interviewees would be asked a number of questions to gauge their likely response to road and traffic changes. These questions would cover the range of reactions condensed out of Stage 1. That is, interviewees would be asked to associate each behavioural outcome with each image. Some questions would require "yes/no" answers, such as "would you cross a road like this to go to shops on the other side if the traffic project displayed were in your neighbourhood?" or "Would you move out of the neighbourhood or community?" Other questions would likely pertain to "how much?" or "to what degree" the interviewees would associate particular outcomes with the traffic project image, such as level of noise, feelings of safety, a sense of community disruption, etc.

4.2.3 Stage 3. Modelling Reaction and Behaviours

Using the data collected in Stage 2, statistical modelling efforts would be undertaken to describe the relationships between information presented in the images and the responses collected with each image. The resulting models would express how changes in the ways in which road and traffic are described correlate with, and can predict, changes in reactions.

The models would allow proponents of changes to estimate how behaviour is likely to change with individual and/or multiple variable simultaneous changes to project activity. The models will provide estimates of the value of each action or variable and the differences in the values of projects.

Because the models express the system of relationships between a range of actions and reactions, such models can be generalised to other populations and situations that fall within the same range. This is likely to apply to many projects and communities within New Zealand. Thus, Stages 1 and 2 would only need be done once and could be periodically updated (e.g. every five years or so) using smaller samples to determine if there has been a change in community attitudes, values and behaviours that would occasion a change in Stage 3. Obviously, if some dramatic event occurs or there is a significant shift in community attitudes towards transport in general, the models would need to be updated. The models should be able to be used without modification so long as the images included in Stage 2 are representative of the systems, technologies and physical environments of concern, i.e. no significant changes to systems or technology have occurred that would require the changes to be incorporated into the images and/or the urban physical environment. Experience suggests that five years is probably a good time to re-assess Stage 3 outputs to establish if changes need to be made.

4.2.4 Stage 4. Measurement and Valuation

Once an appropriate behavioural choice model has been estimated in Stage 3, it can be used to solve the valuation problem by calculating WTP or WTA. The appropriate model depends on the nature of the choices that respondents made. For example, if the task is a choice between the project proposed for their community versus computer-generated images of another project, this is a binary choice. Hence, the likely model variants are based on mathematical equations that allow for violations of the traditional assumptions that the error components of the two projects being compared are independent and identically distributed. If a third choice option is added to the task, such as "these two options are so unacceptable to me that I would do [*something else*]" (where *"something else"* is to be specified by the researcher), the model is a multinomial choice model with two choice options that are constants (i.e. proposed project and do something else). Thus, the form of the choice model would remain fairly simple.

The study requires a theoretically defensible way to measure the value of physical or social severance. Methods for valuing public goods that are not traded in real markets have been extensively studied in environmental and resource economics. The basic theory necessary to solve the problem was proposed and developed by Hanneman (1984) for discrete choice models. One needs to convert utilities or utility differences into money, so that we can measure the implied value of changes in the features of a project, actions taken or differences in projects. One worked example of this approach is discussed in Appendix A.

4.2.5 Adapting the Methodology for Cyclists

The same research would be required to establish the WTP or WTA values for changes to roads as they affect the population of cyclists. Cyclists can be considered simply as an extension of the population of pedestrians, but as their experience of the road environment, and their responses to it, will be quite different, the research described in Stages 1 to 4 would need to be undertaken for separate population samples, using separate research procedures.

In order to establish the social severance costs of a particular project, the WTP or WTA values for the affected cyclist population relating to all the elements of that project would have to be established. This requires the following steps.

4.3 Applying the Methodology

4.3.1 Stage 1. Establishing Project Parameters

Using road engineering, traffic engineering, visual or other analysis, the proposed road project or its variations, together with the existing situation, would be analysed and defined in terms of the variables that have been determined to be relevant to any WTP or WTA analysis.

Because traffic flow varies over time (by hour, by day, by week, and seasonally), an agreed methodology would need to be developed to define these traffic characteristics in ways that will be simple while also ensuring valid comparisons of different projects The appropriate definition of traffic flow may be affected by the details of the road/traffic variables defined in Stage 1 for Pedestrians (Section 4.2.1), and the way people respond to them. They should therefore be established after the WTP and WTA costs have been established.

4.3.2 Stage 2. Defining the Affected Population

The population affected by a particular road project can be defined in a number of ways. A definition of this population should:

- provide for a valid comparison between different projects;
- be applicable along the length of a road project;
- be simple to compile.

For pedestrians, the population could be based on residents/employees within a specified distance of the road alignment, or from counts of pedestrians actually crossing the defined road alignment. The latter appears to be the most relevant but, again, because pedestrian crossing rates vary by hour, day, etc. and will also be affected by weather, some way of sampling the pedestrians crossing a road alignment needs to be used that would ensure consistency between different roads and along the length of any route. For cyclists, it would be best to establish the extent of cyclist usage (for an existing road) or to find some comparative basis for estimating cyclists' use of a future route (in the case of a proposed new road).

The details of the procedure to define the affected population should be established after WTP and WTA values have been established.

4.3.3 Stage 3. Establishing Social Severance Costs of a Project

The costs of the social severance impacts of a particular project must be considered in relative terms, e.g. relative to the status quo and/or relative to other road/traffic options.

The costs would be established by applying the established WTP or WTA costs/person to the affected population, as defined for the alternative options.

4.4 Reviewer's Comments

4.4.1 Overall Comment

Tate's overall comment (in Appendix B) is generally supportive of the methodology set out in this report:

> *The framework proposed is similar to that used by others (Swedish Method) and appears likely to be successful.*
>
> *The use of contingent valuation methods is reasonable, and in Prof. Louvier the researchers have an internationally recognised expert in this area.*

Tate also concludes that *"The separation of behavioural change and reaction from valuation is one of the strengths of the revised approach"*.

Tate has reservations with respect to the following three issues:

1. *Details of exactly what is proposed by way of multimedia images are lacking;*
2. *Little evidence presented to support the assumption that the participants will be able to accurately extract meaning from the multimedia images;*
3. *The initial discussion of the variables to be tested, and the possible levels of these, is inadequate and leads to concerns over how the experimental testing will be conducted.*

Tate has also identified three other issues which he considers bear on the valid use of SP or RP studies. These are:

1. *The degree to which the subjects are able to "understand" the impact or good in question;*
2. *Suitability of the stimuli in conveying information about the attributes of the good in question; and*
3. *The payment vehicle.*

These issues and reservations provide the framework for the following brief discussion of the three issues which Tate considers will need to be addressed during the further stages of research that are still to be carried out

4.4.2 Specific Comments

4.4.2.1 *Understanding the impact of traffic*

Tate has expressed concern that severance impacts are poorly understood by both experts and the public in general. He therefore suggests that, in the early stages of establishing the details of this methodology, checks should be made *"on the relative 'values' that participants assign to the various components to the problem"*. Tate refers to the requests that communities often make for a pedestrian crossing to be installed to address safety issues, but will only make limited use of such a facility when it is installed (e.g. *"However ... we find that parents may in fact not allow young children to cross at a pedestrian crossing unaccompanied")*. A second example is the difficulty, identified by researchers, that many people have in estimating the speed of, and gap between, passing vehicles.

Tate sees this lack of understanding as an issue to be addressed in the careful design of the whole research procedure.

The understanding of survey respondents about the effects of traffic changes on delays to pedestrians when crossing a road needs to be tested. In many situations, delay effects will be modified by engineering works that may not be readily comprehended by survey respondents in the simulated situation (e.g. a new pedestrian footbridge, or changes to traffic signals). To ensure that it is appropriate to include this element in the simulated situation or, alternatively, to ensure that it is excluded from evaluation and quantified as a separate exercise, is important.

4.4.2.2 *Presenting the stimuli*

While Tate acknowledges the benefits that multi-media images provide in this kind of research, particularly in avoiding bias, he is concerned whether it is reasonable to expect this technique to provide a reliable representation of the real world. Issues to be addressed in this area of the research project include:

- the problem of perception of speed;
- providing respondents with adequate knowledge about conditions of the research 'scene';
- the length of time required to provide an accurate understanding of the traffic stream;
- subject fatigue.

Tate (1997) refers to other researchers (e.g. Orland 1999) who, in discussing the developing role of multi-media, note that the respondents need to be immersed in the environment. Tate is concerned that more understanding may be needed of the spatial relationship between the observer and the traffic scene.

4.4.2.3 *Assessing Willingness to Pay (or Accept)*

Tate was interested to gain a better understanding of how the sample of respondents would be chosen, and how the research situation would be framed so that respondents could identify with it in a way that gave relevance to their assessment of some form of monetary trade-off.

4.5 Reviewer's Conclusions

While generally supporting the proposed use of SP or RP methodology, Tate's major concern is to use further research to test the validity of the multi-media images as the means of providing appropriate and reliable stimuli about traffic and roads to the survey respondents. Tate suggests that this issue could be dealt with in the initial research phase with focus groups, or as a separate component of the study. He also suggests, in the event that this technique is too expensive or unreliable, an alternative technique, relying on the respondents' knowledge of real road situations. In either case, the work would be completed before committing to the full scale study.

4.6 Comment on Reviewer's Conclusions

A number of issues have to be addressed in the design of an SP- or RP-based study to assess the costs of social severance of roads.

The methodology itself is well developed and has been widely practised in relation to the pricing of various public goods. The issues raised by Tate are appropriate to consider as part of the development of the detailed experimental design, along with a number of others. Unless the researcher is able to demonstrate that the issues raised by Tate can be adequately addressed by the experiment's design, they can be included in Stage 1 of the experiment. (Reference has been made to this issue in Section 4.2.1 of this report.)

5. The Way Ahead

5.1 Further Research

On the basis of the preceding discussion, the process required to provide a methodology for establishing a monetary value for the physical severance costs of different road projects in New Zealand involves:

- Undertaking research to establish WTP and/or WTA values of the different elements of road projects for pedestrians and for cyclists (as described in Sections 4.2 and 4.3, with a general indication of likely costs for this research provided in Appendix A).
- Undertaking research to establish an acceptable methodology for defining the population affected by any road proposal, and for defining road and traffic characteristics that would be used in such methodology (as described in Section 4.3).
- Other areas of research that may arise as a result of the detailed outcomes of the first two points above.

The original study proposal included the work necessary to quantify and provide monetary costs for the physical severance effects of roads, including the work necessary to complete a case study of the methodology. In response, this study has provided a comprehensive description of the tasks required to achieve the proposed outcome.

However, this study has also demonstrated that the scope and scale of work involved in achieving the proposed outcomes, as set out in the study proposal, is a quantum larger than envisaged when this study's budget was set, and the original study methodology was outlined in the study proposal.

Further development of this project is envisaged to lie in one or more stages beyond the work reported here. The Discussion Paper prepared by Jordan Louviere (Appendix A) sets out a methodology by which a study brief and budget could readily be prepared for this further work.

5.2 The Broader Decision-Making Framework

In reviewing this project and the preceding recommendation, clearly any decision to proceed further should be considered in a wider framework which includes the following considerations:

- the degree of risk involved in proceeding further with the proposed research methodology;
- the cost involved in proceeding further;
- the number of road projects to which this assessment methodology may be applied in the future;
- alternative courses of action that could be considered, separate from or in addition to that proposed above.

Internationally, the accepted approach to assessing the physical severance effects of roads clearly relies on project-specific research that will provide a qualitative comparison of the different road options. This is commonly combined with qualitative assessment of the other impacts of roads that together make up community severance. The result is a broader understanding of social consequences than can be provided by the analytic framework on which this project is focused, which was physical severance alone.

Only two examples have been identified of a methodology to quantify physical severance of roads: the Swedish and Danish methodologies. The Swedish methodology has been found to be deficient, mainly due to the lack of documented justification for its detailed methodology but also due to significant deficiencies in the variables that are measured. The Danish methodology is apparently based on a generally similar approach to the Swedish one and also suffers from a lack of any documentation. In these circumstances, neither methodology can be supported nor adapted for use in New Zealand.

The approach recommended in this report (i.e. contingent valuation) is based on a well-developed methodology. However, as Tate has observed, this methodology has not been extensively applied to valuing elements of roads and traffic. Consequently, some degree of innovation may be required in applying the research technique to this subject. Tate has drawn attention to some of the issues to be addressed in this respect, together with further comments by the author (Sections 4.4, 4.5). This aspect of further research using this methodology may therefore involve some degree of risk, though it is not feasible to assess its extent.

The further research recommended here is relatively expensive (costs are outlined in Appendix A). Therefore Transfund should also consider the benefits/costs of proceeding to establish this methodology. This requires Transfund to consider the number of situations in which physical severance may be significant and in which it would be valuable that it be quantified. If the technique will only be used rarely, then its benefits may not justify the high cost and, at the least, a small degree of risk in seeking to progress further.

The above question poses a further question of course: how can the significance of physical severance (or other aspects of community severance) caused by roads be established without undertaking some kind of research (quantified or otherwise) in the first place.

Other methodologies can also be used to answer the last question and they, in many or most situations, may be sufficient for Transfund's purposes. One example is multi-criteria analysis (discussed in Section 2.2.3) which can use various processes to establish weightings for the different tangible and intangible elements of project impacts. This allows quantified and non-quantified aspects of a project to be compared on a scalar basis. This technique could be used to assess the intangible aspects of a project, but also to allow these aspects to be scaled against the quantified project outcomes.

5.3 Recommendations

The recommendations arising from this study, which was to develop a methodology to quantify and provide a monetary value for the physical severance effects of roads, are that:

- the methodology commenced by Halsted (1999) and Tate (1997) for this purpose is not feasible to develop further;
- the appropriate means of answering the Brief's purpose is to undertake further research based on contingent valuation methodology (costs and further details are set out in Appendix A);
- before making any commitment to such further research, Transfund should consider a number of issues relating to the context in which this research would be undertaken and its result applied, namely:
  - the degree of risk involved in proceeding further with the recommended research methodology, i.e. to apply contingent value techniques to perceptions of roads, which is an area where these techniques have not been widely applied;
  - the relatively high cost of this research;
  - the number of road projects for which this methodology may be justified in the future;
  - the availability of alternative methodologies (e.g. multi-criteria analysis) that could be used separate from, or as an alternative to, contingent valuation in order to understand the costs of physical severance, or even of other aspects of the community impacts of roads.

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Appendix A Modelling & Measuring Physical, Psychological & Social Severance

by **J. Louviere, 2000**

A1. Introduction: Understanding the Problem

Sinclair Knight Metz (SKM) desire to propose and develop an approach to measuring the impact and/or value of severance effects associated with transport projects in association with a larger project for Transfund New Zealand. The objective of this report is to propose and detail an approach to this problem and attempt to determine the likely resource (time and cost) implications of undertaking it in a real setting. Previous work on measuring and valuing severance has been undertaken in Sweden and Denmark and is outlined elsewhere in the SKM report to Transfund, but we do not pursue this approach in this report.

The problem can be stated relatively simply. Some transport projects involve community dislocation, such as major road widening projects that require homes or businesses to be moved, relocated and/or acquired and demolished; or some projects involve significant changes to existing transport structures or systems but not dislocation, such as removal of pedestrian overpasses, limiting access, etc. In the former case, there are issues about dislocation and its impacts and/or changes to individuals' resulting behaviours. In the case of the latter, there may be significant changes in individuals' actual or perceived levels of safety, noise, ability to access or level of difficulty in accessing facilities, etc. The problem addressed in this report is the development of a general approach to solving this problem that can be applied in real field settings.

In the report draft supplied to me (JL) by SKM, the following (italics) was stated:

The changes to roads and traffic that lead to social impacts may include:

- *changes to traffic volumes (which result in changes to noise levels, to the intimidating effects of traffic, delays in crossing roads, changed perception of risk of injury);*
- *changes to the layout of the road and footpath system, including both modifications to existing roads and the construction of new roads or footpaths;*
- *changes to those aspects of traffic flows – noise, dust, glare of lights, visibility – that change the amenity of those living near or crossing roads.*

Changes to roads and traffic can have a number of disruptive (or beneficial) effects on the behaviour and experiences of individuals and communities. Where these changes lead to changes to local trip-making behaviour and thereby to community interactions and linkages, they are referred to as 'community severance' effects. In this sense, the term 'community severance' refers to a relative change in some aspect of a local community's behaviour and experiences.

Community severance effects of roads and traffic can be conceived as the following elements:

- *Physical severance – being the objective measure of changes in trip convenience. These can be defined in terms of the number of trips affected, changes in trip length and factors affecting perceived risks or amenity associated with trips.*
- *Psychological severance effects – relate to perceptions of changed accessibility to or social value of places. These perceptions do not necessarily equate with objective measures of changed accessibility or value. For example, if people perceive a trip or trip outcome as being less convenient, less enjoyable, riskier or less worthwhile, they may change their behaviour or experience a change in enjoyment of a place, even if objective measures show that there is no change in convenience or amenity or risk. If people see a valued place as not worth visiting because of changed (traffic affected) its amenity or context, then that is a psychological effect of roads and traffic (i.e. as if part of that place's social value had been removed or severed and was therefore no longer 'accessible').*
- *Social severance effects – relate to the social consequences of changes in trip making which, in turn, arise from physical or psychological severance effects. That is, all desired (or needed) trips can be seen as having some social purpose, so that the important consequences of not making a trip are the social consequences. Trips are not (or are rarely) made as ends in themselves.*

The dislocation effects of roads and traffic arise from the relocation of households out of an area or the removal or destruction of facilities as a result of road construction, thereby disrupting the social connections of those households that are relocated or those which interacted with the facilities that are removed (e.g. a local park, or a local shop). Where changes to roads (e.g. as with a bypass) would render non-viable any community facilities that provide a community focus or service, then cessation of these services would be another form of dislocation.

All members of a local community can experience the consequences of community severance effects. Those trips that are most affected by changes to roads will be those on foot or bicycle. Those persons who rely predominantly on these forms of transport will experience the greatest relative impacts of changes to roads and traffic. Those who have least recourse to alternatives in coping with community severance effects – the transport disadvantaged – will be the most affected.

A2. The Components of the Problem

A transport project involves decisions about variables, many of which are under the control of the project designers, planners and engineers. For example, a decision to add an extra lane to an existing arterial to satisfy the objective of increasing peak-hour volume and average traffic speed involves (inter alia) the following variables:

(a) the actual road width, including the paved surface and shoulder plus any centre dividing areas and possibly also drainage areas, such as ditches;

(b) the type, number and spacing of cross-arterials;

(c) the number of traffic lights;

(d) the number of marked pedestrian crossings, in addition to crossing associated with cross-arterials, etc.

Thus "widening a road" can lead to changes in a variety of physical variables, which in turn can impact the surrounding community. These changes may impact visual amenity, sound amenity, smells, and perceptions of well-being, safety, hassle, access, etc.

The basic research problem that needs to be addressed may therefore be stated as follows:

> *To provide a logical and defensible conceptual framework by which one can model and measure these impacts and their value to impacted communities.*

A3. Solving the Problem

A3.1 Conceptual Framework

One solution to this problem is to integrate a variety of well-developed approaches that each solve pieces of this problem, but also can be shown to logically fit together. Fortunately, conceptual frameworks are available that can be adapted readily to this problem and technology exists to implement the proposed solution. In fact, this problem has been recognised for some time in other areas of application. For example, approaches are reasonably well-known in cognitive psychology, and can be traced back to the work of Guildford in the 1950s, Anderson in the 1960s, and Louviere in the 1970s and 1980s. Recent discussions can be found in Hensher et al. (1999) or Louviere et al. (2000). The basic framework is shown in Figure A1.1.

Figure A1.1 formalises the stages that individuals go through to form utilities or values and compare their past, present or future states to form overall (holistic) evaluations of projects and respond in some way (i.e. different observable behavioural manifestations and/or different psychological manifestations). The stages form a series of interrelated processes, which are consistent with random utility theory in cognitive psychology and economics. The conceptual framework shows that one can "mix and match" measures from different stages in the process to explain outcomes at later stages. The framework also tells us that behavioural or psychological outcomes can be explained by direct observation/measurement of physical variables and/or managerial actions, like road right-of-way, number of dedicated, marked pedestrian crossings, average traffic volume at time t, etc. (the vector X), but such direct estimation obscures intermediate processes and/or overlooks the potential role of intermediate processes and measures.

Figure A1.1 Overall conceptual framework.

$X_1, X_2, \ldots, X_K$	1. K different actions that change observable project variables (eg, width of right-of-way).
$S_j = f_{1j}(X_{jm})$, m subsets of K	2. J subjective dimensions used by a community to assess project impacts (ie, a project has a value on each dimension).
$v_{ji}(S_{ki}) = f_{2j}[(S_{ji}), Z]$	3. (E)valuations of different subjective values on each dimension by different types of people (Z).
$V_i = f_3[v_{ji}(S_{ji}), Z]$	4. (E)valuations of I different projects as bundles of scores or values on each of the J subjective dimension by different types of people (Z).
$P(\text{Behaviour}_b) = f_4(V_i, Z)$	5. B total Behaviours relevant to the I-th project's severance impacts (eg, change in pedestrian movements) and/or key subjective social impacts (eg, changes in feelings of personal safety).

The advantage of the latter integration is that one can explain outcomes (impacts) in terms of:

1. physically observable and measurable (engineering) variables (X), and/or
2. psychophysical variables (beliefs/perceptions) (S), and/or
3. marginal utility measures (v), and/or
4. holistic utility measures (V), and
5. individual characteristics/differences (Z).

Revealed Preference (RP) methods have been used in transport to try to model the function implied by the composition of equations 1-5 (in Figure A1.1). Stated Preference (SP) methods have been used to model processes involved in stages 2 to 5. It also is worth noting that there has been considerable research in psychology, neurophysiology and human factors engineering involving the implied relations between stages 1 and 2 (called "psychophysics" - mapping physical reality into perceptions).

The framework provides a logically consistent framework with which to develop an approach to solving the overall problem. SKM's interest in understanding physical, psychological, and social severance effects are directly addressed through the measurable relationships between physical changes in roads and traffic, changes in psychological perceptions, social valuations, and trip related behaviours.

In turn, these can act as direct input into decisions about how these traffic changes are likely to disrupt social networks and community functions. The methods used have considerable theoretical and empirical validity for applications like or analogous to these.

A3.2 Proposed Approach

Basically, SKM needs to know how members of affected communities are likely to feel/ react/ behave in response to potential changes in transport systems. This problem requires a researcher to understand and model how community members are likely to react to changes in a transport system. This problem is solved using a multi-stage research program as outlined below.

Stage 1 Context and Issue Specification

Understanding the key impacts on community members in engineering terms and in community members' terms

- *Discussion Group Organisation:* A series of discussion sessions are organised so as to include a broad cross-section of the types of communities of interest to Transfund. The objective of these sessions is to understand the range of ways in which members of the public expect that transport changes could impact them in the short- and long-term and how they think they would be likely to respond to these changes. A short-term response might be to change where they shop, and a longer-term response might be to relocate. The groups need to include a cross section of key groups likely to be affected by potential road and traffic changes. For example, this cross-section might include large and small cities, high- and low-income areas, and those who use public or non-motorised forms of transportation. The groups should also include some individuals who already have and who have yet to experience such changes. A discussion moderator should be assigned to guide each discussion group through the relevant issues with the aim of drawing out the information required to address the project objectives.

- *Discussion Group Introduction:* The initial 15 to 30 minutes of each group should be used by the moderator to explain the purpose of the sessions and illustrate the nature of the coming discussion with a multimedia presentation that educates and informs participants about possible ranges of projects. This will provide participants with a common basis for the subsequent discussion. For individuals who have experienced projects in the past, the multimedia presentation should be used to illustrate other possibilities than what they have experienced.

- *Discussion Session:* After participants are briefed and their questions about the materials answered, the moderator should focus the groups' discussions on how participants think they and their neighbours would react to these and similar road and traffic changes. The discussions should yield a fairly extensive list of the types of variables and/or pieces of information community members are likely to use in making judgements about road and traffic changes, and a fairly extensive list of real and perceived reactions they are likely to make in response to these variables or information.

The judgement information should be of the sort that SKM could use to select from or create images that communicate the kinds of changes that Transfund have in mind in a form that is relevant to community considerations. For example, the discussion may identify visual cues such as size of rights-of-way, number and spacing of protected pedestrian crossings, and number of heavy trucks in the traffic stream. The list of reactions can include impacts that are discrete or matters of degree. For example, reactions can include decisions about whether a community member would change the place they normally shop, the route they take to work, or even move to another community. Other reactions can include indications of how much or to what degree a road or traffic change is likely to affect community members; like feelings of safety, community image, levels of noise, or a sense of community.

- *Comprehensive Specification of Information and Reactions:* The focus group discussions should result in a comprehensive list of possible reactions to road and traffic changes. These will include any changes in perceived physical, psychological and social factors, expected experiences, trip and location valuations, and the resulting behaviours. This list should allow researchers to accurately describe potential changes in terms and images relevant to community members and measure potential reactions in terms relevant to Transfund. If the list of reactions produced by the discussion groups is especially lengthy, it will be necessary to reduce it to a manageable and actionable size. This can be done in a fairly straightforward manner whereby a small sample is used to review the total list to produce a more concise subset of reactions and experiences[1].

Stage 2 Stated-Reaction Data Collection

Collecting quantifiable information about community members' reactions to road and traffic to changes.

A larger number of community members are required for this stage in the project – the size of the sample will need to be specified, based on the number of distinct sub-communities likely to be affected by the proposed changes. These community members are individually presented series of multimedia images (at least 100 images or "project scenarios" in total) that vary according to the transport project actions that may or may not be taken, e.g. some images with heavy traffic and some images with light traffic. The images are specifically selected or created because they express the information identified as important to community members in making judgements about how road and traffic changes will affect them. At least one of these images should be as descriptive as possible of the project(s) proposed for the interviewee's community.

[1] A small sample (no more than 50 people) can be used to capture 90% of the likely responses to changes on road and traffic (Hauser & Simmie 1992). Most/Least analysis (Finn & Louviere 1991) can be used to develop this comprehensive list in a simple and reliable fashion. These 50 (or fewer) respondents are shown the same introductory material as used to brief the discussion groups. Each respondent is then provided a series Most/Least tasks. In each task an experimentally designed subset of reactions is presented for the respondents to review. The respondent indicates which one reaction in the subset they believe is the one that they are most likely to experience and which one they believe they are least likely to experience, should they face changes like those presented in the introductory material.

With each image, interviewees are asked a number of questions to gauge their likely response to road and traffic changes. These questions will cover the range of reactions condensed out of the final stage above. That is, interviewees are asked to associate each behavioural outcome with each image. Some questions would require "yes/no" answers, such as "would you cross a road like this to go to shops on the other side if the traffic project displayed were in your neighbourhood?" or "Would you move out of the neighbourhood or community?" Other questions would likely pertain to "how much?" or "to what degree" interviewees would associate particular outcomes with the traffic project image, such as level of noise, feelings of safety, a sense of community disruption, etc.

There are two ways these images can be created. The first involves using actual images from projects around New Zealand or other areas that Transfund believes to be suitable (e.g. possibly Australia). The second involves using computer-imaging techniques to design images that express the required range of information.

- *Using Actual Images:* Obtain a large sample (at least 100) of multimedia project images representative of all projects in New Zealand and/or that contain as much variation in variables that underlie the actions taken as possible. Each image must be coded for the information it contains about physical changes to the road and traffic conditions. For example, some multimedia images should contain light traffic, others heavy, some with heavy trucks, some without. Some images might describe narrow lanes and other wider lanes; some with few lanes and others with many lanes. To the extent that there is sufficient variation and relatively low levels of collinearity in the variables that comprise the images, one can estimate statistical models that relate the variables measured in each image to individuals' responses. This approach has been used with success in forestry and related applications by environmental psychologists in the US and elsewhere (see cited URLs in "References Cited") to measure how subjective quantities vary with objective, physical measures.

  To accomplish the valuation objective, interviewees are asked to compare each image with the "likely computer-simulated" image of the project proposed for their community. They are asked which image they would prefer (of the two) if the government determines that it is necessary to put the project in their community. A variation on this theme would be to allow them a third choice option, such as stating that "both are so unacceptable that I would take action x" (e.g. move elsewhere as soon as possible to avoid this). Other verbal information is varied with the images, such as the level of compensation paid to households identified as affected (this may vary with distance, and may require different payment vehicles for renters versus owners)[2].

[2] It should be noted that with respect to information about a payment vehicle that is co-varied with the multimedia images, an environmental or resource economist or someone with expertise in valuation should be involved in the design process to ensure that the questions and the way(s) in which they are asked are consistent with economic theory and can be used to derive proper valuation estimates. I'm not an expert in ways of asking such questions to insure that they are incentive-compatible and properly framed, but I have worked with experts in this field (e.g. Richard Carson, University of California, San Diego; Jeff Bennett, ANU; Wictor Adamowicz, University of Alberta).

- *Computer-Designed Images:* The second approach makes use of computer-imaging techniques to create hypothetical composite project images (instead of the real images in Option one) by using experimental design techniques to vary the information associated with each action systematically. This approach has the benefit of controlling for sufficient variability, eliminating collinearity, and providing consistent coding of image information. This approach has been used with success on projects in the US, Canada and New Zealand (e.g. see cited URLs in "References Cited").

Specifically, one obtains samples of still or full-motion video images and sounds representative of projects. An experimental design is used to vary the variables that underlie each image to produce composite images that correspond to each variable combination in the design. For example, previous studies have created composite images that vary the factors people use to evaluate images of remote lakes, forests and associated logging activity to produce composite images for the Ontario Ministry of Natural Resources. These images were used to model the impacts of logging activity on remote tourism choices to estimate tourists' willingness-to-pay for various enhancements to visual and auditory amenity as well as willingness-to-pay to avoid deterioration of visual and auditory amenity.

Stage 3 Reaction and Behavioural Modelling

Capturing and simulating the systematic relationships between physical changes and community reactions.

Using the data collected above, statistical modelling efforts are undertaken to describe the relationships between information presented in the images and the responses collected with each image. The resulting models express how changes in the way in which the road and traffic is described correlate with and can predict changes in reactions. The models allow SKM or Transfund to estimate how behaviour is likely to change with individual and/or multiple variable simultaneous changes to project activity. The models will allow SKM or Transfund to estimate the value of each action or variable and the differences in the values of projects.

Because the models express the system of relationships between a range of actions and reactions, the models can be generalised to other populations and situations that fall within the same range, which is likely to be many projects and communities within New Zealand. Thus, Stages 1 and 2 need only be done once and periodically updated every five years or so using smaller samples to determine if there has been a change in community attitudes, values, and behaviours that would occasion a change in Stage 3. Naturally, if some dramatic event occurs or there is a significant shift in community attitudes towards transport in general, one also would want to update the process. The models should be able to be used without modification so long as the images included in Stage 2 are representative of the systems, technologies and physical environments of concern, i.e. there are no significant changes to systems or technology that require the changes to be incorporated into the images and/or the urban physical environment. Experience suggests that five years probably also is a good time to reassess Stage 3 to determine if changes need to be made.

Stage 4 Measurement and Valuation

Once an appropriate behavioural choice model has been estimated in Stage 3, it can be used to solve the valuation problem by calculating willingness-to-pay (WTP) or willingness-to-accept (WTA). The appropriate model depends on the nature of the choices respondents made. For example, if the task is a choice between the project proposed for their community versus computer-generated images of another project, this is a binary choice. Hence, the likely model variants are simple binomial logit or probit or binary logit and probit that allow for violations of the traditional assumptions that the error components of the two projects being compared are independent and identically distributed. If a third choice option is added to the task, such as "these two options are so unacceptable to me that I would do [*something else*]" ("something else" to be specified by the researcher), the model is a multinomial choice model with two choice options that are constants (i.e. proposed project and do something else). Thus, the form of the choice model would remain fairly simple.

Because most applied work relies on simple model forms, I concentrate my discussion on them. In particular, we need a theoretically defensible way to measure the value of severance. Methods for valuing public goods that are not traded in real markets have been extensively studied in environmental and resource economics. The basic theory necessary to solve the problem was proposed and developed by Hanneman (1984) for discrete choice models. One needs to convert utilities or utility differences into money, such that we can measure the implied value of changes in projects' features, actions taken or differences in projects. Here is one description of how this could be undertaken, as an example case.

Let there be a status quo and a project, say S and P, and let their features be as indicated in parentheses. Then we can write utility expressions for these projects as follows:

$$U_S = 1.214\text{-}0.1(\text{change in travel time}_i) + .00163(\$\text{compensation offer}_i) - 0.0063(\text{change in vehicles/hour}_i)$$

$$U_P = 1.188\text{-}0.1(\text{change in travel time}_i) + .00163(\$\text{compensation offer}_i) - 0.0063(\text{change in vehicles/ hour}_i)$$

We need to calculate the utility of each alternative and the probability that it is chosen. This requires us to calculate the "expected value of max utility" (or inclusive value, IV):

$$IV = Ln[\Sigma_j e^{V(j)}]$$

The value that we want is the difference in IV, scaled by price. This is what economists call the "expected compensating variation" (CV):

$$CV = [1/\text{-}\beta(\text{price})](IV_0 - IV_1)$$

Now, let the status quo features equal zero (i.e. travel time, compensation and vehicles/hour all equal 0), and value a change in vehicles/hour in the project by increasing it 500 per hour. Then we would have the following.

The status quo is:

- $U(S) = e^{1.214} = 3.37$
- $U(P) = e^{1.188} = 3.28$
- $IV_{status\ quo} = 3.37 + 3.28 = 6.65$

To calculate the change we have:

- $U(S) = e^{1.214} = 3.37$
- $U(P) = e^{1.188-0.01x(0)+0.00163x(0)-0.0063(500)} = 0.14$

The probability of choosing S and P is as follows:

- $P(S) = 3.37 / (3.37 + 0.14) = 0.96$
- $P(P) = 0.14 / (3.37 + 0.14) = 0.04$

The compensation amount that equates S and P is:

- $Ln(IV_S) - Ln(IV_P) = Ln(6.65) - Ln(3.51) = 1.89 - 1.26 = 0.63$
- $\$ = (1/0.00163) \times (IV_0 - IV_1) = -613.50 \times 0.63 = \$386.50$

Thus, we would have to compensate each person $386.50 to get them to accept the change in vehicles per hour.

If there are two or more alternatives, the calculations are more complex. We again need to calculate the "expected utility" (IV parameter):

- $Ln[\sum_j e^{V(j)}]$, for all j in C
- expected utility, scaled by price = compensating variation:
- $CV = [1/-\beta(price)] \times [IV_0 - IV_1]$

Now suppose we allow subjects to choose between a proposed project for their community, another project that we show them form the designed experiment described in Stage 3, or relocating somewhere else that is acceptable (and we might want to observe the attribute levels that equate to "acceptable" for the new location). We might have:

- $U(proposed) = -2.5-0.1(travel\ time\ change_i) + 0.00163(\$compensation_i) - 0.0063(change\ in\ vehicles/hr_i)$
- $U(another) = -1.5-0.1(travel\ time\ change_i) + 0.00163(\$compensation_i) - 0.0063(change\ in\ vehicles/hr_i)$
- $U(relocate) = 0$

Calculate implied dollar values from separate functions as before using following base case example:

Project features	Proposed Project	Another Project
Travel time change	–5 minutes	+10 minutes
$ compensation	$5,000 per household	$10,000 per household
Vehicle/h change	+500	+2000

- $U(\text{proposed}) = e^{-2.5 - 0.1(-5) + 0.00163(5000) - 0.0063(500)} = e^{3.00} = 20.09$
- $U(\text{another}) = e^{-1.5 - 0.1(10) + 0.00163(10000) - 0.0063(2000)} = e^{1.2} = 3.32$
- $U(\text{relocate}) = e^{0} = 1$
- $Ln(IV) = Ln(20.09 + 3.32 + 1) = Ln(24.41) = 3.19$

The probability of choosing each option is:

- P(proposed) = 20.09/24.41; P(another) = 3.32/24.41; P(relocate) = 1/24.41
- P(proposed) = 0.82; P(another) = 0.14; P(relocate) = 0.04

The compensating variation of the proposed project relative to another project or relocating is calculated by taking the difference in expected utility of the proposed project versus relocating and another project versus relocating; that is:

- CV[(proposed v relocate = 1) – (another v relocate = 2)] = (1/0.0063) x ($IV_1 - IV_2$)
- CV(1 – 2) = 158.73 x (21.09 – 4.32) = – $2661.90

Thus, to equate the two projects, the compensation offered by project 2 would have to increase by $2,661.90 per person.

A4. Summary of Modelling and Valuation

Compensating variation is the approach used to value changes to existing transport facilities or projects, as well as differences in two or more projects.

When the appropriate choice model is MNL, the calculations are relatively straightforward and simple as illustrated above. If the functions are non-linear (e.g. utility is a non-linear function of compensation), the calculations are more complicated. If the functional form of the model is not additive, the calculations are more complex.

If the model is not MNL, then the calculations depend on the model form. Generally speaking, it may be easier to embed the model results in a decision support system (DSS) rather than try to do the calculations "by hand" or explain the process to a client. That is, once the results are provided in the form of a DSS, it is a very simple matter to show a user how to calculate CV by using the DSS to do it. The user doesn't need to understand mathematics to do this, and the process is intuitive and easy. For example, if the above equations were in a DSS with a user-friendly interface, it would be simple to show someone how to make a change in a feature and then adjust compensation up or down until the effect of the change in the feature is exactly compensated by the change in compensation. I would recommend this approach in general for consulting applications.

A5. Anticipated Costs

Memetrics has discussed costs with its wholly owned subsidiary, Mementum Pty, Ltd. Mementum is a major web development company, recently awarded a Telstra/Fin Review Award for best multimedia site in last year's competition. We have produced what we believe to be reasonable upper and lower bounds for the costs of producing the required multimedia stimulus materials, analysis and reporting. We did not estimate the costs of fieldwork because this would depend on sample sizes. However, Memetrics wishes to make it clear that this does not constitute a bid on our part to undertake such work, and each project would have to be costed on its own specifications.

We estimate that the cost of producing the materials would be $30,000 to $ 50,000. The lower range applies to applications in which SKM provides all the images or pictures (no composite images required), and the upper range applies if composite images are required. That is, these costs are for the development of the multimedia presentation materials that would be used on all interviewees, including focus groups, as well as the experimental materials in the case of composite images. These costs reflect the large amount of manual labour involved in creating images and presentations.

In addition to the materials costs we estimate the following costs for other items:

- $5,000 for background, initial meetings and research design
- $8,000 for instrument design
- $45,000 for modelling and analysis
- $12,000 for report writing and presentation

subtotal = $70,000

Total with materials = $100,000 to $120,000, exclusive of data collection

A6. References

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Appendix B Project Review Assessment of the Community Severance Effects of Roads

by **F. Tate, 2000**

B1. Background

This review is the second of two, which considered the overall choice of method proposed in order to investigate and "value" the Severance Effects of Roads. Our first review undertaken in May 2000, considered a proposal based on the so-called "Swedish Method". The elements of this method were summarised as being:

Step 1 The development of an expression, which assesses the magnitude of a barrier in terms of the road and traffic characteristics.

Step 2 The quantification of the effect of a particular barrier in terms of:
a. Delay and
b. Disturbance (which represents the users responses of risk and insecurity).

Step 3 Determining the exposure to the barrier for different groups.

Step 4 The monetarisation of the impact using:
a. the value of time for delay and
b. a range of monetary values representing the impact of the disturbance on different groups.

The principal tool for this work was to be the use of video recordings of road and traffic scenes, which would be presented to a range of subjects. Subjects would be questioned as to the relative impacts of each scene in order to determine the *Disturbance* that each barrier may generate. The *Disturbance* scores to which an economic value would be attached from the Contingent Valuation Method (CVM) would be combined with the economic value of the delay component which could be either a measured or calculated.

However following our first review the researchers have revised their position in the light of more recent investigations. The revised approach is now:

Stage 1 Understanding the key impacts of changes to roads
Stage 2 Collecting data on stated preferences
Stage 3 Modelling reaction and behaviours
Stage 4 Measurement and valuation

The revised approach is in fact similar to that of the Swedish Method, the exceptions being that:

1. Step 3 of the Swedish Method is dropped (presumably to be addressed in another component of the research).
2. Delay which is considered as a separate impact in the Swedish Method is no longer considered specifically but combined in the overall assessment of Stage 3 and Stage 4.

3. Step 4 of the Swedish Method, monetarisation of the impact has been broken down into Stage 3, which explicitly considers behavioural change and Stage 4, which uses contingent valuation methods (CVM) to value the impact.

The last point, the separation of behaviour and valuation, adds strength to this revised approach. By linking behavioural change to valuation increases the transparency of the work. CVM are established tools, which are often used in the valuation of a wide range of impacts. Together with the fact that Prof. Louviere is internationally renowned in this field provides some confidence that the research is heading in the right direction. There are however a few "practical" issues which remain of concern.

B2. Introduction

By way of a brief introduction, CVMs seek to establish a hypothetical "market" in which participants are encouraged to "trade" (express preferences for one good over another) in as realistic manner as possible. The key issues related to the use of CVM are the:

1. degree to which the subjects are able to "understand" the impact or good in question,
2. suitability of the stimuli in conveying information about the attributes of the good in question, and the
3. payment vehicle.

B3. Understanding the Impact

The focus group sessions will obtain information on the perceived reactions and information value associated with "cartoon" scenarios. In this respect the focus groups will provide valuable information with respect to the first issue. However, many researchers have noted that severance impacts are poorly understood by both the "experts" and the public in general (Clark et al. 1992). It would therefore be a good idea to ensure "checks" are made at this early stage on the relative "values" that participants assign to the various components to the problem. Anecdotal evidence would suggest that pedestrian crossing facilities are viewed by many as desirable and may be used to mitigate the barrier impact of a road. From time to time calls are made for a crossing here or a crossing there because a road is dangerous. However when looking at the specific groups such as young children we find that parents may in fact not allow young children to cross at a pedestrian crossing unaccompanied.

Another example relates to the perceptions that people hold about the speed of vehicles on a particular road. When undertaking surveys of traffic speeds, the concealed surveyors have at times been accosted by members of the public who will tell the surveyors that "traffic always speeds on this road" or how "dangerous this road is". That the data suggested otherwise led the researchers to consider whether the public perceptions were being influenced by the presence of a small number of fast vehicles.

This being the case, a higher order percentile measures of speed would be expected to correlate well with subjects (perception) scores. However this was not the case (Tate 1997).

Both examples are based on actual experience when undertaking surveys of the perception of the danger of roads and traffic. Neither provides a solution but indicate that there are likely to be problems in people's understanding of the issues and concepts.

B4. Presenting the Stimuli

A key issue in the design of the CVM questioning mechanisms is how to provide sufficient information about a poorly understood situation or impact, without inducing bias. The use of multimedia presentation as the stimuli should help to reduce the potential for priming of this type. There are, however, a number of concerns as to the degree to which even a sophisticated multimedia presentation can represent the impact. If at the completion of the research it is found that a factor such as traffic speed has little impact on behavioural choice, we need to be sure that this is because there is no impact and not because speed variation could not be adequately conveyed to the participants due to the nature of the stimuli. This issue was raised in the earlier review with specific comments on the impact of:

1. presentation resolution on the perception of vehicle speed and distance (gap or time to collision) judgements;
2. knowledge about conditions and the duration that may be required to provide an accurate representation of a traffic stream;
3. subject fatigue and the number of possible scenarios that may be needed to be modelled (especially if as the researchers point out the potential for multicollinearity is to be minimised).

Apart from a bland statement *"This approach has been used with success in forestry and related applications by environmental psychologists in the US and elsewhere (See cited URLs in "References Cited") to measure how subjective quantities vary with objective, physical measures"* (Appendix A, p.49), these important practical issues have not been addressed in any detail. This is both surprising and concerning, given the detailed discussion of the utility functions. Having visited the cited URLs of the ImageLab, it appears that the bulk of the applications are essentially visual.

Research into the impacts of roads and traffic has identified safety, perceived danger, fear and intimidation as major concerns related to roads and traffic (Morton-Williams et al. 1978; May et al. 1985; and Hillman et al. 1992). In discussing the developing role of multimedia and virtual reality, Orland (1999) notes:

> *The virtual environment should provide realistic depth information that enables observers to judge the correct three-dimensional relationships of virtual objects.*
>
> *The virtual environment should provide the illusion of immersion within the environment.*

Clearly the immersiveness of the environment and the spatial relationship between the participant and the traffic scene will be a critical factor when seeking to elicit a reasonable behavioural response. At one end of the scale we can have a still photograph of a traffic scene while at the other a full virtual world or indeed a real road. Just where the proposed multimedia presentation lies along this scale is unclear.

The "other side of the coin" is where we might ~~we~~ expect the multimedia presentation to lie and what evidence is there to support this. Unfortunately Orland (1999) also notes:

> *The investigation of a virtual world user's ability to accurately extract meaning from the displayed data is still largely unexplored.*

A literature search on this issue has found very little that allows us to accept or reject the use of virtual presentations of roads and traffic. Three articles have however been found at the ImageLab URLs cited and these may help answer this key question:

> Larson, J.R., Orland, B. 1988. The Residential Street: The Effects of Street Width and Presence of Vehicles on Perception. EDRA 1988 Proceedings, EDRA, Pomona, California.
>
> Sullivan, R., Orland, B. 1988. Driving for pleasure I: Designing an Ecological Representation of the Roadway Experience. *Proceedings, Social Science in Resource Management*, Urbana, Illinois.
>
> Orland, B., Sullivan, R., Messer, G. 1988. Driving for Pleasure II: A Roadway Simulation Case Study. *Proceedings, Social Science in Resource Management,* Urbana, Illinois.

Unfortunately these are all conference papers and I am having some difficulty in obtaining copies (including an as yet unanswered request to ImageLab on 2/01/01).

There is also a concern about the number of scenarios that may be tested. The description of the methodology suggests that some images will have heavy traffic and others light traffic, some will include trucks and others will not. Feelings of danger from road traffic have been found to relate non-linearly to traffic volume measures (Morton-Williams et al. 1978; Swedish National Road Administration 1986; Road Directorate Denmark 1992; Tate 1997). This finding is encouraging since it implies that, when presenting images of different traffic scenarios, small differences in traffic volume are unlikely to impact heavily on perceptions. Thus simplifying the design of the study.

It does however beg the question as to whether perceptions are likely to be linearly related to other variables, e.g. traffic speed or the proportion of heavy trucks using a road. Some sources (Road Directorate Denmark 1992) suggest that there may be a linear relationship while other sources (Swedish National Road Administration 1986) use more complex forms. Only defining two levels for such an attribute (with heavy truck and without) will not be sufficient to identify this. While considerable discussion has taken place over the methods to be used little attention has been given to the boundaries of the problem.

In the first review, an assessment was made of the number of experimental conditions that would be required to produce a full factorial design. It was suggested that around 90 combinations would be required to test the impact of traffic volume, carriageway type (two-lane two-way and four-lane two-way), percentage of heavy vehicles, and mean speed. The impact of lane width and crossing provisions/ facilities were not included and could double or treble this number. It is recognised that such issues will be refined following the focus group sessions. However based on the literature review and a general understanding of the characteristics of roads and traffic, some preliminary assessment can and should be made. These initial assessments will be necessary in order to generate a preliminary set of images needed for the initial testing. Given the level of investment in the images some initial tests should be commissioned before the researchers are locked into this approach.

B5. Responses and the Payment Vehicle

The selection of subjects and the construction of the scenarios are two further areas, which are light on detail. The three broad categories of subjects are likely to be:

1. Elderly
2. Able bodied "middle aged" adults.
3. Young children

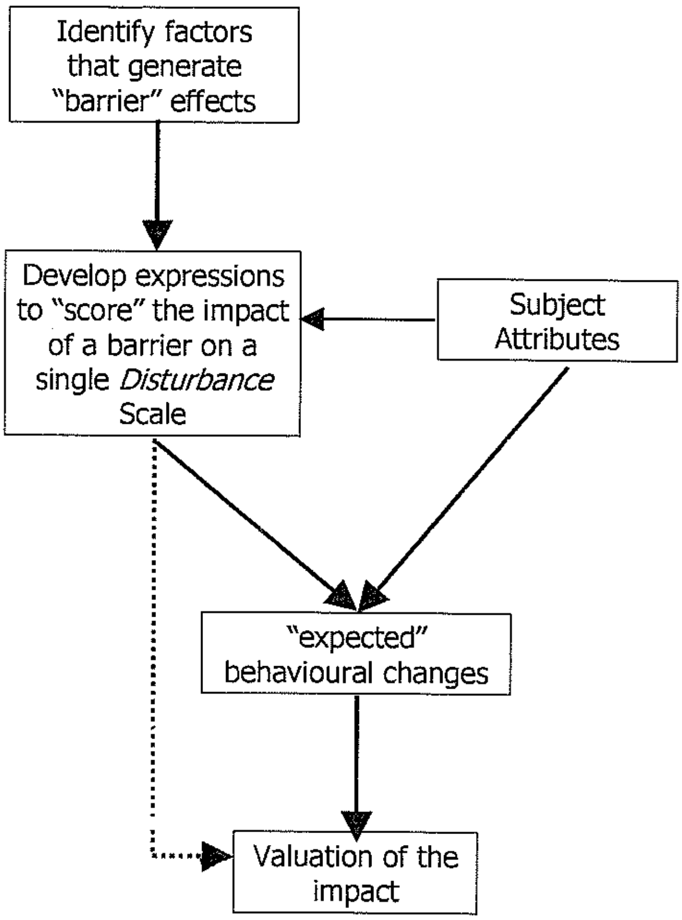
While the first two can be expected to answer on their own behalf, how to get realistic perceptions for the latter is more difficult. The most likely solution would be to ask the parents of children about what they would or would not allow their child to do. Even then, there are likely to be problems as this decision may depend on the trip purpose. For example parents may restrict a child who wishes to venture into "uncharted" territory while allowing them to cross, similar roads when making a regular journey in an area the child knows well. Separating the issue from the context is likely to be a problem when constructing the scenarios. This may also apply when considering the behavioural response e.g. if the child must cross road X on the way to school, the parent's response may be to drop them off on the way to work. In this case the Willingness to Pay or Accept Payment (WTP/WTA), will be related to any additional journey costs and the inconvenience. If the child wishes to make the same journey in a different context the parent may simply not allow them to make the trip. How the payment vehicle might distinguish between the two or cover the two situations is difficult to imagine.

One possible way would be to standardise the presentation so that participants were asked to consider how they would view such a road if it was the main road at the end of their street 200m away, or three blocks (1000m) away. To do this the researchers would need to know the distribution of pedestrian trip distances. This can be found in the New Zealand National Travel survey and would be required when considering how the final methodology will be used to assess real projects.

The separation of behavioural change and reaction from valuation is one of the strengths of the revised approach. Exactly how the separation will occur is however not completely clear. In Figure B1, we outline how we have interpreted the framework in which the research will:

1. Identify the factors that contribute to the "barrier" effect of roads and traffic.
2. Develop an expression (or expressions) to quantify the impact of a barrier in terms of a single score on a scale that represents the total severance or *Disturbance* associated with a barrier. This is expected to vary by subject group.
3. Identify the behavioural changes "expected" at a various levels of *Disturbance*. Taking account of the subject attributes and the level of *Disturbance* estimate the probability of a particular behaviour occurring.
4. Valuation of the impact from the expressed behavioural reactions rather than directly from the level of *Disturbance*.

This approach would allow the estimates of *Disturbance* to be compared with the findings of Transfund NZ Research Report No. 80 (Tate 1999). It will also allow the valuations generated by the CVM to be compared to alternative estimates using travel cost methods.



B6. Summary

The framework proposed is similar to that used by others (Swedish Method) and appears likely to be successful.

The use of contingent valuation methods is reasonable and in Prof. Louvier the researchers have an internationally recognised expert in this area.

However a number of issues that were raised in the first review with respect to the suitability of video images remain un-answered. In particular:

1. Details of exactly what is proposed by way of multimedia images are lacking;
2. Little evidence presented to support the assumption that the participants will be able to accurately extract meaning from the multimedia images;
3. The initial discussion of the variables to be tested and the possible levels of these is inadequate and leads to concerns over how the experimental testing will be conducted.

B7. The Way Forward

Our principle concerns relate to the description and use of the multimedia images. To calm these concerns the researchers may wish to obtain more evidence to support the use of multimedia images as a means of conveying data related to road and traffic situations and the associated impact of danger.

If such evidence is not available, the fact that something has not been attempted should not constrain the research. If this were always the case, nothing would ever be accomplished. However given the level of cost associated with the generation of a large set of images it would be prudent to adopted a staged approach which allows Transfund some control over the progress.

We would recommend that:

1. the focus groups be used as intended to develop a comprehensive specification of information and reactions.
2. a limited number of multimedia images should be developed and used to establish the degree to which the images are able to represent/convey attributes of the road and traffic situation. This work could be undertaken as part of the focus group sessions or as a separate exercise and reported to Transfund before investing in the generation of a large set of images.

If at any point there are indications that the multimedia images are either inadequate or prohibitively expensive, the researchers may consider using the same framework but relating the questions to real roads for which the characteristics are measured.

The use of real roads does have a number of advantages. In particular the cost of data collection is likely to be considerably less than for multimedia images. Some initial thoughts on this alternative are:

1. Use the Transfund National Traffic Database to select a sample of say 100 roads possibly in 10 groups of 10 (or 5 groups of 20) where the roads are geographically grouped.
2. Road-specific data would be collected using a traffic classifier to obtain flow speed and %Heavy Goods Vehicles for each road over a week.
3. Physical measurements would be made of the road width, parked cars, lane markings, the presence of crossing facilities, and possibly photographs (slide quality) could also be taken to aid the participants recognition of the situations/locations about which the questions are being asked.
4. Checks would be made to ensure the roads initially selected did not resulting in high levels of multicolinearity and if necessary a further sample could be collected.
5. Questionnaires to obtain the stated reaction data could then be administered through group sessions. Such group sessions could then be arranged through schools and or other community groups. This can at time be problematical but it is suggested that schools be approached and paid to supply a room suitable for the needs of the session and also to provide an adequate sample, to meet a pre-specified profile. Most schools could do with some extra income, and in the past have been interested in doing such things.
6. At each session the researchers would display maps of the area together with photographs of the specific locations that are being talked about. Subjects would then be asked to undertake the choice exercises as proposed by Prof. Louviere with respect to the actual locations identified. Specifically subjects could be asked to rank/rate the actual roads with respect to their knowledge of the road, their perception of the traffic speed and flow, as well as the danger that these roads pose to those crossing.
7. The specification of the behavioural change could then be investigated. One difficulty with this approach is that the subject base will be those who have remained in the area, where in some cases a major road has been constructed. This will limit the range of behavioural choices that may result. To overcome this a "what if questions" could be asked, e.g.:
   - 7.1. "On the scale above (that where speed flow or perceived danger was rated) where would the road outside your home be rated?";
   - 7.2. "What would your reaction be if the road outside your home was to be improved to make it similar to road Y?";
   - 7.3. This is an immediate example and may result in "confusion" between severance impacts and other issues such as noise and visual amenity. The former is accounted for in the Transfund Project Evaluation Manual. The alternative would the road at the end of your street or similar.

Although a little out of touch with the costs of such data collection in New Zealand, it is expected that sub-contracting out the road data collection to one of the specialist traffic counting companies would see the data collected for around NZ$20,000 ($200 per site by 100 sites). This is significantly less than the amount estimated for the development of multimedia images. Another advantage is that the relationship between the subject's "home" and the road can also be explored. The other costs associated with focus groups and the development, testing, analysis and reporting of the stated reaction task would be as proposed.

B8. References

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